Flinders UNIVERSITY
ADELAIDE · SOUTH AUSTRALIA

"*Thank you, Google*™"

The impact of students' information-communication technology use on their learning in active learning contexts.

By

Gillian Ruth Kette

Thesis
Submitted to Flinders University
for the degree of

Doctor of Philosophy

College of Medicine and Public Health

06/10/2021

1 CONTENTS

ABSTRACT

One of today's central educational concerns is how to combine the contemporary students' ability to control their information needs using Information-Communication-Technologies (ICT) and their ability to manipulate ICT with active-learning (AL) curricula which were clearly not designed to accommodate ICT. Especially the potential negative impact this has on students' learning is a cause for concern. AL pedagogies routinely presume students activate their biological memory to retrieve knowledge, not their smart ICT devices' memory. Yet, the ubiquitous access to vast amounts of information via ICT devices has pervaded all levels of our lives, and education is no exception. It is these ICT-afforded students who are now undertaking higher education formal AL courses. University education seeks to guide students from novices to experts and proficient, lifelong learners in their chosen field of study. Current students are the academics, researchers, and professionals of the future and have to become competent medical practitioners. Medical students need help to navigate seemingly endless pre-requisite medical information and understanding from the pervasive resource of the ICT environment. Students must master a great deal of information, understand how to learn, become lifelong learners, be problem solver, gain medical skills, and integrate all these requirements into an empathetic, competent practitioner. It was against this backdrop that this research was conducted.

This research sought to understand students' effectivities (abilities) to informally supplement their formal AL tutorials with informal ICT perceived affordances (functionalities) and, importantly, determine how these student ICT-seeking behaviours either augment or hamper learning in the AL environment. The research focused, therefore, first on understanding the ICT-afforded students' perspective of the learning benefits of their ICT interactions. This was followed by identifying events in which students controlled the ICT affordances during formal AL and interpreting these events from the perspective of their AL educational implications. By this, I aimed to better understand the contemporary students' uses of ICT affordances during formal AL to inform future educational design in face-to-face and online teaching.

I employed a cognitive constructivist interpretivist qualitative research methodology that positions the product of learning as knowledge and understanding in biological memories, learning or the specific way in which information is stored in as students' biological memory is an individual activity and largely depends on the students' prior knowledge and life experiences. It is also impacted by the students' ICT effectivities to navigate their learning needs both formally and informally. In order to study this complex learning environment, I used a purpose-built conceptual framework using and combining Bandura' Social Cognitive Theory of learning and the group of Information Processing Theories. This framework provided the lens to determine the student's effectivities of using ICT affordances for AL. The ICT affordances enable students to access a near infinite resource of information and facts and create online learning spaces and opportunities by communicating with

diverse communities to develop knowledge collaboratively and capitalise on ICT's convergent functionalities. Superficially, these ICT affordances should align with the AL tenets of construction of knowledge through collaborative interactions whilst working on contextually relevant scenarios. So, the five affordances of ICT in education, creation, collaboration, communities, communications and convergence, combined with the three of active learning, constructive collaborative and contextual learning, can be used to evaluate where and when both sets of affordances align. One would assume that contemporary ICT savvy students are adept in navigating and using ICT affordances during active learning settings. However, investigating the alignment of ICT and AL affordances has been central to demonstrating that educators can not assume students digital confidence translates into digital competence for academic learning. In fact, many students are drowning in the unnecessary complexity they have created by misappropriating ICT affordances that may or may not enhance their learning. Hence highlighting students need help to align ICT and AL affordances to promote academic growth and development.

First-year graduate-entry-medical students volunteered for their routine AL tutorials to be video-recorded. A selected set of ICT interaction events during their AL tutorials formed the basis for in-depth analyses. The rich multi-modal data sets included videos, observations, transcripts, photos, VSRTA, group work, ICT history logs and surveys. These were triangulated and qualitatively analysed using data analysis software. Subsequently, they were interpreted using the conceptual framework with the five ICT and the three AL affordances. This research methodology allowed for unique, in-depth insights and perspectives relevant for educators and students to be aware of. One example is that students generate a learning environment fraught with ICT complexity with minimal direct learning potential resulting in increased extraneous cognitive load.

Other consistent findings of this study were that students' ICT effectivities to use ICT affordances for their personal lives do not automatically translate into students knowing how to use ICT for learning. Students assume that they are 'digital natives' who have grown up with ICT and can therefore use ICT seamlessly and with great facility in any given situation. As a result, students overestimated their ICT effectivities in using ICT in the AL setting. But this digital confidence did not simply translate into digital competence in the arena of academic AL. Instead, it led to complex learning traps. Inversely, educators also assumed students to be digitally competent, so they left this learning arena untouched.

Consequently, students' ICT knowledge and skills for learning were not commensurately scaffolded and developed alongside other subjects within their formal AL courses. Furthermore, when creating their own ICT-afforded learning environment, they did not invite academic teaching staff, such as social media groups. As a result, when students sever the connection between the bounded, quality controlled learning environment of the formal curriculum and instead relied on the infinite and poorly quality-controlled informal learning environment of the internet. In doing so, they

lose the scaffolding and safe guards provided by the educators and need to make judgements about the veracity of information themselves.

When ICT affordance or applications selection was left to the students, I found they were drowning in self-selected complex online resources, which increased extraneous cognitive load considerably. Students created multiple layers of disparate and disconnected information and formats for which they expended massive extraneous cognitive effort and learning time but which they could not use under time-constrained conditions. They were using ICT affordances to create extensive learning networks consisting of multiple online libraries with excessive numbers of digital textbooks, websites, images and notes, which they mistakenly perceived to be beneficial. They further created multiple online self-selected learning groups, used multiple ICT devices and multiple online applications, which were all purported to help them learn and organise their study life balance. Essentially, students were creating and storing multiple disparate pieces of information, but these remained isolated and could not be searched and accessed purposefully. Therefore, students keep relying on search engines, such as Google, to find just-in-time information. Consequently, students become lulled into believing their collected pieces of information is the same as their own biological knowledge. But the mere fact that these ICT repositories are unsearchable demonstrates how much this is in direct conflict with the AL tenet of construction of biological knowledge.

In light of this, students increase reliance and dependence on ICT fuelled their intolerance of uncertainty which, in turn, droves their need to be correct and decreased their confidence in their knowledge. As a result, they were uncomfortable and felt a need to quickly resolve unknowns, uncertainties and check their biological knowledge before sharing anything with the other students. Because of this, students relied on having continuous internet connectivity to retrieve just-in-time information to cater to this desire always to ‘know’ and have answers. When internet access was not forthcoming, they manipulated their ICT devices to ensure connectivity even at the expense of face-to-face AL opportunities.

There are two important implications to consider with this ‘need-to-always-know’ and have answers. Firstly, the AL safe environment of small group learning, which presents learning triggers of unknowns and uncertainties to motivate shared cognitive meaning-making, is not utilised. In such an AL environment, students can proffer diverse information for collaborative learning. Offering perfect answers does not allow for this learning. Instead, students can learn from their own and each other's mistakes in the traditional AL context to negotiate a path towards groups consensus and resolution. With these quick resolutions of their ‘unknowns’ and ‘uncertainties’, the AL affordances inherent in small group learning for collaborative construction of knowledge are truncated as AL is not about answers or quick resolution. Instead, AL recognises the cognitively effortful learning journey to contextually construct memorable long-term memory schemas that can be quickly retrieved when the practical situation requires it.

Secondly, by relying on internet connectivity, students form transactive memory relationships with their devices. Some students, struggling with the volume of information to learn, delegate the role to remember to their ICT device rather than their own biological memory, and in doing so, they mistakenly believe this ***is*** their learning. Although previous research in more experimental settings found that students formed ICT transactive memory relationships, which enabled them to remember where the online information was but not the information itself. In my study with students in their naturalistic learning group and under time-constrained conditions, they could not even remember where to find the information and, consequently, the information itself. The salient point here is that when students are provided with enough time, they could potentially navigate to their ICT stores to resolve unknowns, but when under pressure, as in real practice, they simply cannot.

This leads to the pivotal role of the individual student's prior knowledge in accessing ICT affordances in a meaningful and effective way under time-constrained conditions. Limitations in their working knowledge in combination with the pressure of group work expectations repeatedly led to surprisingly significant errors in keyword writing and judgement. These errors were surprising because the searches seemed so simple for somebody with the relevant prior knowledge. So, when students have on-topic prior knowledge, they are better positioned to navigate entry to and selection of appropriate ICT collaboratives and communities of knowledge. This prior knowledge then means they can judiciously write keywords and judge the search engine results (SERs) for veracity and relevance. So, on-topic prior knowledge is an absolutely necessary prerequisite. But if students, do not have sufficient on-topic prior knowledge to communicate with the ICT affordances succinctly, they make remarkably simple errors in keywords and mistakes in judging the SER's as they go on attempting new keywords without obtaining relevant answers. When this occurred, students invariable abandoned their search to no avail.

This also has possible important implications for open book and online examinations. If the students have not prepared, committed, and processed information to their biological memories, they will be unlikely to quickly find answers and information to help them pass their examinations. ICT affordances do not provide the correct information unless the students' effectivities of prior knowledge guide their online search. Similarly, students who do not have sufficient prior knowledge lose valuable time away from the AL affordance of collaborative promotive interactions and miss thus out on its benefits for their learning in the task context.

The act of online searching is a cognitively demanding activity. Despite many students' belief that they can 'leave an ear open for interesting information!' whilst searching online, students in these situations made simple errors in both the ICT search domain and the collaborative domain of the face-to-face group. Obviously, multiple demanding activities lead to attentional focus splitting resulting. This not only leads to a situation of insufficient attention for each of the tasks in themselves, but the continuous task switching takes up cognitive resources as well. Despite the

assumption that contemporary students are better multi-taskers, such dividing of attention between cognitively demanding tasks means that students dilute their cognitive capacity between the tasks and cannot multi-attention or multi-task in such learning situations. This explains one of the important findings as to why students made simple errors, were frustrated at not succeeding in simple tasks and had to eventually abandon either the online search or AL involvement.

Contemporary students are proficient informal ICT consumer and are able to navigate their ICT devices technically very well. But this study exposes the vulnerability of contemporary students who use ICT affordances to converge their role as students with the educator's role. The latter occurs because students deliberately do not connect the formal and informal learning spaces or the ones between themselves as ‘digital natives’ and their educators as ‘digital immigrants’. Although students, who control their informal informational needs through ICT affordances, believed they were learning, they still wanted and sought as many informal and formal learning opportunities and resources as possible. In fact, students want it all.

Another finding highlights the convergence of the students' role and that of the educators. By controlling their information needs, students have converged with the educators’ role who oversee the curriculum and instructional designs. The students have clearly gained a sense of agency and control over how they learn, but as a result, they lack the necessary guidance on managing the huge number of affordances and the vast amount of information that they find extremely difficult to navigate. Or, to put it differently, the line between student and educator has blurred. Therefore, directly acknowledging this ICT-afforded convergent situation will open up future research perspectives to explore conduits for educators and students to work closely together to broker an educational design to support learning strategies that resonate and promote incentive for students to explore and develop. The principal aim is to develop their academic digital competencies to interweave ICT and AL affordances successfully. For this to occur and to successfully interweave ICT and AL, the ICT affordances of communication, communities, collaborations, creation and convergence, and AL of constructive, collaborative and contextual will need to guide all educational design.

The currency of AL is that information is processed biologically by the learner into knowledge and eventual wisdom and, who during this learning journey, will develop life-long learning skills. This takes persistent cognitive effort and time, with repeated rehearsal, performance and reflection. Students in AL courses and for lifelong learning must be prepared to and be willing to be incorrect, know how to work through one's and each others’ understanding and learning needs. Essentially learning is not easy. It takes time and requires students to apply and question themselves and others irrespective of the collaborative space. ICT affordances can supplement this process, but they cannot replace it. Learning is hard work with no shortcuts, with contemporary students of today being no exception.

DECLARATION

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed.....

Date....15th May 2021.....

ACKNOWLEDGEMENTS

It was my great fortune to have Professor Lambert Schuwirth as my principal supervisor and Associate Professor Julie Ash as supporting supervisor. I have valued their friendship, perceptions, support, and most of all, their belief in me and my research.

I am indebted to the 2016 first-year graduate-entry-medical doctorate students at Flinders University who shared their active learning tutorials with me and were generous and honest in sharing their thoughts, time, perspectives, and critical internet search information.

Invaluable help was provided by Fiona Smith for helping me format this dissertation, Svetlana King, Koshila Kumar and Leila Morsey for discussions and support and the collegiate, supportive, and academic environment of Prideaux Centre for Research in Health Professions Education in the College of Medicine and Public Health at Flinders University.

I thank Ruth, my Mum, and posthumously Douglas, my Dad, for both raising me to believe anything is possible. My Dad was a great educator in secondary schools and believed in education for all people, no matter what walk of life they came from. He would have relished the ICT afforded world of today that has democratised education.

Finally, to my husband Frank, children Sofia, Francis, and Claudia, thank you all so very much for your unwavering support, and especially for your love and belief in me. Thank you for granting me this time to indulge in this long part-time research journey and for keeping meals on the table.

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION CHAPTER

This dissertation presents an investigation into the impact of having continual access to informal Information Communication Technology (ICT during formal active learning (AL) on contemporary higher education students' learning. To undertake this qualitative research, a conceptual framework was developed integrating Bandura's social-cognitive theory (Bandura, 1986), Information Processing theory by Atkinson and Shiffrin (Atkinson & Shiffrin, 1968), and Mayer and Moreno's cognitive load theory of multimedia learning (Mayer & Moreno, 2003). The conceptual framework formed the lens for exploring how students' learning was affected by access to informal ICT affordances (Friedman & Friedman, 2008, 2013), examining what students' ICT learning effectivities were and how these aligned with the formal AL tenets (Schmidt, 1983).

This chapter briefly introduces the concepts of learning drawn upon and the student learning environment pre and post ICT. The rationale that led to this research and the research objectives is then presented.

1.1 Active Learning

Historically, AL arose out of well-established constructivist learning theories as reviewed by Ertmer and Newby (Ertmer & Newby, 1993), in which students are considered active participants in their learning building on their prior knowledge. This contrasts with behavioural instructional designs that consider students passive receivers of information from their teachers (Ertmer & Newby, 1993). A key AL process or tenet is that students construct their own knowledge through understanding contextually relevant and memorable cases that arise from collaborative interactions, such as discussions, questioning, listening, and challenging (Azer, Peterson, Guerrero, & Edgren, 2012; Barrows & Tamblyn, 1980; Chickering & Gamson, 1987; Dolmans, De Grave, Wolfhagen, & Van der Vleuten, 2005; G. R. Norman & Schmidt, 1992; Schmidt, Rotgans, & Yew, 2011). The goal of AL in medical education is not merely to solve the presenting cases but to explore and understand them from basic underpinning scientific principles, physiological mechanisms, pathophysiology, social and clinical sciences that inform the subsequent clinical management of the problem. Therefore, the student develops knowledge and expertise about the presenting clinical cases and takes responsibility for their life-long learning.

1.1.1 Problem Based Learning

In 1968, the AL instructional design Problem-Based-Learning (PBL) was introduced as

the central educational strategy of a new medical curriculum at McMaster University, Hamilton, Ontario. The aim was for students to develop cognitive skills in keeping with medical clinical reasoning and better prepare them for clinical practice (Barrows & Tamblyn, 1980; Neufeld & Barrows, 1974). Since then, PBL-based curricula have been implemented in many different schools worldwide and adapted to suit the local contexts (Hung, Dolmans, & Van Merriënboer, 2019). The central common themes are that clinical problems are presented to students in the context of clinically relevant medical scenarios to promote and motivate students to construct their own knowledge. Students view the new scenarios through the lens of previous experiences and prior knowledge (Barrows, 1983, 1996; Barrows & Tamblyn, 1980; Dolmans, Snellen-Balendong, & Van Der Vleuten, 1997; Hmelo-Silver, 2004). Therefore, prior knowledge and experiences are essential. They work collectively in small groups to brainstorm and share their prior knowledge. As such, students share and receive components of each other's prior knowledge, which leads to challenges and stimulates individual and collective cognition and increases the groups' exposure to different ways to view the problem, and, in doing so, increases the depth of understanding. Ensuing group discussions teased out what was known and what was not known. In this research, the Flinders University graduate-entry -medical-doctorate PBL model (Finucane, Nicholas, & Prideaux, 2001) was used as my 'laboratory'. The PBL as an instructional design was adapted and based on the McMasters PBL model (Barrows & Tamblyn, 1980; Neufeld & Barrows, 1974) and has been anecdotally adapted to the needs and constraints of the Flinders University medical programme setting.

The unknowns, or learning gaps, form the basis for Self-Directed-Learning (SDL) research (learning issues). Therefore, AL central tenets are described as constructing knowledge through collaboration with peers working on contextual, relevant problems to promote SDL (Dolmans et al., 2005) forms the central tenets of AL methods such as PBL.

1.2 Students pre-Information Communication Technology

When AL's central tenets were developed, information communication technology (ICT) was in its infancy (Licklider, 1960) and not available to students. Today, all students have access to ICT, anytime and anywhere, using smart ICT devices. In an ideal situation, the central tenets of AL and the affordances of ICT use should be compatible and integrated. But there is doubt as to whether they really are. One issue that may cause misalignment is that the university typically controls the AL curriculum but has limited or no control of how students use ICT devices. Indeed, it is only recently that the possibilities these devices offer for learning are being explored (Martínez Rivera &

Duță, 2015). Before the advent of ubiquitous ICT devices, students in AL courses were expected to rely solely on recalling information from memory and validated resources, such as edited textbooks. Students would make suggestions, question each other, listen, and discuss ideas. They would recall and share prior knowledge, past experiences and report research on learning issues to their PBL group. They took risks sharing information when they might not have been certain these were correct. Group learning was achieved through refining these ideas, and group understanding resulted in meaningful knowledge schemas for long-term memory formation. The process of developing an understanding was considered just as important as finding the 'right' answer. External learning resources such as traditional validated textbooks and other resources were discouraged in PBL tutorials to promote reliance on long-term biological memory and a willingness to share what they knew. This reliance on self-knowledge fostered lifelong learning strategies.

1.3 Students post-Information Communication Technology

Nowadays, students have access to a plethora of information via their mobile ICT devices that offer a range of ICT-enhanced learning possibilities (affordances). Students with access to the internet have more information at their fingertips than ever before, anytime and anywhere. But we do not know how they manage, incorporate, and utilize information from ICT affordances for their learning. The self-directed characteristics of AL potentially aligns with the ubiquitous access to information from ICT to supplement students' learning. Yet, we do not know whether formally choreographed AL university courses are compatible learning partners with informal student-controlled unchoreographed ICT learning resources.

1.4 Research Aim

The aims of this study are to explore and interpret student ICT-seeking behaviours during formal AL tutorials and examine whether such behaviours augment or hamper learning in the AL environment. My research aims to understand what students do when they use ICT affordances informally during formal AL sessions (PBL) and examine how students are learning and whether they are learning effectively. Information about how students are using ICT affordances for learning will enable educators to better understand whether, when, and where ICT use supports or hampers student learning in an AL setting. This understanding will then help educators design AL sessions, adapt AL practices, and support students in achieving effective ICT-afforded learning within an AL-type curriculum.

1.5 Research Background

1.5.1 ICT Information and Learning Strategies

This research in this dissertation arose from my observations as a PBL tutor of student usage of online information during PBL tutorials in a graduate entry medical school. Initially, I noticed that during the problem analysis phase of a PBL tutorial, several students were surreptitiously searching for answers on their ICT devices instead of exploring what they knew from prior experiences and knowledge (as required by the PBL approach). Furthermore, they were not using memory to identify and share what they did or did not know. During this critical problem analysis phase of learning, students are expected to brainstorm or recall knowledge from memory to explain and propose hypotheses, documenting ideas collectively on a shared board for all to consider and critique (Barrows, 1983; Barrows & Tamblyn, 1980; Neufeld & Barrows, 1974; G. R. Norman & Schmidt, 1992; Schmidt, 1983; Verkoeijen, Rikers, & Schmidt, 2005; Wood, 2003). Students are further encouraged to express their thoughts logically to each other to reach a point at which they can identify areas of incomplete knowledge which they need to understand and learn (Albanese & Mitchell, 1993; Azer, 2004; Dolmans et al., 1997; Hmelo-Silver, 2004; G. R. Norman & Schmidt, 2000; Prince, 2004; Schmidt, 1983; Schmidt et al., 2011; Wood, 2003).

My observations as a tutor were that, unlike the usual problem-analysis behaviour, whereby the group determines what they know and do not know, some of the students seeking ICT information kept their new information to themselves. Surprisingly, they rarely collaborated or shared it with the group. When students did share their ICT sourced information with the group, this information was accepted with less questioning and did not necessarily lead to group discussion as expected in a PBL session.

Supporting these observations was Adrian Ward's research that found students' online information seemed to have increased confidence in the 'feeling of knowing' (Ward, 2013b). The environmental ICT affordances with the behavioural 'confidence of knowing' have been described as students now knew the answers after finding them on ICT (Fisher, Goddu, & Keil, 2015) and did not need to learn more. Dunlosky and Rawson (2012) observed that this quick student response to finding answers via ICT provided increased metacognitive confidence in their judgment that the ICT information was correct, which in turn reinforced the use of ICT-derived solutions as an effective learning strategy (Dunlosky & Rawson, 2012). They concluded that ICT access discourages students from considering alternative learning strategies (Dunlosky & Rawson, 2012).

It could be argued that students seeking direct answers during AL and placing more

credence on ICT information circumvents the intrinsic motivation for learning that arises from ‘not knowing’. Also, that not sharing information with the group for critical discussion compromised the collaborative AL process. As mentioned, when and if ICT sourced information was shared with the group, nearly all students seemed to believe and trust ICT-derived information more than information transmitted by their own or others’ prior experiences and knowledge. Furthermore, I found that students questioned and challenged ICT information less than information retrieved from memory. Therefore, the group was increasingly focused on seeking answers instead of asking and working through the presenting problem together. This led to noticeable change and, in many cases, a truncation of group discussion and collaborative construction of shared knowledge written on the tutorial whiteboard. These shortcuts in the AL process during PBL reduced the development of learning strategies and the ability to resolve learning issues.

My concern was that students ignored one of AL's major learning strategies, promoting the learning journey by identifying what they do and do not know. The realisation of ‘not knowing’ serves as a strong intrinsic motivation for students (Deci & Ryan, 1991; Ryan & Deci, 2000). They are intrinsically motivated to seek understanding and persist by elaborating through underpinning basic concepts until they feel satisfied with their level of understanding (Dewey, 1929; Rotgans & Schmidt, 2011; Schmidt, 1983; Schmidt et al., 2011). The promotion of student autonomy through SDL offers students the choice to follow their interests, making learning enjoyable, forming an enduring long-term memory. This makes learning memorable and enables the development of analogical transfer of knowledge to other medical scenarios. (Rotgans & Schmidt, 2011).

I suspected students were not activating their prior knowledge to construct and integrate into new richer knowledge long-term memory schemas but they were also not learning to problem-solve. I felt they relied on ICT devices as their external memory source as ICT quickly resolved unknown and found answers. As a PBL tutor, I was concerned that students ignored the available face-to-face AL strategies in preference to the Internet, and in doing so, disrupted effective personal and group learning. One obvious solution was to ban ICT devices during AL PBL sessions, as some tutors had done. The original PBL method required students to report back on their learning purely from memory without using books or notes. Disallowing such affordances for the purpose of better learning effectivities has been a characteristic of some AL methods such as PBL. However, banning ICT devices would be contrary to AL tenets and the principles of SDL and does not reflect the current ICT-enabled environment in which students live and learn and in which they will practice medicine. ICTs are now an integral part of our society and the workplace, so it is necessary to adapt and

incorporate ICT affordances in education. Accordingly, I chose to observe further the impact of students' use of ICT affordances on individual and group learning.

1.5.2 Source of ICT information

As part of the AL PBL process, tutors would meet with individual students to provide tutor feedback and as an opportunity to raise issues that might impact their study. During these meetings, students talked of being overwhelmed by the vast amount of online information they found. They also expressed concern about identifying and judging the depth and relevance of the information for the medical program. It was at this stage, during formative student meetings, that students showed me their ICT notes. I noticed many had ‘cut and paste’ patchwork pieces of information from various informal ICT sources.

Moreover, many students had collected this ICT-sourced information without critically reading or cognitively engaging with it before selecting and storing it. Illustrative comments such as “how can I remember all this” and “do I really need to know all this” (anecdotally from my PBL students) cemented the need to help our students. It appeared that students were discovering less of what they did not know or understand to drive learning.

1.5.3 Contemporary use of ICT

Students' pervasive ownership of ICT devices has enabled them to become paperless and access their work, write, or communicate anywhere and anytime. Importantly, universities have not ignored the benefits of ICT affordances for administration, communication, course access, and content. For example, in the medical PBL tutorials I conducted, students were assembled in small groups to work face to face, but all resources for the PBL tutorial cases were accessed online during the tutorial and available afterwards. The impact of placing content online for the tutorial, which was initially designed for face-to-face sessions, was not evaluated, so how this impacted students’ interactions and use for AL and student learning is not known. However, it was assumed to be equivalent to the paper version.

In conclusion, there is a perception that students today have grown up with ICT and are, therefore, proficient at using ICT for all walks of life. Universities have assumed today’s students are ‘digital natives’ and consequently adept at using ICT affordances for learning, whereas educators and parents who have not grown up with ICT are ‘digital immigrants’(Prensky, 2001a). Prensky went on to say that these students ‘learn differently and have short concentration spans’, so as educators, we must adapt our teaching to accommodate these students (Prensky, 2001b). In this research, I will

question these assumptions about contemporary students' informal ICT afforded to learn in a formal AL course by universities and educators. Also, without understanding and exploring what and why students seek ICT affordances during their learning and problem-solving could impact the development of robust lifelong learning skills and their future medical career path.

1.6 Research Objectives

The research objectives to be addressed are:

1. To understand the informal ICT affordance-seeking behaviour and subsequent student effectivities for learning during formal AL tutorials.
2. To explore the level of alignment between the formal AL tenets with the students' abilities to manipulate their ICT affordances to benefit learning.
3. To gauge the interaction of and student dependency on ICT affordances during the AL process and the subsequent impact of these on students' cognitive engagement.
4. To evaluate the impact of informal ICT affordances on cognitive load regarding the individual student and the group's information processing system.
5. To explore the overall influence ICT affordances have on the students' learning strategies and ICT's impact on the development of metacognitive strategies for self-directed learning and lifelong learning essential to AL methods.

1.7 Dissertation Structure

Chapter 1 briefly introduces the concepts of learning and explains the research background from my perspective as an AL Problem Based Learning tutor and the dissertation structure.

Chapter 2 contains a literature review of the relevant evidence of what is known about how ICT affordance influences student learning.

Chapter 3 describes the construction and rationale of my conceptual research framework. Established learning theories, Social Cognitive Theory of Learning, and Information Processing Theory are overlayed with the AL tenets and ICT affordances as described in Chapters 1and 2.

Chapter 4 presents the methodology, material, and methods. I commence by reviewing the methodology through my own perspectives on ontology and epistemology. The

materials and methods are then described.

Chapter 5 presents the demographic and attitudinal data obtained from first-year medical students voluntarily undertaking an online questionnaire.

Chapter 6 presents the data collected and analysed from volunteer AL groups videoed during their formal AL tutorial. A sub-group of these students also volunteered to undertake Video-Stimulated-Recall-Think-Aloud (VSRTA) interviews.

Chapter 7 integrates the conceptual framework I used as a lens to evaluate the students who participated in VSRTA and provided logs of their ICT activities during AL tutorials.

Chapter 8 discusses the insights and findings of the result chapters

Chapter 9 conclusions drawn from the findings and significance to university education, educators, and future AL implications in an ICT afforded world. The research objectives and the limitations and strengths of this research are addressed, followed by recommendations.

2 LITERATURE REVIEW CHAPTER

2.1 Introduction

Chapter 1 outlined the purpose of the study to understand and explore how Information-Communication-Technology (ICT)-afforded students learn when freely accessing informal ICT information during formal Active Learning (AL) sessions. Chapter 2 presents contemporary published views and theories about how individuals interact with ICT, in particular, during formal AL courses. There is a plethora of literature on ICT use for learning from the perspective of how the teacher controls the content and flow of information in more didactic pedagogies. In my research, I have addressed learning from the perspective of student control of the content and flow of information via their ICT affordances. In AL, students are expected to be actively involved, which requires them to accept greater responsibilities over their learning and learning strategies. But we do not know how prepared and capable students are at accessing, sifting through, and judging the volume and diversity of ICT information during AL sessions, nor how their experiences with the social use of ICT modify their learning strategies and whether they develop and acquire new ICT skills for academia.

Literature Review Method

A narrative literature review methodology (Greenhalgh, Thorne, & Malterud, 2018) was employed to obtain an evidence-informed perspective to examine the main concepts and evidence for AL, associated cognitive processes, and evidence for the impact of ICT on learning in order to identify knowledge gaps. A narrative literature review provides the flexibility to explore this broad topic from many frames of reference with more room for insight and opportunities for speculation guided by the conceptual framework (chapter 3) to assess the veracity of the papers reviewed. Therefore, a comprehensive search of the current literature was conducted. Initially, I commenced using keywords, such as AL and ICT; learning and ICT; cognition and ICT, to online search databases. I accessed a diverse range of databases to identify the prominent researchers and relevant bodies of work in ICT affordances and AL interaction. Databases used were PubMed, Medline for Medicine, ERIC, ProQuest for education, Google Scholar, Current Concepts for Neurobiology, and PsycArticles for Psychology. Subsequent hand searching of journals and follow-up references ensured a comprehensive appraisal of the available literature. Successive search terms broadly sought articles on general learning theories and ICT, Social Cognitive Theory of learning and ICT, Information Processing Theory and ICT, ICT affordances, effectivities, and learning. According to Bloom's updated criteria (Krathwohl, 2002), subsequent searches refined the terms to include cognitive principles (Anderson, Krathwohl, & Bloom, 2001) and ICT.

Literature review organisation

In this chapter, I present the literature review in five sections:

1. Learning and active learning in the study of medicine.
2. The Theory of Affordances and how it is applied to ICT properties and its relationship to the notion of effectivities.
3. Learning and the role of cognition, metacognition, and self-directed learning, and the role of ICT affordances.
4. Factors influencing AL and the impact of ICT.
5. Conclusion of the chapter with a discussion of the research gaps and research questions.

2.2 Learning and Active Learning in the study of medicine.

2.2.1 Learning

Three main learning theories, Behaviourism, Constructivism, and Cognitivism, have formed the basis of instructional design for learning over the last century. Each has been passionately debated, rigorously researched, and extensively implemented. I will briefly outline these theories and discuss the latter two further in the methodological chapter (Chapter 4).

Briefly, according to Behaviourists, learning occurs by acquiring an observable and objectively measurable new or behaviour change. The core premise is that only behaviour can be directly observed. Hence thought processes, which cannot be objectively observed, are not considered (Skinner, 1963). The learner is provided with information and motivation to learn through extrinsic rewards or punishments (Skinner, 1963). With similar stimuli, the environment stimulates a habitual response, rather than internal processes, to induce a conditioned learned reaction.

The contemporary learning theories of Constructivism and Cognitivism predominantly refute behaviourism regarding the role of the learner's mind. These two learning theories overlap and are related through their shared focus on the active learner and the role of their mind (Bruner, 1997) and the information processing architecture of the brain (Atkinson & Shiffrin, 1968; Mayer, 2012). Learning involves acquiring knowledge that can be applied to various new situations, hence remembered and transferable to new situations (Mayer, 2010)—thus implying that knowledge cannot be given to the learner (Tudge & Winterhoff, 1993). The learner actively assimilates and accommodates new information through cognitively constructing understanding, making sense, and meaning (Piaget, 1978). Internal motivation drives the learning process as opposed to the external motivation relied upon in behaviourism.

To be an active learner is to have meaningful learning experiences and engage in thinking and being involved in the learning process (Prince, 2004). Therefore, learning requires cognitive effort through engaging cognitive processes, leading to the construction of knowledge schemas stored in long-term memory, which are available for manipulation through the process of thinking (cognition)

(Phye, 2004; Mayer, 2003). Knowledge can be dynamically transformed and adapted according to experiences accumulated over time (Mezirow, 1999), such as in the practice of medicine. These cognitive processes do not occur in isolation. Information is contextually and collaboratively integrated to make meaningful and logical connections through shared language, social, and cultural background (Vygotsky, 1978; Wittgenstein, 1956). The resultant mental representation of knowledge is a uniquely personal frame of reference (Mayer, 2003; Mezirow, 1981). A mental challenge occurs when new information cannot be explained or understood utilising prior knowledge and this creates a cognitive conflict (Piaget, 1978) or disorientating dilemma (Mezirow, 1981; Kitchenham, 2008; Slavich & Zimbardo, 2012). This is the crux of AL as when a learning need is created the learner is motivated to resolve this need. The resultant active learner learns through self-directed learning, cognition, metacognition, reflection, and internal motivation, plus through the impact of external processes from the environment.

Formal higher education degrees have generic, research, and domain-specific knowledge acquisition with commensurate assessment as prime outcomes, for example, medical practicing qualifications. Knowledge and practical application are achieved through hard work and persistence to gain pre-requisite knowledge, facts, skills, practical and theoretical understanding, determined by the University Faculty and professional accrediting bodies. For example, the Australian Medical Council requires university medical knowledge of various medical disciplines such as human anatomy, physiology, and pathophysiology within their socio-cultural context for the student o become a proficient, competent medical practitioner. One must master a great deal of information, become a lifelong learner, become a problem solver, gain medical skills, and integrate all these requirements to become an empathetic, competent practitioner (Barrows & Tamblyn, 1980).

2.2.2 Active Learning

AL is an umbrella term for a group of instrumental designs that focus on knowledge acquisition as a product that is greater than the number of accumulated facts it is a continually evolving exercise, and the process is life-long learning (Grabinger & Dunlap, 1995) (Bruner, 1997, 2004). The learner, or student, undertakes meaningful learning activities that promote the utilisation of both intrinsic and extrinsic factors to construct his/her unique knowledge within his/her socio-cultural environment (Vygotsky, 1980). New knowledge forms within the context of individual existing knowledge structures or long-term memory schemas of the brain. In other words, according to the gestalt school, knowledge is not a product of accumulated facts, but it is an active, always evolving process far greater than the individual pieces of information (Koffka, 1922). Therefore, the learner is considered a vibrant, active, and vital component of their own learning. To do this, they personalise their learning by putting new information into their own words; they ‘digest’ the information and merge it with their prior knowledge. The resultant understanding is shared with others, modified by others, and expanded upon collaboratively and socially with others (Bruner,

1997; Tudge & Winterhoff, 1993; Vygotsky, 1980).

AL assumes that the student arrives to undertake formal academic learning with a pre-existing knowledge base. The knowledge base is unique to each student's prior experiences, declarative, and procedural knowledge (De Jong & Ferguson-Hessler, 1996). The term AL stems from the view that we learn by actively getting involved in what and how we learn (Dewey, 1929). Bonwell and Eison (1991) define AL as,

> *"Instructional activities involving students in doing things and thinking about what they are doing". (Bonwell & Eison, 1991, p. 2).*

Humans have always learned through experiencing and interacting with their environment (Kolb, Boyatzis, & Mainemelis, 2001), but what has evolved is that AL has been formalised into teaching pedagogies to address perceived shortcomings of behaviouristic learning strategies. Behaviourists considered students as 'empty vessels' who relied on the teacher for information. These students were considered at risk of surface learning through rote learning information to pass exams rather than learning to understand the scientific concepts from primary principles characteristic of deep learning (Biggs, 1987; Entwistle & Peterson, 2004; Marton & Säljö, 1976). However, both strategies are utilised successfully by high achieving students (Biggs, 1987; Carr, Palmer, & Hagel, 2015; Ertmer & Newby, 1996). High-achieving students are adept at being responsible for organising their learning by being self-directed learners (Pilling-Cormick & Garrison, 2007; Pintrich & De Groot, 1990; Zimmerman, 1990) and process the information themselves to form meaningful learning (Bonwell & Eison, 1991; Chickering & Gamson, 1987).

Contemporary AL principles and tenets are construction, collaboration, and contextualisation that originate from the cognitive constructivist theories of learning.

Construction of Knowledge

AL pedagogies assume and acknowledge students arrive at University, or an educational institution, with prior domain knowledge and life experiences. They are not empty vessels. Their prior knowledge forms a rich foundation for new learnings to be viewed through, incorporated into, and then reintegrated into previously encoded long-term memory schemas (Chi, De Leeuw, Chiu, & LaVancher, 1994; Dochy & Alexander, 1995). It is timely to highlight that prior knowledge includes the students' ability to use and engage with their ICT devices. The educational strategies to elicit or activate prior knowledge during learning sessions (Gijlers & de Jong, 2005; Wetzels, Kester, & Van Merrienboer, 2011) are a central feature of AL.

Collaboration with peers

To learn essentially means individuals gaining knowledge and know-how in their chosen field of study. However, students are rarely alone in their learning and professional life. They interact and

communicate with others every day. The sharing of information, experiences, opinions, and knowledge is the fabric of human interaction. We are social beings. In most AL settings, students work together in small groups to discuss their ideas (Gijlers & de Jong, 2009; Johnson, Johnson, & Smith, 2007; Slavin, 1983), to share with others their diverse understanding (Fonteijn & Dolmans, 2019). The group sessions provide a conduit to increase time to think, listen and discuss prior knowledge and new issues (Chickering & Gamson, 1987). Working with each other in these groups creates a sense of belonging along with the inherent responsibilities that increase motivation (Deci & Ryan, 1991; Ryan & Deci, 2000) to optimise their learning.

Contextualisation

AL pedagogies that employ scenarios, problems, tasks, or cases situate the learning to be studied. AL has been prevalent throughout all education levels in various forms (Maudsley, 1999). The prominent forms in medical education since the 1960's are Problem-Based-Learning (PBL) (Barrows, 1996; Schmidt, 1983), Case-Based-Learning (Thistlethwaite et al., 2012) , and Team-based-Learning (Michaelsen & Sweet, 2008). Each form essentially has a theoretical backbone that consists of the AL tenets but with substantial variations on the implementation strategies (Dolmans, Michaelsen, Van Merrienboer, & Van der Vleuten, 2015).

Learning when situated in relevant, interesting areas of study becomes more memorable. Hence, learning contextually can facilitate the recall and transfer of knowledge from long-term memory during different times and settings (Dolmans et al., 2005; Ertmer & Newby, 1996). The students encounter and work through the pertinent information that underpins their unique understanding and knowledge construction (Scardamalia & Bereiter, 2006). The aim is to be able to recall relevant knowledge when required. The more frequent and the more situationally diverse contexts knowledge is recalled in, then applied, modified, and continually added to the more substantial the long-term memory structures.

2.2.2.1 Active Learning in Medicine

AL was first introduced in the 1960s at McMasters University Medical School, Canada (Barrows & Tamblyn, 1980; Neufeld & Barrows, 1974). The original rationale was to address perceived flaws in the traditional didactic teaching methods popular in medical education that were considered insufficient in preparing the graduated students for the rigours of clinical practice. Hence, pedagogies were developed that promoted learning for understanding (Barrows & Tamblyn, 1980). Learning by making meaningful connections between prior knowledge and the required medical knowledge are assumed to equip students to be better problem solvers. Therefore, the educational problem-solving approach reflects the medical graduate's clinical practice of applying their learning to solve complex clinical problems. Consequently, graduating students are considered better prepared for the rigours of the clinical arena. Barrows and Tamblyn saw an opportunity to link and apply information to real-life clinical scenarios. These scenarios are designed to stimulate and

motivate students to learn and develop life-long learning skills and clinical reasoning strategies from day one of entering medical school (Barrows & Tamblyn, 1980). The scenario, the problem or the case are typically presented first, before any formal lecture content (Schmidt, 1983). The scenario is specifically written to address the course's learning objectives, including both basic and clinical sciences (Wood, 2003). They are also written at a level appropriate for the assumed level of students' prior knowledge (Azer et al., 2012). In brief, the scenarios are explicitly choreographed for the students and to the course or curriculum requirements. The aim is to focus on the learning process and not the solving of the problem. As such, students are learning through contextually relevant medical cases. Figure 2-1 depicts the overview of the AL cycle I created to explain the stages of PBL used throughout this research setting to describe the learning stages. PBL day one, the problem-analysis phase, consists of presenting a new scenario for students to identify key information for students to propose potential differential diagnoses and mechanisms commensurate with the combined understand. Using critical thinking/clinical reasoning, the students suggest what further information they require and identify collectively what they know and do not know. The self-directed learning phase is motivated to resolve what they do not know through understanding primary mechanisms. The final phase, the report-back, is when the small group reconvenes to collectively discuss individual research and re-contextualise the scenario back into the original scenario.

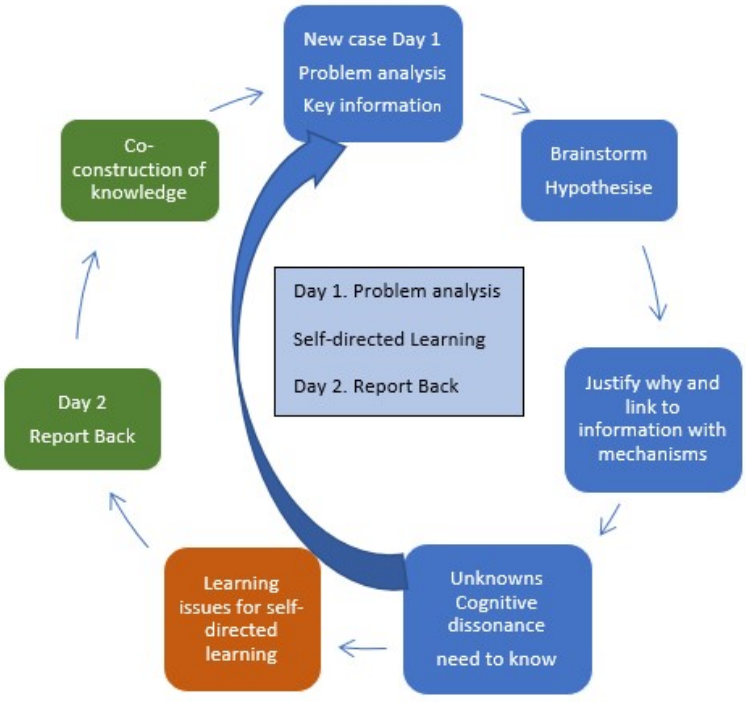

Figure 2-1 Active Learning Circle depicts an overview of the AL cycle I created to position the PBL model I researched at the Flinders University GEMD. This model is instrumental in highlighting the researched points that data was collected.

The theoretical basis for this approach is based on cognitive constructivist learning theories for lifelong learning practice (Drew & Mackie, 2011; Grabinger & Dunlap, 1995). Students are encouraged to construct their knowledge schemas based upon the combination of their prior knowledge, identification of the knowledge gaps and the subsequent learning activities (Azer, 2004; Barrows, 1996; Hmelo-Silver & Barrows, 2006). The role of collaboration with their peers strengthens and expands their understanding (Schmidt et al., 2011) and helps consolidate the construction of knowledge schemas stored as long-term memories (Dolmans & 2019; Fonteijn & Dolmans, 2019). When confronted with complex problems, students will retrieve knowledge schemas from long-term memories to their working memories (Wetzels et al., 2011). This transfer of application of prior knowledge schemas to seemingly new AL cases problems is expected to lead to more rapid problem-solving in the learning and clinical settings (Barrows, 1983; Barrows & Tamblyn, 1980). For this to work, though, PBL students will have to be prepared to share and justify ideas and listen to differing opinions and questions throughout the tutorial. Students must be prepared to have their views and knowledge challenged. The notion of being comfortable with others questioning and challenging ideas, and being prepared to accept they might not know it is a crucial trait in AL and medical practice (Barrows & Tamblyn, 1980; Fonteijn & Dolmans, 2019; Van Blankenstein, Dolmans, Van der Vleuten, & Schmidt, 2011).

2.2.3 Role of biological memory in active learning

From AL's initial implementation, students were encouraged to rely on their biological memory. Resources were allowed but were restricted to paper, pens, a medical dictionary, and a whiteboard to document ideas and discussions (Maudsley, 1999). The tutorial's success required students to activate their prior knowledge and experiences and, importantly, share and elaborate with the group (Azer, 2004; Schmidt et al., 2011). Through rigorous discussions and collaboration around what is known and not known about the problem and what students need to know and understand the problem, students would identify learning issues (Blumberg, Michael, & Zeitz, 1990). The resultant list of learning issues formed the basis for independent, self-directed learning (SDL) between tutorials. Students have time expressly set aside between tutorials to allow them to undertake SDL. During this time, students relied heavily on a well-resourced, accessible library (Martin, 2003; Neufeld & Spaulding, 1973) to support their learning. Subsequently, students would attend the report-back tutorial and combine their study findings, resulting in a collaborative construction on the whiteboard and shared understanding as relevant to the AL problem. This form of learning relies heavily on the recall of knowledge from the student's memory, their willingness to have their ideas and knowledge scrutinised by the group, and critically examine other students' contributions.

Many universities adopted AL instructional design (such as PBL) to deliver medical education (Neufeld & Barrows, 1974; Schmidt, 1983) and other disciplines. This was accompanied by an explosion of research investigating its utility and effectiveness (Bate, Hommes, Duvivier, & Taylor,

2014; Savery & Duffy, 1995; Schmidt, 1983, 1994; Wood, 2003), and from 1984 to 2014, one in three top-cited article themes in medical education journals was associated with PBL (Rangel, Cartmill, Martimianakis, Kuper, & Whitehead, 2017). The early decades of research into the effectiveness of PBL occurred during a period in which students did not have access to affordances beyond paper, pen, and university libraries. This is markedly different from today's learning environment. Students now control access to information anytime, anywhere via their ICT devices to meet their learning needs and expect an ICT-rich environment to supplement their learning alongside the formal learning course content. They want it all (Hood, 2013). However, the salient point is that AL presumes the learner activates their memory, not their smart ICT device's memory.

2.3 Information and Information Communication Technologies

The currency of learning is information being processed by the learner into knowledge and wisdom. Evidence for learning is described as an enduring change of behaviour (Schunk, 2012).

Learning, such as in the domain of medicine, expects students to acquire and understand course-specific information which traditionally has been selected and then conveyed through formal educational environments. The technological advancements throughout every era across history have always been heavily influenced by the way information resources were historically presented. For example, before the printing press development, books were rare and owned by the university. Lectures consisted of readings from Lecturers from these books to the students to convey the necessary information for learning (Schaefer, Dominguez, & Moeller, 2018). It wasn't until the Gutenberg printing press's development over 550 years ago that students could afford books for their study, which dramatically influenced how we learn (McKee, van Schalkwyk, & Stuckler, 2019). Since the 1800s, students have increasingly owned textbooks to supplement formal information from lectures, practicals, and library resources. More recently, over the past 50 years, another significant technological advancement in the form of digital Information Communication Technologies (ICT) has similarly revolutionised the sourcing of information and, potentially, the way we learn. The rapid rate of uptake of ICT devices such as desktop computers, smartphones, laptops, and tablet devices have eclipsed these previous technical innovations and, in doing so, has taken education by surprise as the shift of information ownership has moved into the hands of the students. For the first time, students can control the flow of information. With their convergent functionality, these ICT devices provide ready access to the mobile phone, calculators, compasses, camera, the addition of a myriad of applications and computer functionality that enables students to store information, to access information from libraries (books, journals, and audio-visuals), or to search the internet.

Essentially, students have access to voluminous informal information created and shared by unseen ICT communities at their fingertips to use for their learning. Therefore, the traditional

sources of formal information, as held by libraries and teachers, are no longer the central 'go to' source of information. Information is now in the hand of the student and is portable, ubiquitous, diverse, and easily accessible. The recent 2021 January Global snapshot of internet users aged between 16 and 64 found 60.1% of the total global population averages 6 hours 56 minutes on the internet per day (Kemp, 2021). University students are no exception; most if not all own several ICT devices.

With this in mind, students access all forms and formats of domain-specific information from anywhere in the world via the internet, intermingling formal university information with informal information. Information is no longer confined to academia. It is un-vetted and, now available to anyone; information has been democratised. Hence, this era has been termed 'the information age' (Castells, 1997). The students' learning environment affords them a vast array of self-perceived relevant information for all learning levels, such as from novice to expert. Accessing this diverse learning environment requires cognitive effort to navigate, judge, and select information relevant to their learning. This ubiquitous and voluminous ICT information places the onus onto the student to choose which information to use. The decision-making strategies employed ultimately lead to an increase in cognitive effort beyond that of the information sanctioned and recommended by the educator (Bettman, Johnson, & Payne, 1990; Zhong, 2013).

There are three types of ICT accessible information identified in the literature with differing authority or credibility levels.

Firstly, formal information authored by experts in their field of study which instils a sense of trust by the reader/learner. This includes peer-reviewed and edited information published in reputable journals or online membership peer-reviewed websites. ICT information recommended by the teacher, irrespective of the source, is also considered formal. Such information has been scrutinised and deemed appropriate. In this situation, students judge the credibility of information based on who has authored and recommended the content (Westerman, Spence, & Van der Heide, 2014).

Secondly, informal ICT information, socially derived and shared, is defined as being created by anyone (novice, expert, or someone with an opinion) and posted online; it is user-generated content (social media; Web 3.0). The educator or course co-ordinators has not recommended this, but students independently sought it to support their learning. Judgements as to the credibility and relevance are up to the student to make. As such, we all are continually undertaking interpretation to assess and understand or use the formal and informal information from the environment in which we live.

Thirdly, ICT information, a mixture of informal (social) and formal (semantic) information, forms the final category. The educators have not seen and hence have not recommended this information.

Therefore, educators cannot judge the authenticity and applicability of the information to the learning situation. This role is then up to the student. Students rely on the internet to create and discover connections for keywords with relevant contextual information (semantic web; Web 3.0; Web 4.0 The Internet of Things) (Blaum, Jarczweski, Balzer, Stötzner, & Ahlers, 2013; Patel & Patel, 2016). Students are using mobile semantic web applications as a tool to filter vast online reservoirs of information using smartphones connected to 3, 4, and 5 G networks with hyper-connectivity to a plethora of internet information sources and devices. The technological advancements are continual, and therefore the ICT the students use today will be forever changing.

The information from the latter two areas, Social and Semantic Web, being student-sourced and assessed will be the focus upon in this research. However, what is of particular interest is whether students can detect, judge, use, and apply these resources for the betterment of their formal AL. That is, do students have the requisite digital know-how to adapt their routine daily social ICT skills to the formal AL environment, which is cognitively challenging to promote life-long learning in a continual technologically progressive environment.

2.4 Theory of affordances

The ever-changing ICT environment has led many in the current literature to use the theory of affordances that requires the user to perceive an object's uses (Boyle & Cook, 2004; Conole & Dyke, 2004; Dotov, Nie, & De Wit, 2012; Gaver, 1991; Turvey, 1992). The theory of affordances, posited by James J. Gibson, (Gibson, 1977) has been employed in this research to provide a consistent and stable lens from which to view students' interactions with their ICT devices without being influenced by the genre of ICT devices or Wi-Fi platforms. ICT systems and devices are developing rapidly as the technology of electronics, networking, data processing, communication, and human-computer interfaces grows. The buyer of ICT devices is continually lured into upgrading to the next significant ICT advancement. The marketing strategies are directed to make the buyer need the latest upgrades so purchase the next ICT model or change to the newest ICT devices and operating systems (Tien, Van Dat, & Chi, 2019). So, identifying and describing a consistent set of perceived uses (affordances) of ICT devices and their employment during learning encounters allows for research to be undertaken without being influenced by the subtle differences of the ever-changing ICT devices.

The notion of affordances was first posited by the ecological psychologist James Gibson in 1979. He created the term affordance from the verb ‘to afford’ to represent possible actions available in the environment yet are dependent upon the actor's capabilities.

He then went on to define affordances as

> *"The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. The verb to afford is found in the dictionary, but the noun affordance is not. I have made it up. I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment." (Gibson, 1986, p. 127)*

He described that the affordance of an object does not change. It is invariant and always there to be perceived. Gibson's theory of Affordances created a wave of intellectual debate that I will briefly cover as there are important aspects from each discussion that culminates in the term being applied to and making the term of ICT affordances.

Originally Gibson (1986) intended the term to reflect that

> *"the object offers what it does because it is what it is".(Gibson, 1986, p. 138)*

This alludes to an 'affordance' as something that exists naturally and does not need to be identifiable but can be by those who can see it. Then Norman argued that an affordance is of no use if it is not visible to the user (D. A. Norman, 1988), and as such, it can be explicit. Norman explained and justified this in terms of perceived and actual affordances. Each is designed into the object hence not unique to the person's way of using them. Gibson refuted this; he devised this theory to explain objects in the natural environment. It seems a small point, but the middle ground for understanding an affordance as applied to ICT affordance has both perceived and actual affordance components. Our environment is not only limited to the natural components of our world but also includes components that are manmade, such as ICT access and devices. The design of the object, in this instance, the smartphone, has specific design features that enhance the user's ability to communicate. This could be seen as an explicit ICT affordance. However, the extent to which the user can utilise ICT affordances to communicate is at the behest of the user, hence a perceived affordance.

2.4.1 Effectivities

It is this perception of possible uses that forms the crux of this discussion. If the ICT device user cannot perceive the benefits or does not know how to use them appropriately for the intended task, then the ICT affordance remains unused or misused, respectively (Warren, 1984). However, if the user can perceive the potential uses and implement them successfully, this is an 'effectivity' (Greeno, 1994; Turvey, 1992). This relationship forms a vital point for my research since ICT affordances are ubiquitous in the learning environment, but ICT utility is only practical when the student behaviours and abilities to detect and implement them during the AL setting are in alignment; that is, does the student have the prerequisite effectivity.

To expand further, a students' effectivity resides in their ability to process and engage with the ICT affordances on a cognitive level. That is, to activate their prior knowledge to select the ICT affordances to supplement their learning successfully. This process requires a judgement of ICT resources relevant to the learning need that contribute to learning and passing; the outcome. Therefore, from a cognitivist point of view, effectivities are both cognitive processes that lead to learning outcomes.

2.5 ICT Affordances in Education

Associating ICT with the theory of affordances and education was first proposed by Conole and Dyke in 2004. They posited a detailed taxonomy of ICT affordances to systematise an approach to learning and teaching using technology (Conole & Dyke, 2004). By reviewing the literature, they identified ten common themes and distilled them into ICT affordances that could help educators design and implement ICT into their teaching practice. This list describes ICT affordances that encompass actual uses such as accessibility, speed of change, diversity, immediacy, and multimodal (many formats), and non-linear (many paths) (Conole & Dyke, 2004; Conole, Dyke, Oliver, & Seale, 2004). For example, today, with smart ICT devices, these affordances provide a conduit to access an immediate diversity of information in multiple hyperlinked formats anytime and anywhere. Conole and Dyke's ICT affordances aptly describe students who access the internet through their ICT devices in the immediate sense, but not necessarily the perceived uses that depend upon their ability and cognition to effectively navigate these affordances for their active learning environment.

Essentially, the taxonomy of ICT affordances, according to Conole and Dyke, provides tools for educators to be aware of but does not explicitly reflect the formal AL pedagogy researched in this dissertation. Therefore, I have aligned and selected ICT affordances that are theoretically compatible with AL pedagogical tenets. Implicit in this relationship is the students' effectivity variables of navigating their prior ICT knowledge for the betterment of their formal learning. Thus, ICT perceived uses for learning are in the hands of and under the students' control of their ICT affordances and is consistent with the theory of affordances (Boyle & Cook, 2004; Chemero, 2003; Chemero & Turvey, 2007; Dotov et al., 2012; Gibson, 1977, 1986; Greeno, 1994).

With this in mind, Conole and Dyke proposed two highly relevant perceived ICT affordances consistent with the AL tenets; collaboration and communication (Conole & Dyke, 2004; Conole et al., 2004). By extrapolation, if students perceived and utilised these ICT affordances, they would be constructing their own knowledge as per the AL tenets of construction, collaboration, and contextual processing (Dolmans et al., 1997).

Friedman and Friedman also identify the ICT affordances of collaboration and communication as described by Conole and Dyke (Conole & Dyke, 2004) but they additionally described significant characteristics that aligned with the AL environment through their description of the online ICT learning environment (Friedman & Friedman, 2013). However, they stopped short of calling them ICT affordances. Instead, they described them and other social media characteristics as the,

> *"Unique character of the social media technologies, the features that unite these seemingly disparate technologies under a single umbrella. These characteristics of social media can be summarized by the 5 C's: communication, collaboration, community, creativity, and convergence". (Friedman & Friedman, 2013, p. 4)*

Because of this, these five broad umbrella categories are interchangeable with the ICT affordances for learning and are described as

1. Communication via continuous online access for sharing information (texting, voice calls, email, Facebook, video calls, blogs etc.)
2. Creativity is facilitated by developing unique collaborative opportunities to share and create knowledge and points of view.
3. Communities of like-minded people arising from a diverse array of backgrounds (friends, colleagues and outsiders (Deeds & Edwards, 2011))
4. Collaboration, is cooperatively working together online to solve problems or share information and ideas with anyone, anytime, anywhere in the world, and
5. Convergence is of mobile device capabilities enabling phone, camera, computer, information, media, entertainment on one device. Additionally, the convergence of roles whereby the lines are blurred between information developers, distributors, producers, and consumers. In education, this equates to convergence between the role of the educator and that of the student.

Adapted from(Friedman & Friedman, 2008, pp. 2-3)

Given the literature, I have re-categorised Friedman and Friedman's social media learning characteristics as ICT affordances that acknowledge ICT uses for learning as timeless. In doing so, this facilitates the research to proceed, irrespective of the rapid technological advances of individual ICT devices. Additionally, the ICT affordances applicable for learning, as reported above, are aligned with the AL tenets. Therefore, providing a framework (figure 2-2) whereby the ICT affordances for learning and the yet-to-be-discovered students' effectivities provides a method to determine whether the students' effectivities and the ICT affordances align with the formal AL tenets.

The AL tenets' similarities with these informal ICT affordances look alike, but this is not assumed. That is to understand by identifying and evaluating the student's effectivities using ICT affordances to create knowledge, collaboratively communicating with online communities on convergent

platforms whether they align with the AL tenets. These student ICT effectivities are not known and therefore are central to my research. Figure 2-2 summarises the repurposed Friedman and Friedman social media characteristics that reflect broad informal ICT affordances categories and how I align the AL tenets of knowledge construction whilst collaborating in small groups on contextually relevant scenarios (Barrows & Tamblyn, 1980; Dolmans et al., 2005; G. R. Norman & Schmidt, 1992; Schmidt, 1983)

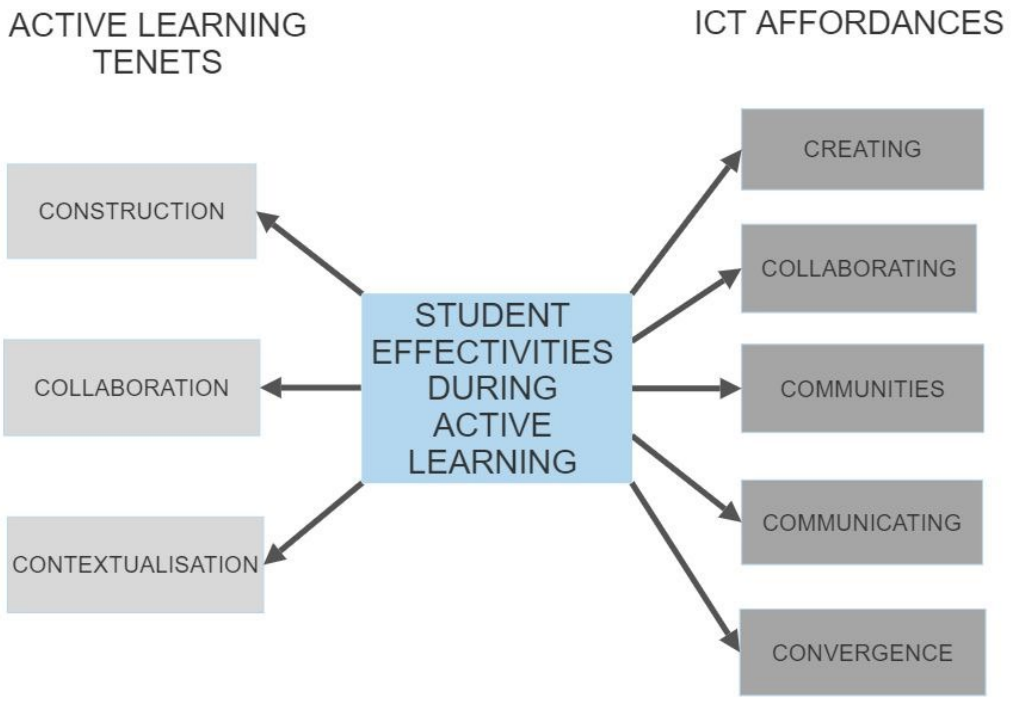

Figure 2-2 ICT affordances for learning aligned with active learning tenets and the student effectivities variable.

2.5.1 Digital native debate

Every generation in the past, present, and future has and will be influenced by an array of new affordances that contribute to their learning environment. It has been proposed that contemporary students think and learn differently. They have grown up in the rapidly evolving ICT-enhanced environment instead of those who learnt without ICT affordances. It has long been predicted that computers will impact the way humans learn. In 1980, Samuel Papert (Papert, 1980) postulated computers would be carriers of powerful ideas that will influence cultural change and, ultimately, change the way we think and learn.

The generation of students born since the 1980s have been exposed to ICT all their lives and have been described as the 'net generation' (Oblinger & Oblinger, 2005; Tapscott, 1999, 2008), the 'millennials'(Howe & Strauss, 2000) or as 'digital natives' (Prensky, 2001a, 2001b). In other words, Marc Prensky proposed that students born since 1984 who have been exposed to ICT all their lives have naturally acquired ICT skills. This concept that new resources, such as ICT, can lead to

differences in how we learn and think is not new. As a teacher, Prensky was finding his students were becoming increasingly disengaged during traditional classroom teaching.

Consequently, to educate his students, Prensky observed they had different learning behaviours, which he described as ‘new skills.’ These ‘new skills’ consisted of their need for quick access to information, the information needed to be brief as he said they had short attention spans, they were able to multitask, and ‘thrived on instant gratification’ as in rewards and they function best when networked (Prensky, 2001a). He coined these students ‘digital natives’ and those born before 1984 as ‘digital immigrants.’

Over the decades since Prensky coined the term ‘digital native’ the list of anecdotal student ‘new skills,’ has been hotly contested (Helsper & Eynon, 2010; Judd, 2018; P. A. Kirschner & De Bruyckere, 2017; Selwyn, 2009). The new skills are at odds with current knowledge of the human cognitive processing capacity (Sweller, 1988; Sweller, Van Merriënboer, & Paas, 2019; Sweller, Van Merriënboer, & Paas, 1998; Van Merrienboer & Sweller, 2005) and the information processing system (Atkinson & Shiffrin, 1968; Baddeley, 2003b, 2011; Baddeley & Hitch, 1974). The digital native, as defined by Prensky, is not a complete reflection of the contemporary students, as it purports ICT skill sets that are anecdotally assumed and are not dynamically evolving with the ICT affordances of today and for future students.

Despite these assumptions, the term digital native is used extensively and is defined in the Oxford English Dictionary as

> *digital native n. a person who was born or has grown up since the use of digital technology became common and so is familiar and comfortable with computers and the internet.("Digital native ", 2021)*

In view of the above discussion, the term digital native is more aptly described as the students' effectivities or abilities to access ICT affordances for their learning. As the students' abilities are not linked to which decade they were born in but more accurately reflects their digital competence and digital confidence (Passey et al., 2018) to navigate ICT affordances for the benefit of their learning.

2.6 Learning and the role of cognition, metacognition, and self-directed learning and the role of ICT affordances.

2.6.1 Cognition

One of the important components of biological learning occurs when the learner is mentally and actively engaged in the learning process (Bruner, 1997; Chickering & Gamson, 1987; Dewey, 1929; Piaget, 1976; Prince, 2004; Tudge & Winterhoff, 1993; Vygotsky, 1980; Zull, 2011). That is, the learner activates their cognitive skills. They recall prior knowledge, attempt to understand this

knowledge in the context of the issues at hand, and then apply it. According to Bloom's taxonomy of cognition, these steps are surface cognitive learning steps (Anderson et al., 2001; Bloom, 1956; Krathwohl, 2002). Surface learning implies that students superficially engage with the information (Biggs, 1987; Entwistle & Peterson, 2004). If the learner is motivated to persevere and dedicate time, they delve into deep cognitive learning by analysing what they know and working out their knowledge gaps, and they actively search for information that helps their understanding. With this extra information, they synthesise a new or modified understanding to incorporate it into existing knowledge, leading to new knowledge (Anderson et al., 2001; Bloom, 1956; Krathwohl, 2002). Students are considered deep learners (Biggs, 1987; Entwistle & Peterson, 2004). All these cognitive processes involve the evolution and judgement of the prior knowledge and newly found information's relevance to the task or problem (Anderson et al., 2001; Bloom, 1956; Hmelo-Silver, 2004; Krathwohl, 2002; Slavich & Zimbardo, 2012). Students institute these cognitive processes by reading, writing, listening, discussing, and questioning the task or problem (Anderson et al., 2001; Bloom, 1956; Bonwell & Eison, 1991). Cognitive processing relies upon prior knowledge formation and experiences to act as scaffolding for new knowledge and experiences to develop from information and learning triggers.

The anatomical architecture for cognitive information processing necessitates the learner to consciously attend to the information, rehearse the information, make sense, manipulate, and elaborate upon it in their working memory using prior knowledge (Dochy & Alexander, 1995). The working memory has cognitive load limitations (Chen & Cowan, 2005; Miller, 1956) and can be overloaded with as little as seven plus or minus two pieces of unrelated information (Miller, 1956). Cognitive Load Theory recognises the working memory limitation and the role of long-term memory. When pieces of information are chunked together and are associated with recalled pre-digested prior knowledge (schemas) from the long-term memory, the working memory capacity can be increased (Sweller, 1988). Educators have used this characteristic of information processing to scaffold students' learning to avoid cognitive overload in AL (P. A. Kirschner, 2002; Van Merriënboer, Kirschner, & Kester, 2003) and online learning (Mayer & Moreno, 2003; Mayer, Moreno, Boire, & Vagge, 1999). The students' trajectory from naïve to an expert is explained by the increasing number and complexity of knowledge schemas and the time taken to recall relevant schemas (Antonenko, Paas, Grabner, & Van Gog, 2010; Sweller, 1988; Sweller et al., 1998; Van Merriënboer & Sweller, 2010). These schemas are stored into long-term memory, which can be retrieved when required, elaborated upon, combined with prior knowledge and re-stored (Ghosh & Gilboa, 2014; Sweller, 1988). When retrieved, the memory schemas' complexity facilitates the working memory to have a greater working capacity, as evidenced by experts having more complicated schemas to draw upon than novices (Chi, Glaser, & Rees, 1981; Sweller, 1988; Sweller et al., 2019). The concepts of working memory and long-term memory are part of the Information Processing Theory of learning (Atkinson & Shiffrin, 1968; Baddeley, 2003b; Baddeley

& Hitch, 1974; P. Chandler & Sweller, 1991; Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Shiffrin & Atkinson, 1969; Sweller, 1988; Van Merrienboer & Sweller, 2005) and will be discussed further in Chapter 3. Information Processing Theory builds on objective evidence from Electroencephalography (EEG), and functional Magnetic Resonance Imaging (fMRI) (Antonenko et al., 2010) and subjective cognitive think-aloud methods methodologies (Durning et al., 2013).

2.6.2 Metacognition

As well as the learner cognitively biologically processing information, they critically monitor their cognitive skills by the internal process of metacognition (Flavell, 1979; Zull, 2011), a method of reflecting on one's thoughts, understanding, the setting of learning goals, and self-monitoring of performance (Ellis, Denton, & Bond, 2014; Zimmerman, 2000). For example, determining 'what is known versus what is not known' is integral to cognitive knowledge construction. When the learner is confronted with an unknown, a cognitive need arises (Bergman et al., 2013; Dewey, 1929; Mezirow, 1999; Piaget, 1976), stimulating and motivating learning. The interface of new information with prior knowledge and external factors is dynamic and in continual flux and challenges the learner (Dochy & Alexander, 1995). Consequently, the impetus to learn is achieved by activating prior knowledge and is dependent on internal and external factors. Internal factors consist of the learners' cognition, motivational state, metacognition, and emotional state interacting within a framework of external factors such as rules, rewards (passing exams), and pressure from individuals, groups, or organisations (Ryan & Deci, 2000).

As Ryan and Deci (2000) described, the Self Determination Theory focuses on fulfilling the learner's psychological needs, leading to autonomously generated motivation to learn. To be intrinsically motivated to learn involves taking risks and being challenged by cognitive conflicts. Mistakes are made, yet these mistakes are seen as learning opportunities (Kusurkar, Ten Cate, Vos, Westers, & Croiset, 2013; Papert, 1980) rather than requiring punishment to discourage incorrect answers (Skinner, 1963). Knowledge is not something that can be given to the learner; it is not ready-made (Piaget, 1976). Implicit to learning is that tasks cannot be dissociated from their context or society (Vygotsky, 1980). A task or a problem, as in PBL, is a powerful learning motivator as it creates a challenging experience, such as a cognitive need to resolve, it situates the learning into relevant and memorable contextual environments (Eva, Neville, & Norman, 1998; Hmelo-Silver, 2004; Rotgans & Schmidt, 2011; Schmidt et al., 2011; Sockalingham, Rotgans, & Schmidt, 2011).

2.6.3 Cognition and Metacognition with ICT

Brain circuitry observations have guided the development of computing systems and the analytical algorithms that underpin artificial intelligence (Ullman, 2019). Humanistic features of pattern learning and recognition underpin the development of Deep Learning in Artificial Neural Network algorithms for machine learning systems (Schmidhuber, 2015). Machines, ICT devices are

becoming more sophisticated with increasingly powerful computing systems (Miikkulainen et al., 2019).

In turn, research is now demonstrating that ICT can produce acute and sustained alterations in the human brain's cognitive processes (Loh & Kanai, 2015), attention focus, memory processing, self-esteem, and social lives through the inherent neuroplasticity of the human brain (Firth et al., 2019). To learn is a human trait: an individual expression of unique intuition, perspectives and tacit knowledge. Human learning is an active personal cognitive, constructive process with working memory limitations whereby the product is greater than the individual parts. However, when human cognition and ICT Deep Learning in Artificial Intelligence systems are skilfully and strategically combined, a more detailed result is achievable. For example, in medical practice, in radiological procedures, the detection and diagnosis of conditions are enhanced by human and ICT involvement (Yasaka & Abe, 2018). However, the machine diagnostic algorithms provide concrete answers and not other possibilities or differential diagnoses (Ruffle, Farmer, & Aziz, 2019).

Consequently, clinicians' medical and procedural expertise must be at a high level to select, judge, and contextualise the ICT results with the overall patient presentation. Deep Learning Applications require human manipulation to adapt to the context, for example, in voice recognition applications (Deng, Hinton, & Kingsbury, 2013). Clinicians are experts in their field and can quickly respond to situations as they have well-developed prior knowledge schemas and pattern recognition to call upon to retrieve relevant knowledge. This is unlike novice learners, as in medical school, who are in the cognitively effortful learning process. The critical aspect to consider here is these novice learners are not yet qualified to broker these forms of ICT results in the clinical sphere. They have not developed the expertise.

Students' development from novices to experts in their chosen field of study requires cognitive effort, motivation, and persistence, to name a few. Learning for understanding and the construction of knowledge cannot be done for them. It is hard work. However, increasingly students are taking shortcuts in their learning by taking ICT information as their own (Sparrow, Liu, & Wegner, 2011; Ward, 2013a), as they are forming memory sharing relationships with ICT, a phenomenon called 'transactive memory' (Ward, 2013b; Wegner & Ward, 2013). Students do not necessarily remember the specific ICT sourced information, but they remember how to navigate back to find it under experimental conditions (Sparrow & Chatman, 2013; Ward, 2013b). Likewise, photos can trigger powerful cues for retrieving biological memories, as shown in the rehabilitation of traumatic memory loss patients (Berry et al., 2007), and the emotional component of viewing photos can increase recall (Harrison, 2002). However, instead of remembering from direct observation, photo-taking decreases recall when the image is not present (Soares & Storm, 2018). Henkel termed this the photo-taking-impairment effect (Henkel, 2014). Again, students mistake the external shared memory systems for their own memory and form transactive memory relationships with ICT

devices (Ward, 2013a, 2013b; Wegner & Ward, 2013). Therefore, the novice who relies on external memory systems such as ICT could be denying themselves cognitive opportunities to develop and build on prior knowledge.

Prior knowledge is critical when confronted with an unknown. The unknown stimulates the recall of relevant information from long-term memory. The novice will have less prior knowledge than an expert, but this develops as they learn. However, students are tempted to truncate their biological recall by thinking of access to the ICT search engine first (Barr, Pennycook, Stolz, & Fugelsang, 2015; Sparrow & Chatman, 2013; Sparrow et al., 2011). If immediate access to ICT is unavailable but is expected to be available at a later stage, students are still less willing to offer and share their prior knowledge information even if they have valid information, to offer (Ferguson, McLean, & Risko, 2015; Risko, Ferguson, & McLean, 2016).

Interestingly, when students seek new information, check and concur with ICT resources before they proffer answers, they have an altered sense of intrinsic knowing (Barr et al., 2015; Ekeocha & Brennan, 2008). They now know. Risko and Dunn have described this ICT-dependent behaviour as metacognitive and cognitive offloading (Risko & Dunn, 2015; Risko & Gilbert, 2016). Rather than the student expending cognitive effort to discern the relevance of or judge the credibility of information for their learning, they seek ICT as a metacognitive strategy to relieve them of this cognitive burden and responsibility quickly.

Additionally, students do not want or like to be incorrect. Risko also found that when ICT was available, students' quantity of answers decreased, but the quality of correct answers increased (Risko et al., 2016). They appear to become less confident of their prior knowledge when ICT was available or near-by. In contrast, students who knew they would not have ICT available offered more information than those who had ICT available (Ferguson et al., 2015).

The studies above provide salient points about the interaction of cognition and metacognition with ICT. The majority of research was under experimental conditions, with the learning environment manipulated to test multiple hypotheses. The students were not behaviourally undertaking their everyday learning nor were not at liberty to utilise their usual learning environment's ICT affordances as they perceive necessary. Consequently, there is a gap in the literature in understanding how students in their natural learning setting behave with their own ICT affordances.

2.6.4 Self-Directed learning: Self-Regulated Learning

The learner’s control of their learning processes is referred to as either Self-Regulated Learning (SRL) (Zimmerman & Schunk, 2009) or Self-Directed Learning (SDL) (Barrows & Tamblyn, 1980; G. R. Norman & Schmidt, 1992) (Loyens, Magda, & Rikers, 2008). The distinction between these terms is subtle but significant. From a cognitive psychology perspective, SRL engages cognitive, metacognitive, motivational, and external learning strategies to facilitate learning (Bandura, 1986;

Zimmerman, 1989). Therefore, in SRL, the environment is provided by the educator. On the other hand, SDL includes the above and the individual learning how the learner becomes an independent learner by orchestrating their learning activities and resources for their learning from a socio-cultural perspective when working on a task or problem (Pilling-Cormick & Garrison, 2007). Motivation to know is intrinsic in both and includes the learner's belief in their own capacity to learn; self-efficacy (Bandura, 1986). SDL underpins and aligns with AL, particularly Problem-Based-Learning, whereby the students manage their learning tutorials and control resource selection. It is up to the student, not the educator, to determine the students' learning needs (Azer, 2004; Dolmans et al., 2005; Hmelo-Silver, 2004; G. R. Norman & Schmidt, 1992; Schmidt, 1983).

2.6.5 Learning with ICT affordances

Cognitive and metacognitive processes form the individual's unique personal learning determinants. The flow of information from the external environment depends on the individual's learning behaviours, such as attention, perceptions, judgements, and comprehension. Initially, sensory systems activate an adjustable attentional focus to convey external information to the working memory. This system ensures that external information is processed and integrated into the working memory with declarative and procedural information schemas retrieved from long-term memory. Essentially, visual and acoustic information from mobile informal ICT devices is analogous to the formal instructional design of the multimedia cognitive load theory (Mayer et al., 1999). By utilising this theory, one can potentially predict the cognitive cost on students when accessing informal ICT during formal AL courses.

2.6.5.1 Attentional Processes

Students today commonly engage with their laptops or smartphones throughout the face-to-face tutorials, lectures, other university sessions, and personal lives. They are minimal paper consumers and convey their work, ideas, and organisation straight to their mobile ICT device. Universities reinforce the paperless mindset as they capitalise on course delivery's ICT affordances addressing fiscal concerns, student needs, and environmental awareness (George et al., 2013; Oates & Goulston, 2011).

Consequently, the AL problem presentation has changed from text on paper to text on the screen or other ICT formats. These formats range from simple PowerPoint presentations over a series of screens (similar to progressive paper handouts) to a multimedia presentation of the problem. A Norwegian study of 15 to 16-year-old school students found the transition of reading paper text to screen resulted in lower reading comprehension (Mangen, Walgermo, & Brønnick, 2013). When time pressures were added to reading from the screen, there was a further reduction in reading comprehension (Ackerman & Lauterman, 2012). In 2011, Ackerman and Goldsmith demonstrated lower academic outcomes when learning was undertaken from reading information from the screen alone. The act of reading online appears to blunt the spatial signposts that guide metacognitive

thinking and facilitates the reader to return to specific sections of information (Rose, 2011). For example, online reading is undertaken by continuously scrolling a disappearing page on an ever-present screen instead of reading a book where pages are turned, and information is signposted by position on the page, the chapter, and the book. Thus, signposting when reading online text is difficult (Rose, 2011). Practically, this seemingly innocuous shift from paper to screen has changed the way we access, interact, and utilise the diverse array of information afforded by ICT. The formation of knowledge schemas and cognition are potentially altered by the lack of metacognitive signpost posting when accessing ICT only for learning. Therefore, the online format by which information is detected can determine if the attentional processes convey information to the working memory or if they are not perceived and, as such, ignored.

2.6.5.2 Multitasking behaviour

In addition to attentional process variables associated with the information format, ICT affords the student access to multiple sources of information and undertakes tasks concurrently, multitasking or sequentially, task switching. For example, having several computer applications open simultaneously, plus alerts set for new emails, news feeds, listening to music and Facebook, etc., momentarily shifts the adjustable attentional focus away from the task and is likely to overload the limited working memory capacity. Additionally, other distractors such as advertisements that follow page scrolling or introduce new advertisements to encourage the reader to look. But are students able to learn whilst multitasking under these conditions?

Media multitasking refers to simultaneously using several media devices, such as smartphones, iPad, computers, and television, whereas computer multitasking refers to simultaneously accessing a range of online sites (Courage, Bakhtiar, Fitzpatrick, Kenny, & Brandeau, 2015). Eye gaze studies demonstrated that attention switching to be more than four times per minute between computer use whilst watching television (Brasel & Gips, 2011); a significant interruption of attention. Interestingly, ICT-proficient students believe they learn under these conditions and consider themselves skilled multitaskers, as they simultaneously, rather than sequentially, switch between ICT devices and ICT online sites for work, learning, and play (Barry, Murphy, & Drew, 2015; Courage et al., 2015). They are always connected (Prensky, 2001a, 2001b). Consequently, students are dividing their attention between devices and/or ICT sites.

Additionally, attention interruptions are compounded by computer multitasking (for example switching between web pages, email, databases etc.). During self-directed learning sessions in University computer laboratories (Judd & Kennedy, 2010, 2011), the research showed that 49.5% of computer time was devoted to computer multitasking. Plus 72.2% of computer sessions contained at least one multitasking segment (Judd, 2013, 2015). Judd subsequently proposed three types of computer multitasking behaviours. Focused behaviour (maximum of two task instances), sequential behaviour (at least three task instances but no repeated tasks) and

multitasking behaviour (contains more than three task instances and one or more repeated tasks) (Judd, 2013). The impact on comprehension and long-term memory schema development has not been studied.

There is a gap in the literature as students are no longer constrained to the university computer laboratories. Most students own a computer and a smartphone and connect to the internet at anytime, anywhere. Their ICT devices are personalised to their personal, social, entertainment, and academic needs. Students using their mobile devices would have more opportunities to multitask and task switch than on a university computer. Therefore, it is plausible that Judd's findings would be magnified and have a more profound impact on cognitive processes during learning.

Students perceive that they are learning whilst multitasking and task switching, believing this is an efficient use of their time and that multitasking promotes mental flexibility (Sparrow & Chatman, 2013). However, cognitive restrictions are primarily attributed to structural limitations of working memory (Salvucci & Taatgen, 2008; Wang, Irwin, Cooper, & Srivastava, 2015). Tasks are thought to be sequentially processed by the central executive system that controls attentional focus and task switching (Baddeley, 2003a). When comparing single-task conditions to dual-task conditions, students have a slower response time, increased error rate, extended completion time, and overall decrease in performance (Adler & Benbunan-Fich, 2012; Carrier, Rosen, Cheever, & Lim, 2015; Courage et al., 2015; P. A. Kirschner & Karpinski, 2010). When formal learning tasks are controlled using multiple sensory modalities, such as visual and auditory, learning can be facilitated (Mayer et al., 1999; Moreno & Mayer, 1999). During formal education, the educator controls the multimedia cognitive load by carefully manipulating shared sensory modalities, particularly audio-visual input, to promote an effective and appropriate learning level (Mayer & Moreno, 2003). In other words, learning is choreographed. The content to be learnt is also incrementally monitored to control the intrinsic cognitive overload. However, when students govern the use and selection of informal ICT information, there is no formal choreography or safeguards in place. This is up to the student. Working memory cognitive capacity limitations suggest that sequentially performing several related tasks or simultaneously performing two associated tasks may be possible (Salvucci & Taatgen, 2008; Taatgen, Katidioti, Borst, van Vugt, & Mehlhorn, 2015). But if these tasks are not related or competing for working memory, then there will be a cognitive cost.

Logically, multitasking can lead to an interruption and distraction of attentional focus and working memory in order to sort out priorities. Therefore, by extrapolation, information gleaned to working memory will be brief, patchy, and possibly non-relevant information with minimal or scrambled cues to activate prior knowledge from long-term memory. Students thought processes have been shown to be disrupted when their mobile device is present (Rosen, Carrier, & Cheever, 2013), when they listen to music (Evano, 2013; Rinato, 2014), and even when distracted by their peers' computer

screen (Sana, Weston, & Cepeda, 2013). Experimentally inducing multitask conditions has demonstrated that one task will dominate over the other, yet both tasks will be poorly performed (Adler & Benbunan-Fich, 2012). The use of fMRI has indicated the posterior lateral prefrontal cortex involvement in attentional and central information processing "bottleneck" (Dux, Ivanoff, Asplund, & Marois, 2006).

2.6.6 Lower order cognitive skills of remembering, understanding and applying

The cognitive processing of information from contextually relevant problems activates interest and attentional processes (Bandura, 1986, 2001a). Thus, the situational interest (Schmidt et al., 2011) of PBL tutorials stimulate small groups of students to brainstorm collectively, remember, understand, apply and collectively elaborate (Schmidt et al., 2011) what they know and identify what they do not know (Fonteijn & Dolmans, 2019). The importance of brainstorming and remembering prior information in the initial stages of a PBL tutorial cannot be understated. When students first encounter a complex problem, they identify, compare, and contrast the new information with long-term memory schemas (Barrows & Tamblyn, 1980) and undertake reasoning processes (Krawczk, 2012). The method of finding analogies between new information and prior knowledge includes detecting unusual or unexpected patterns, anomalies, ascertaining something that is by determining what it is not, discerning antimonies, and conceptualising oppositional relationships between two entities, antitheses (Dumas, Alexander, & Grossnickle, 2013). It is unknown to what degree students routinely undertake these possible cognitive skills and what reasoning processes they use when supplementing PBL tutorials with informal ICT information. There are perceived benefits when ICT is accessed during tutorials to provide extra information or answers to simple issues raised during the unfolding AL problem.

Mobile ICT devices are becoming vital environmental determinants of learning that create causal forces that exert and shape learning behaviours. When confronted with an *unknown,* students are behaviourally thinking ICT search engine (e.g. *google)* first (Sparrow et al., 2011; Wegner & Ward, 2013) in preference to retrieving prior knowledge from long-term memory; remembering (Sparrow & Chatman, 2013). In this instance, the student is taking control of their learning by quickly seeking information from ICT rather than relying on long-term memory or the educator to provide information. This represents a significant metacognitive shift of thinking and potentially impacts remembering information. There are benefits and pitfalls for the development of long-term memory. Quick access to ICT can provide useful and timely information to simple questions posed within a simple or complex problem. Such timely information is analogous to providing learning scaffolding of *just-in-time* information (Vandewaetere et al., 2015) to overcome knowledge deficits *(unknowns). Just in time* information, such as definitions, propagates group discussion and promotes individual cognitive processing of information. Ultimately increasing group time for rehearsal and performance of critical knowledge for long-term memory construction (Bandura,

1986; Dewey, 1929; Tudge & Winterhoff, 1993) and focus on complex unknowns rather than simple unknowns.

There are potentially several sources of information that can assist learning behaviours in small AL groups. Firstly, as described earlier, just-in-time information facilitates the resolution of unknowns quickly and subsequently reduces unhelpful extraneous cognitive load. The newly found information can then improve the level of discussions. The quick answer removes simple impediments of not knowing, resulting in freeing up the limited capacity working memory to focus on the topic at hand hence not caught up on simple unknowns that add extraneous load (Van Merriënboer & Sweller, 2010). An example of just-in-time information in this instance is defining the meaning of a word enabling the students to continue working through the complexity of the AL problems. Secondly, the other information source is when students preferentially seek ICT to quickly provide information rather than activate prior knowledge from long-term memory. For example, seeking a diagram to help illustrate a biological mechanism shared with the group to assist understanding of the complex AL problem. The third source of information relies solely on the student using ICT to remember information for them. Hence, the student remembers where to find the ICT information but not the actual information For example, in controlled experiments, students who had access to ICT remembered how they navigated to the particular webpage but had less recall of the content found (Sparrow et al., 2011). These three sources convey subtle differences that are potentially significant when considering lifelong learning. At which point is information encoded and stored in long-term memory or stored externally when using ICT has not been fully explored in natural learning environments. The implications for subsequent retrieval of prior knowledge are dependent on the information processing systems and the rigour of the long-term memory schemas formed.

This then raises the question about the quality of informal just-in-time information. How does just-in-time information differ when provided by an educator or formal information sources when the student conducts online searches to find informal information. ICT search engines provide crowd-sourced pre-digested answers (Westerman et al., 2014) to many simple and complex AL problems. Solutions sought range from simple definitions to fully worked-out “pre-digested” answers, all freely available online and are a mixture of individual or group opinions that may or may not have been critically constructed (Deeds & Edwards, 2011). When students use this ready access to answers, it might alter the group's length of time brainstorming, discussing, rehearsing, and performing ideas and information. The cognitive need to learning through not knowing has then been usurped. Answers to knowledge gaps (unknowns) can potentially reduce motivation (Ryan & Deci, 2000) to spend time understanding and researching a complex problem. Thus, it is plausible that truncating group discussion and collaboration could lead to decrease knowledge construction. It is also unknown if this truncation of lower-order cognition results in a decreased activation of higher-order cognitive skills of analysing, evaluating, and creating a subsequent decrease to long-term memory

deep learning.

2.6.7 Higher-order cognitive skills of analysing, evaluating, and creating

Working through complex problems during AL necessitates the activation and retrieval of prior knowledge from long-term memory stores. The combination of retrieved prior declarative knowledge with prior procedural knowledge forms the basis for strategic expertise of knowing what, how, and when respectively (Phye, 2004) for problem-solving. This knowledge base results from the enduring formulation, accumulation, and constant retrieval and modification of stored knowledge schemas (Shuell, 1990). To learn is considered the result of an enduring change of behaviour (Schunk, 2012; Zimmerman & Schunk, 2009) with an accumulation of knowledge schemas.

When challenged with new information or a complex problem, the quality and range of prior information schemas strongly influence activation and implementation of the higher cognitive skills; analysing, evaluating, and creating (Anderson et al., 2001; Bloom, 1956; Krathwohl, 2002). The difference between a novice and an expert is defined by the number and quality of knowledge schemas upon which to refer to and retrieve (P. Chandler & Sweller, 1991; P. A. Kirschner, 2002; Sweller, 1988; Sweller et al., 1998).

Each individual in small group learning undertakes cognitive processing of new information and compares it with what they already know. Once the initial new information is processed, the individual and the group launch in-depth analysis, distinguishing between relevant and irrelevant information and important through to unimportant details.

Today the environment in which we learn is changing. Mobile ICT devices feature heavily as students increasingly rely on them for their independent learning and as institutions depend on them to deliver courses. The academic learning environment has changed, but we do not know how this impacts cognition and ultimately in the instructional design of AL.

The act of accessing informal information from ICT appears to increase the student's self-efficacy of knowing. As previously discussed, students are thinking of 'Google' first and mistaking the googled information as to their own (Ward, 2013a). Students' cognitive implication of having a greater sense of knowing does not necessarily equate to deep learning (Ward, 2013a), nor does it represent prior knowledge from long-term memory but from transactive memory relationships (Sparrow & Chatman, 2013; Sparrow et al., 2011; Wegner & Ward, 2013). Overconfidence after accessing search engine information has been attributed to inaccurate self-evaluation, potentially leading to underachievement (Dunlosky & Rawson, 2012) and superficial also unsophisticated study skills (Rambe, 2012). Online information could decrease the collaborative interactions central to collaborative AL tutorials of face-to-face AL (Bate et al., 2014; Hommes et al., 2014) but this has not been investigated.

As applied to a group, transactive memory systems reflect a shared cognitive system combined with an individual's memory system forming a shared understanding (Wegner, 1987). The development of transactive memory systems is positively associated with higher group performance levels, especially in complex dynamic environments, such as medical teams (Burtscher, Wacker, Grote, & Manser, 2010). This group-dependent behaviour improves performance and the prediction of group members' input and communication (Wegner, Giuliano, & Hertel, 1985).

When students work face-to-face with peers, many nonverbal cues enrich long-term memory and group transactive memory development as in small group learning. Group members learn from nonverbal, verbal, visual, and tacit means to understand and, importantly, retrieve information from long-term memory. However, according to Wegner, transactive memory divides the expertise in a group, which negates everyone's needing to learn the same thing (Wegner, 1987). He refers to the expert in the group, or as extrapolated by Sparrow and colleagues, refers to ICT when they need information (Sparrow & Chatman, 2013). Thus, there is a potential conflict with the AL tenet of collaboration and construction. Group performance does not equate to collaborative learning whereby each AL student constructs their own unique understanding and their frame of reference (Mezirow, 1999). Therefore, the construction of knowledge into long-term biological memory is facilitated contextually by collaborative interactions but ultimately is an effortful personal cognitive activity.

2.7 Factors influencing active learning today

In the AL environment, an increased time of face-to-face interaction, as in the PBL group, fosters transactive memory development between students as they anticipate each other's strengths and weaknesses (Hommes et al., 2014). They share the cognitive load. The development of a rich learning environment takes time, of which transactive memory appears to play a central role. This collective memory system is analogous to our ICT device relationship (Sparrow et al., 2011; Wegner & Ward, 2013). We are dependent on our mobile ICT in many aspects of daily life; it's our diary that sends us reminders, it stores phone numbers, addresses, photos, etc., ICT contextually connects information for us (Web 3.0, 4.0, 5.0), we are lost when we lose our ICT device or if it fails. We are dependent on our ICT devices and the affordances for daily living. This leads to the unanswered question of how ICT is used during AL and whether there is a similar dependency based upon the proposed ICT/students transactive memory relationship?

2.8 The gaps in the literature summary

The reviewed literature has highlighted the diversity and wealth of information about ICT and the interaction with learners and their learning outcomes. The prominent perspectives have been from the educational, psychological, and neurobiology research platforms to identify and understand

how ICT can be used and manipulated by educators to educate contemporary students. Most of the research has been conducted under contrived experimental conditions to test hypotheses through quantitative or qualitative research methods. This has led to a paucity of research centred on students in their natural learning environment, undertaking their regular AL sessions with ICT affordances. Contemporary students have a high level of ICT device ownership and control of their ICT resources, not the educator. Therefore, my research will address this gap and research the students in their routine AL tutorials using their own ICT devices with no experimental interventions.

Additionally, prior research methods have relied on the student self-assessment of learning with ICT and objective assessment learning outcomes through online surveys. Students report they like ICT integration and want more ICT afforded learning opportunities. Therefore, leading to educationalists assuming that students wish to have more ICT-enhanced options and that their ICT know-how to learn using their informal/social ICT affordances is sufficient. Although, several authors observed that students also want more face-to-face and online ICT sessions, highlighting underlying learning problems and dissatisfaction. This is an area that warrants further investigation, notably from the perspective of current AL learning theory frameworks. Thus, enabling an informed research method to objectively assess how, when, and why students use ICT affordances during formal AL pedagogies in higher education and the subsequent consequences for their learning.

Educators also assume that as today's students are digital natives, they know how to use ICT to benefit their learning. However, this common assumption will be challenged by exploring what students' ICT effectivities are and why they seek ICT during formal AL. Thus, determining students' ICT effectivities and the relationship with the formal AL and the informal ICT affordances form the central component of my research.

In summary, the current literature focuses on the educators' assumptions of the students ICT abilities, the educator perspectives of the role ICT has in education and how to control the AL tutorials through scaffolding. The educator aim has been to ensure students achieve the formal learning outcome. Yet, students are encouraged to be self-directed learners. Many studies have attempted to assess students use of ICT through online survey methodologies. They have relied on student assessment of ICT benefits and opinions of online courses to their learning. Generally, the students concluded they want more online learning opportunities. Yet, the problem with this research style is that it does not probe the contemporary students' thinking (cognition), planning (metacognition) and if the students' effectivies are aligned with the informal ICT affordances with the formal AL course. Therefore, the proposed research objectives address these gaps in the literature to understand contemporary students' informal ICT affordances-seeking behaviour and their ability to successfully detect (student effectivities) and use these seemingly limitless ICT affordances to supplement and align or interfere with their learning during formal AL course.

3 CONCEPTUAL FRAMEWORK CHAPTER

3.1 Introduction

In Chapters 1 and 2, I presented the background for the research questions. I explained why it is necessary to explore how students are learning in this highly Information-Communication-Technology (ICT)-afforded environment. However, in order to centre the research process and be able to meaningfully interpret the data, the development of conceptual frameworks is indispensable. As purposefully combined theoretical perspectives, conceptual frameworks provide lenses on how we see what the data is 'telling us' to gain insight into today's students learning.

This chapter presents the underlying rationale for the conceptual frameworks. I purposefully researched the theories of learning and selected those that aligned with the instructional design of AL before undertaking this research. As such, it informed the narrative literature review and served as the lens for collecting data, analysing, and interpreting the research phenomenon. This entails explaining the specific aspects of those learning theories that I think apply to my research. In addition, I will discuss which parts I have decided not to use and why I consider them less pertinent to my research.

Conceptual frameworks that centre around understanding cognitive processing and learning theories are critical for this project's main research domain. This enables me, the researcher, to explore and interpret the students' cognitive learning domain to investigate how knowledge and intellectual skills are gained. In my research, I explore how students learn whilst managing informal sources of information from ICT during the formal active learning (AL) process. For this, students must continually reconcile interacting with ICT and interacting with the AL and group processes. As these interactions can either collide with each other or be synergistic, learning theories and theories for cognitive processes are positioned to be the best illuminating lenses on these interactions.

Consequently, the learning theories I have drawn upon are the Social Cognitive Theory of Learning (SCT) (Bandura, 1986) and the Information Processing Theories (Atkinson & Shiffrin, 1968). These two theories combined form the underlying structure of my conceptual framework. Also, I have overlayed three other cognitive theories that are inherent in the Information Processing Theories that focus on the working memory's capacity and limitations (Baddeley, 2011; Baddeley & Hitch, 1974). These include, firstly, the cognitive load theory (P. Chandler & Sweller, 1991; Sweller, 1988; Sweller et al., 1998; Van Merriënboer & Sweller, 2010) and secondly, the cognitive theory of multimedia learning, which specifically focuses on the formal use of multimedia in education (Mayer & Moreno, 2003; Mayer et al., 1999). Thirdly, the cognitive components of the framework are explored through an examination of cognition through cognitive taxonomy (Anderson et al.,

2001; Krathwohl, 2002), metacognition (Pintrich & De Groot, 1990), and attentional focus (Cowan, 2011; Cowan et al., 2005). The resultant framework is then viewed through the lenses of, I incorporate the theory of ICT affordances (Friedman & Friedman, 2008) and student effectivities (Turvey, 1992) to compare and contrast AL tenets during identified learning events to address the research questions.

In this chapter, I will first explain the key elements of these learning theories, followed by defining the integration into the conceptual framework utilised in this research. Finally, although it is beyond the scope of this dissertation to provide an in-depth review of each theory, I will argue and incorporate the attributes of these theories relevant to this research throughout.

3.2 Social Cognitive Theory

The Social Cognitive Theory (SCT) is a comprehensive learning theory that predominantly focuses on individual learners' cognitive abilities, experiences, and how they observe and reciprocally interact with the society in which they live. The learner plays a pivotal and interactive role as they negotiate the available environmental resources, which, in turn, influences their learning behaviours. The recent primary environmental determinant that has changed the way we learn is the highly accessible ICT affordances. Inherent with these changes is the students' ability to interact and seize opportunities ICT affords for their learning. These behaviours are referred to as students' effectivities. The learner has cognitive attributes that form the basis for their engagement with new learning situations in conjunction with their prior experiences and knowledge. SCT emphasises the importance of these attributes and is referred to as personal determinants. The reciprocal processes and interactions of these environmental, personal, and behavioural determinants led to selecting this theory as a foundational theory. SCT is an extensive theory that explains human functioning. I focus on three components of Albert Bandura's SCT (Bandura, 1986) most pertinent to AL with ICT for my research. They are:

1. The Triadic reciprocal causation model proposes a reciprocal determinism that signifies an interdependence of behavioural, personal, and environmental determinants in learning (3.2.1).
2. Personal Agency that characterises students as agentic learners. Students make learning choices that capitalise, regulate, and reflect upon their learning opportunities (3.2.2).
3. Observational learning whereby learning occurs through observing others. This is pertinent in the ICT multimedia format of information dissemination (3.2.3).

3.2.1 Triadic Reciprocal of Causation Model

The first central concept of the Social Cognitive Theory is the triadic reciprocal causation model (Bandura, 1986, pp. 23-30). I am applying this model as the central core for my theoretical framework, which I have adapted slightly. In essence, the model describes the interactivity of the

person (personal determinants) with their environment (environmental determinants) and the resultant behaviour (behavioural determinants). Bandura's model was written before ICT was readily available for learning. However, the determinants are flexible, timeless, and adaptable to old, contemporary, or new emerging resources in any era. Bandura himself has acknowledged the impact of ICT on mass communication (Bandura, 2001a)and globalisation (Bandura, 2002) that is now enmeshed in our societies. This is especially important as the learning environment changes according to the type and availability of resources, such as books and ICT. Today's students live in the era of ubiquitous and freely available information from ICT that is available anytime, anywhere, and on any topic that interacts and informs their independent learning.

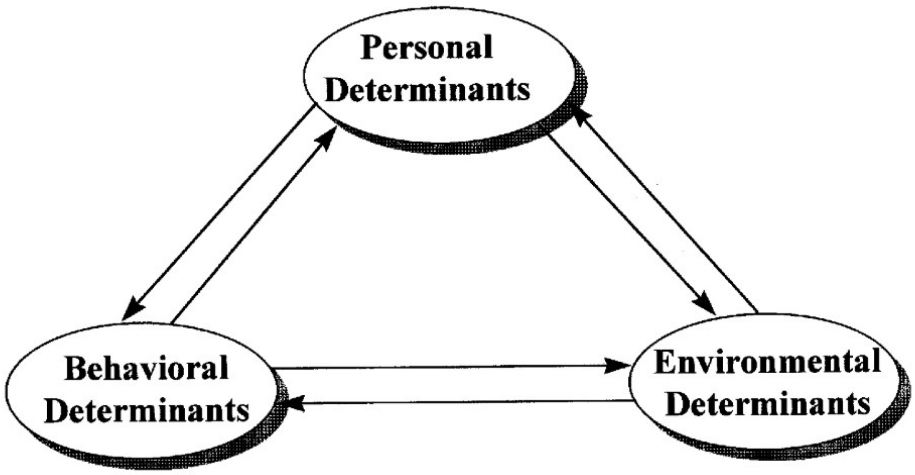

Figure 3-1 The original Triadic Reciprocal Causation model as schematised by Albert Bandura (Bandura, 2001a, p. 266) copyright 2001 by Taylor & Francis. Reprinted with permission.

Figure 3-1 represents Albert Bandura's original Triadic Reciprocal causation model, which assumes human behaviour as being influenced bidirectionally by environmental and personal determinants (factors). That is, each component affects the other but at various rates according to the situation. The environmental determinants of society and culture are centrally recognised. However, today's students' major influencing factor is the impact of ICT Affordances, which has only recently been considered (Conole & Dyke, 2004; Hammond, 2010).

The explicit adaptions I have made to the original model are subtle but significant and are portrayed in figure 3-2. The inversion of the model signifies the importance of ICT affordances in our environment and the observable behaviours. Therefore, it reflects the ubiquitous nature and the increasing dependency on ICT affordances. I have highlighted this as the publicly evident and readily witnessed ICT-seeking behaviours. The underlying unseen component of the personal determinants is inferred and the subject for exploration and interpretation through the proposed theoretical framework.

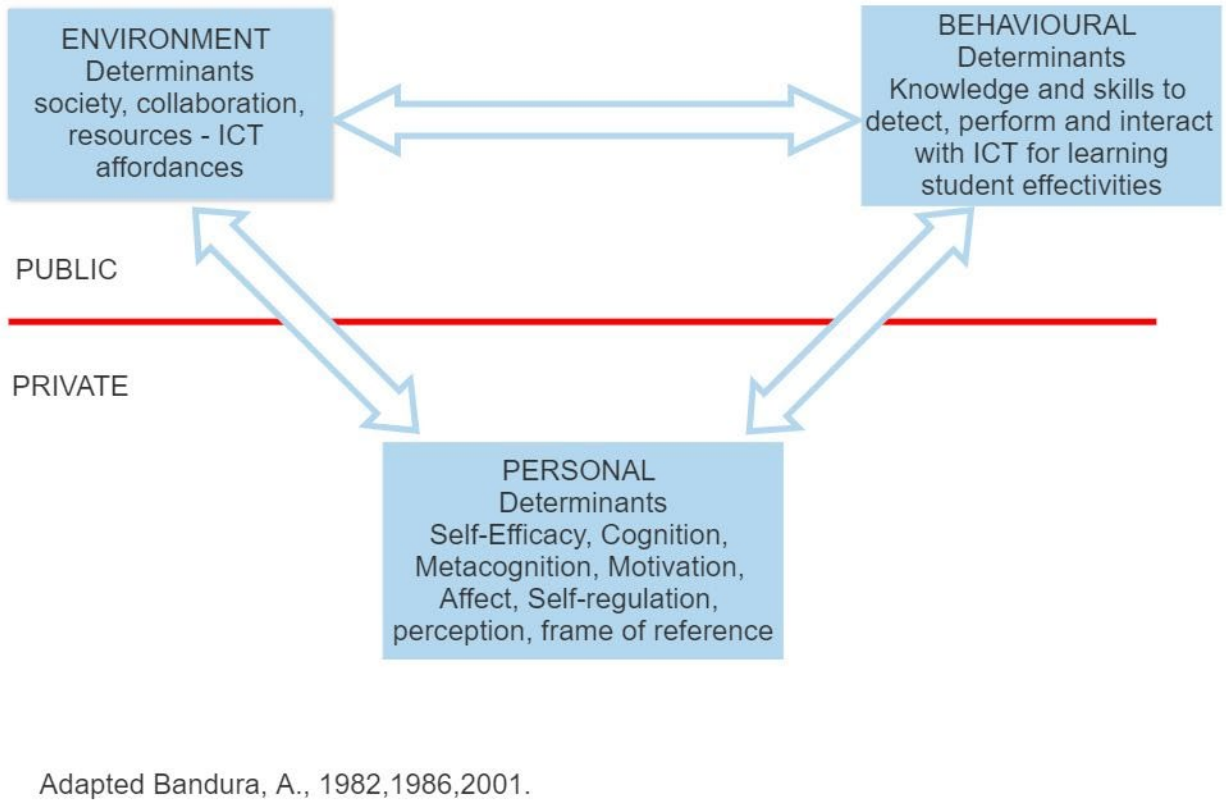

Figure 3-2 Adapted triadic reciprocal causation model. The division between the public and private world emphasises the bidirectional impact of ICT affordances and the personal abilities to know how and when to use these affordances

In this research, the behavioural uptake of ICT Affordances is dependent on how and if students activate their personal determinants of prior knowledge, skills, and abilities to use ICT to capitalise on the available ICT affordances to supplement their learning. These qualities are seen as observable actions, behaviours, referred to as student effectivities. In my research, these personal student beliefs and capabilities will be inferred through a Video-Stimulated-Recall-Think-Aloud (VSRTA) interview method to explore and evaluate the students' cognition, metacognition, self-regulation of learning, and self-efficacy.

Generally, the environmental determinants of learning include societal norms, formal instructional design, for example, AL, and resources, such as ICT affordances. Students are capitalising on ICT affordances by adapting them for their own learning needs (effectivities). But this does not automatically mean that they do so effectively and successfully. In order to explore this, I have specifically aligned the ICT affordances with the tenets of AL (Chapter 1). So, in exploring how and why students adapt their ICT devices for learning, it is relevant to recognise that using ICT as a learning resource depends on the personal determinants of cognition, metacognition, and personal agency to drive learning behaviours. For example, student-controlled ICT affordances free the student to choose their own learning partners by communicating with their own created ICT communities; they are not restricted to the formal tutorial group or face-to-face meeting with their

peers but can be part of multiple communities simultaneously. They are at liberty to join groups of like-minded learners from anywhere in the world and at any time. Likewise, students adapt their everyday social online ICT communication networks to support their learning needs. Furthermore, ICT smart devices have many functions that the students coordinate for their learning, which leads to ICT convergence. The other ICT affordances of the creation of knowledge and collaboration could align with the AL tenets of collaboration and knowledge creation.

The students studied in this research enrolled in a formal AL course. Yet, these AL pedagogies are designed prior to the advent of ubiquitous ICT affordances. Essentially, AL pedagogies and ICT affordances have been assumed to be compatible. For example, before ICT affordances, students would have been guided by the course curriculum with recommended library resources serving as a guide of depth and breadth for their self-directed learning. They relied on the library to access learning resources, as evidenced by high library use in AL courses (Martin, 2003; Neufeld & Spaulding, 1973).

However, with students controlling access to information, via ICT affordances, they are less reliant on formal (library) resources, as evidenced by a decline in library use (Boruff & Storie, 2014) and is also corroborated in this research. Therefore, more than ever before, students can be truly self-directed learners. But this freedom to choose their learning resources and partners can incur cognitive and learning outcome costs. As such, this learning approach is highly dependent upon the student's abilities to capitalise on the ICT affordances to a level of proficiency to support their academic learning. For this to occur, they must have the personal capabilities and abilities to recognise and seek the affordance and the behavioural outcome to successfully navigate and utilise ICT to benefit their learning. The learning behaviours applied to utilising the ICT affordances are referred to as student effectivities, as previously discussed in chapter 1. Hence, areas that will be examined include the ICT affordances of communication, communities, creating, collaboration, and convergence.

Also, argued in chapter 1, the students today are said to be "digital natives" (Prensky, 2001a, 2001b). However, even though they might be proficient at manipulating and are comfortable using ICT affordances on their smart devices for their social and personal lives, we cannot assume this translates to being proficient in applying this know-how to their academic learning life. A simple analogy is that one might know how to drive a car but not know the road rules; hence, it is not road safe. The bidirectional nature of the Social Cognitive Theory encapsulates the importance of the students' ICT affordance environment and how it can influence and interact with learning behaviours, student ICT effectivities, and the resultant impact and development of personal determinants of cognition and memory. This point is essential as the students seek and utilise ICT resources for their learning needs as they are agentic learners.

3.2.2 Agentic learner

The second important component of the Social Cognitive Theory for this study is that students are agents of their own learning. That is, to be an agentic learner requires the learner to identify learning opportunities within his/her environment to intentionally capitalise on the goal of maximising their learning (Bandura, 2001b). The agency concept is relevant as it provides a foundation for my thinking and exploration of the student's personal determinants. Students are strategic managers of their ICT-enriched environment to achieve their learning goals (Bandura, 1982, 2001b). The agentic student expands and transforms external information to internal memories through cognitive processes.

Students create, interpret, and contribute ideas as well as consume thoughts from others. Ultimately this leads to meaningful goal-directed learning experiences. For example, the agentic student will intentionally seek resources to supplement their learning, and they will plan and organise their learning through setting goals. Also, they self-regulate their learning by linking these plans into actions. Then, they reflect on their actions and thinking (metacognition) and assess the effectiveness of their learning outcomes. This leads to adapting and developing as learners and, importantly, growing as a self-efficacious learner who trusts their own learning capacity to function and adjust their learning approaches (Bandura, 2006) with the available informal ICT affordances. An example of being an agentic learner is when students select their learning resources, including ICT, according to their own needs, and in doing so, they have more choices of information and format of information than at any other time in history. So, the extent to which the student utilises recommended (formal) resources may contrast with the breadth and quality of a self-selected online ICT source. These selections might also discriminate the self-efficacy of the confident learners from the non-confident learners (Zimmerman, 1990). These attributes apply to the ICT-afforded student, and I utilise these in my research analysis. Consequently, the student's personal agency sits within the personal determinants, including cognition, metacognition, self-efficacy, and resilience that will vary between students and over their lifetime and determine how well they manipulate their ICT affordances for their learning.

3.2.3 Observational learning

The third component of Bandura's work originates from his early work on the impact of observational (vicarious) learning on behaviour (Bandura, 1971).

Observational learning through accessing ICT exposes students to vast amounts of online information. My research acknowledges these learning opportunities are no longer confined to the classroom, nor are they controlled by the educator, but the student essentially controls them. Universities have attempted to cater to this information source and have developed online Learning Management Systems (LMS) for their students. However, the uploading of lectures, learning resources, and provision of collaborative spaces are not necessarily relatable to the ICT-afforded

students, and often students prefer to select their own resources. Students can visit distant knowledge repositories and seek online learning communities of their own choice for their specific learning needs at any time and from anywhere. The ICT communities enable lengthy or brief immersion into the virtual space. However, observational learning, according to Bandura, depends upon several processes for learning to occur. The first process, attentional, requires the identification and judgement of the information found. Therefore, it is dependent upon the cognitive skills, preferences, and prior knowledge of the student. The next two processes are concerned with memory; time to rehearse and perform the new information to consolidate and retain memory. Finally, the level of motivation determines the degree to which the student persists and engages with the information (Bandura, 1971, 1986). For these reasons, Bandura acknowledges the role of memory and the mind in learning with unique brain features of neuroplasticity that enable the brain to adapt, attend to, and process information to form knowledge stores (Bandura, 2001a).

In summary, Bandura's SCT has many strengths that help make meaning of the learner's position in today's ICT afforded world.

The Triadic reciprocal causation model structure forms an underlying scaffold for my theoretical framework. The strength of this model is that it is timeless and can readily be applied to the ICT-enhanced environment of today and tomorrow. It reflects students as agents of their own learning in organising and seeking different information sources and in adapting to any of the ICT information formats. Although Bandura has often been labelled a neo-behaviourist, his work post-1980s reflects his understanding of the importance of personal and contextual determinants of behaviour and applies to human functioning across all domains of living. Learning is also recognised as a cognitive process whereby the brain has intrinsic neuroplasticity capabilities to form new knowledge schemas based on prior knowledge, new information, and ideas (Bandura, 2006). I have incorporated these SCT components for my research as they directly relate to the informal ICT and formal AL environment.

Consequently, this leads me to the next section that will outline the Information Processing Theory of learning, which expands upon Bandura's work.

3.3 Information Processing Theory

The second group of learning theories draws upon the assumption that humans are continually receiving all forms of information to develop mental representations for cognitive processing (Mayer, 1992, 1996). It is an umbrella term for a group of theories that hypothetically explain how the processing of external information is received and assimilated into existing or creating new stores of internal knowledge structures. It is based on the notion that learning is a continuous human activity. The rationale for including these Information Processing Theories is to expand my theoretical framework component of the personal determinant described earlier by Bandura.

There are three main Information Processing Theories I draw upon are:

1. The Information Processing Theory (IPT), initially proposed by Atkinson and Shiffrin that draws on Miller's research on the nature of short-term memory (Atkinson & Shiffrin, 1968; Miller, 1956; Shiffrin & Atkinson, 1969).
2. The second builds upon this theory, the Cognitive Load Theory. The Cognitive Load Theory expands our understanding of information and memory processing capacities and limitations (P. Chandler & Sweller, 1991; Sweller, 1988; Sweller et al., 1998).
3. The final theory is from the Cognitive Theory of Multimedia Learning, which considers the two primary forms of stimuli available from ICT devices, visual and audible, and is pertinent to my research (Mayer & Moreno, 2002, 2003; Mayer et al., 1999; Moreno & Mayer, 1999; Van Gog, Pass, & Sweller, 2010).

The importance of selecting these theories is that they contribute to previous groups of research that can be utilised to describe and assess Bandura's personal determinants. We understand that external information does not automatically permeate into knowledge stores (schemas). Learning takes awareness, effort, and commitment. Therefore, initially, the learner becomes aware of the relevant stimuli and then actively attends to them before incorporating and examining the importance of their prior knowledge. The Information Processing Theories (IPT) are often best understood by drawing analogies between how a computer processes information and the brain. The human brain and computer both receive information, record it, adapt it for individual use, and store it for later use. Each of these processes has limitations in memory storage capacity and time for both the human brain and the computer.

The historical IPT purports a theoretical sequence of external information processing that channels information into internal memory structures, resulting in storing knowledge schemas. Research has demonstrated that there are inherent temporal and spatial limitations that can cognitively overload the memory system. This observation stems from Miller's work in 1956. He demonstrated that up to seven independent pieces of information could be recalled, for instance, a series of unrelated numbers, but any more would be lost. Also, in order to learn information beyond the seven 'units of information', the learner/student creates meaningful chunks or groups of information, developing their own memory code to enhance recall. This highlighted critical variables facilitating the development of memory, such as the degree of contextualisation of information – the degree to which the new information could be connected to existing information in the long term memory, time taken to rehearse, and the volume of information (Miller, 1956).

Atkinson and Shiffrin followed on from Miller's work to propose the Information Processing Theory of learning (IPT), which schematically describes learning as a system of interconnected brain-wide neuronal structures that detect, process, and transform external information to internal long-term memory schemas (Atkinson & Shiffrin, 1968) with inherent limitations in capacity and time (Miller,

1956). Figure 3.3 depicts the flow and fate of external information. There are several steps the information (external stimuli) must travel to be processed or not processed and lost. The information type, strength, constancy, and importance of the external input determines whether it passes the sensory (attention) and short-term storage (working memory) to form memories for long-term memory storage. The notion of information being lost or ignored during these processes has been extensively investigated.

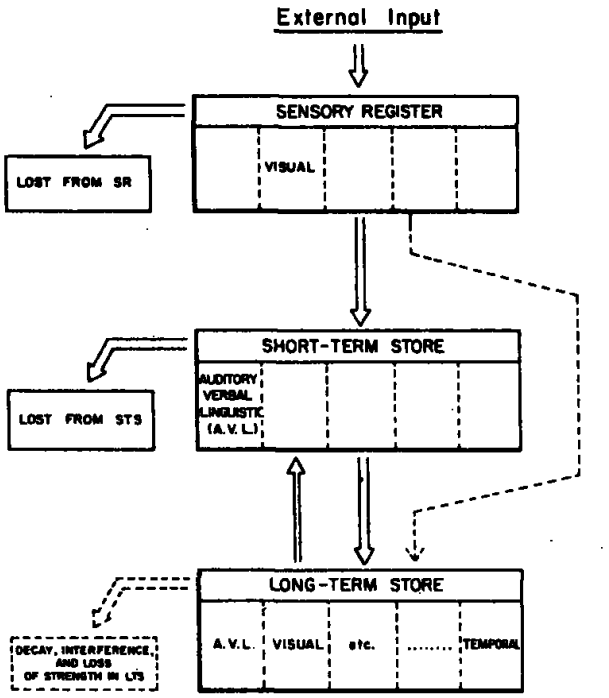

FIG. 1. Structure of the memory system.

Figure 3-3 Information Processing Theory flow of external stimuli, information, attention, perception, and cognitive processing, resulting in long-term memory schemas. Source : (Atkinson & Shiffrin, 1968, p. 93) Copyright 1968 by Elsevier. Reprinted with permission.

3.3.1.1 Attentional processes

Inherent in the Information Processing Theories is the need for students to be aware of and detect relevant information through their sensory systems of the body before it can be processed. This awareness, attentional processing forms a gateway for information and other stimuli to enter the IPT. We live in a complex world. There will always be more information available than the student is aware of or can attend to, and some form of filtering inputs will be required. The attentional focus and perception of what is important and the amount of time the information remains in the sensory system are rate-limiting steps. Cowan demonstrated that the focus of attention is adjustable with limitations both temporally and spatially. Also, he found that the adjustable attention process can focus on three or four items or chunks at a time, and the spatial arrangement of the information determines which is selected and concentrated on, with the first and last items focused upon more than the middle items (Cowan, 2011; Cowan et al., 2005).

Therefore, applying this knowledge to learning highlights the potential differences and pitfalls for attentional focus between hard copy resources, such as textbooks and online ICT information. Hard-copy resources require effort to navigate through strategically. Also, one resource might not be enough. The learner, the students, are hence seeking and reading several physical resources for their study. When seeking online information, there is a myriad of resources available with little effort required or expended to access them. However, with most online resources, there is a reduction of spatial cues, such as the continuous “disappearing page,” with no tangible signposts for the reader to refer to (Rose, 2011). In addition to reduced spatial cues, the temporal cues are impacted because the vast volumes of information can be quickly scrolled through. When students search online, they are confronted with endless screens of search-engine-results-pages (SERP). SER’s are geared to entice the person to open them. Predominantly, students trust the search engines' algorithms, such as those used in google, to focus on what they perceive as trustworthy information. According to search engine optimization research, the first SER page and the first entries are the most accessed and coveted position (Evans, 2007; Zhang & Cabage, 2017). They are coveted as the advertising revenue is linked to the number of hits an online site receives. These are marketing strategies that are at play every time keywords are typed into a search engine. Therefore, many online factors are competing for the users' attention, leaving it up to the user to perceive the potential to supplement their learning.

3.3.1.2 Working Memory

Once a student’s attentional focus has selected the information, it theoretically moves into the working memory. The working memory also has limited volume and time capacity (Baddeley, 2003a, 2011; Baddeley & Hitch, 1974; Miller, 1956), impacting whether the information is actively retained and made available for cognitive processing or whether it is discarded. The working memory capacity can be expanded by the retrieval of already processed neuronal schemas from long-term memory. Cues from working memory trigger the recalling of relevant schemas into the working memory. Therefore, long-term memory schemas act to increase functional working memory capacity.

3.3.1.3 Long-term memory

As opposed to working memory, long-term memory has an undefinable capacity (Atkinson & Shiffrin, 1968; Cantor & Engle, 1993) and its formation is dependent upon the individual's attentional focus, working memory, and how they engage their cognition, metacognition, and inherent motivation to construct knowledge schemas. Long-term memory schemas are essentially how the brain encodes information for retrieval when required. Well-organised and contextually relevant information is easier to learn by chunking together to later recall into the working memory (Ericsson & Kintsch, 1995). The relevant chunks (schemas) are then retrieved into the working memory stimulated by cues from the working memory and attentional focus. Further modification or reinforcement of the schemas continually occurs when activated and throughout the student’s

lifetime. Figure 3.4 depicts the flow of external information through to encoding of internal long-term memory schemas and the subsequent recall. This process forms the basis for AL pedagogies, whereby students' prior knowledge is activated explicitly by learning cues built into the formal course curriculum. The critical limitation is the student's prior knowledge and whether it is retrieved and subsequently employed.

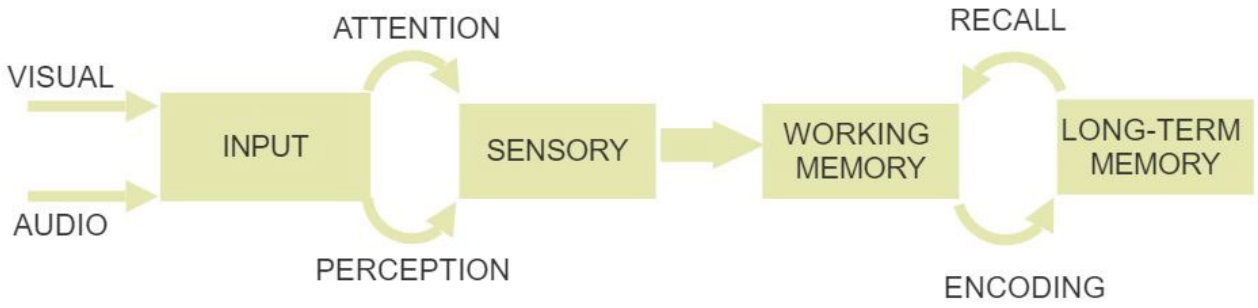

Figure 3-4 Schematic representation of the Information Processing theory used in this research adapted from Mayer and Moreno (Mayer, 2014, p. 52; Mayer et al., 1999; Moreno & Mayer, 1999). Copyright 2001 by Taylor & Francis. Adapted with permission.

3.3.2 Cognitive Load Theory

The Information Processing Theories of learning explains the many limitations of cognitively processing new information, which led to the development of the cognitive load theory. During the 1980s, Sweller suggested that too much information during problem-solving interfered with learning (Sweller, 1988). Thus, he posited the cognitive load theory. Sweller and colleagues recognised that a novice learner solves problems from a means-end level, which is slow, cumbersome, and more complex. On the other hand, an expert will solve a problem within their expertise quicker than a problem outside their expertise. The main difference between a novice and an expert is that the expert has well-developed long-term memory schemas, whereas the novice has very few and was forced to use more generic problem-solving strategies that can result in overloading the working memory. Therefore, the number and size of long-term memory schemes are hypothesised to be unlimited.

Consequently, there is always an interplay between long-term memory to increase working memory capacity (Baddeley, 2003b; Baddeley & Hitch, 1974). Schemas are described as pre-digested information organized into chunks that have been processed into knowledge for rapid recall to the working memory during problem-solving activities. In this setting, learning increases the number and quality of long-term memory schemas and the ease with which they can be connected meaningfully to the information in the working memory.

Cognitive load has been categorised as intrinsic, extraneous, and germane.

Intrinsic Cognitive Load

Intrinsic cognitive load is the difficulty inherent in the content to be learned. It is immutable. It is pre-prescribed by the course content and knowledge required for the student to achieve the specific course academic level (Sweller, 1988). Inherent in this property of intrinsic load is that learners' level of prior knowledge is assumed (Van Merriënboer et al., 2003). Information is presented in a stepwise fashion of increasing complexity to support the students learning throughout the course. Vygotsky first described this as being within the “zone of proximal development” (Bruner, 1997; Tudge & Winterhoff, 1993; Vygotsky, 1930). The volume and incremental steps of information complexity are tailored to the student level and monitored by the educator to ensure students are challenged but not overloaded during the teaching process. Educators are vital as they can control the learning environment, and in doing so, control the intrinsic cognitive load. Therefore, students rely on the educator for the required level and volume of content to be learned. The introduction of AL pedagogies shifted this educator dominance and encouraged students to be self-directed learners. Rather than just learn what was presented to them, they were encouraged to explore from their own learning perspective what they required to understand the course's intrinsic content. However, this is an important consideration for this research, as the intrinsic load produced by ICT affordances is not controlled by the educator but by the student. Extraneous Cognitive Load

Extraneous Cognitive Load

Another form of cognitive load, previously controlled by the educators, is extraneous cognitive load. Extraneous cognitive load is when unnecessary instructional and procedural burdens impact and reduce cognitive capacity to learn. Therefore, lessons are choreographed or scaffolded by the educator to mitigate and control the extraneous cognitive load. The unwanted, confounding and unnecessary burdens form one of the main criticism of AL pedagogies, such as Problem-Based-Learning and Case-Based-Learning (Paas & Van Merriënboer, 1994; Van Merriënboer et al., 2003).

However, a feature of AL courses is that students are encouraged to be self-*directed* learners (Loyens, Magda, et al., 2008; Schmidt, 1983). At this juncture, it is essential to note that self-regulated learning (SRL) is associated with students negotiating their learning within the confines of the course. Self-directed learning (SDL) encompasses SRL and more. SDL encourages students to control their learning by setting their own learning goals, a feature of AL pedagogies. The learning journeys SDL students take is dependent on their prior knowledge and experiences. Therefore, each student is different. As such, they control their learning sessions by identifying their individual and group learning needs. They then develop learning issues that form the basis for their self-directed learning between formal AL sessions. Despite this, the intrinsic load in these formal AL courses have a minimum knowledge level requirement. AL extraneous cognitive load

practice is also minimised through the PBL tutor choreographing tutorials by using scaffolding (Dolmans et al., 2002). The aim was to reduce the instructional methods of cognitive load burden to focus on learning the AL process and information required.

Germane Cognitive Load

The third category, germane cognitive load, refers to the cognitive resources allocated to address the intrinsic load (Sweller, 2010). For example, the complexity of intrinsic cognitive load information influences whether the students are motivated to persist, devote cognitive effort, and reflect the amount of working memory capacity allocated to learning (Paas & Van Merriënboer, 1994) . The AL tutor would guide and determine the best way to support or scaffold the students' information. A well-organised and suitably challenging tutorial with clear guidelines with AL process steps to follow is an example of increasing germane cognitive load strategies (Kalyuga, Chandler, Tuovinen, & Sweller, 2001; Sweller, 1988; Van Merriënboer & Kirschner, 2017). Students controlling and using ICT affordances are potentially at risk of missing out on these germane cognitive load strategies.

3.3.2.1 Formal Cognitive Load teaching methods

However, educator-constructed instructional designs, such as AL, have been identified as increasing unnecessary cognitive load that interferes with learning (P. Chandler & Sweller, 1991). AL pedagogies, such as Problem-Based-Learning (PBL), Case-Based-Learning (CBL) etc., utilise problem-solving methods to contextualise learning. Although the educators are said to “play a passive role” during the AL sessions, the entire AL program is orchestrated (Papinczak, Tunny, & Young, 2009) to ensure students learn within the appropriate zone of proximal development. Additionally, the flow and depth of students’ contributions in AL tutorials are scaffolded to provide a learning environment free from unnecessary interruptions. The group and the tutor agree upon learning ground rules during introduction sessions. For example, the seven-jump method for conducting a PBL tutorial was developed to standardise and scaffold the AL sessions (Schmidt, 1983). To scaffold a PBL ultimately reduced the extraneous cognitive load on the student. Each University has implemented its own version of AL and scaffolding that works for its socio-cultural learning environment. The tutor's role is consistently one of facilitating and scaffolding the group process and group learning. Despite this, task complexity and extraneous load were still considered too high for novices (P. Chandler & Sweller, 1991; P. A. Kirschner, 2002; Sweller, 1988; Sweller, Kirschner, & Clark, 2007). Consequently, further recommendations to scaffold complex learning, such as problem-solving techniques in AL, were proposed (Van Merriënboer & Sweller, 2010).

However, despite these tutor-derived techniques to lower extraneous load and ensure intrinsic load to the ZPD level, students access information based on their own perceived needs via informal ICT

affordances. Additionally, they access ICT information throughout formal AL tutorials as well as during self-directed study. There are several steps the student must undertake and navigate to select an appropriate resource. Initially, they must decide which search engine to use, then the relevant keywords, followed by judging which ICT search-engine-result (SER) information to choose, read, and then incorporated. Additively, this can overload the working memory, resulting in reduced learning efficiency (Wopereis & Van Merriënboer, 2011). Additionally, students interact with several personal smart ICT devices, interact with the formal ICT for the AL case presentation, manage paper resources, and interact face-to-face with peers during their formal AL tutorial. Consequently, this raises the question of how students manage all these multiple resources, each with different formats, switching between them, and negotiating their biological memory resources all during formal AL sessions?

3.3.3 Cognitive theory of multimedia learning

To focus on the impact of informal access to ICT devices, Mayer and Moreno's work in 1999 is drawn upon, Figure 3.5. Their Cognitive Theory of Multimedia Learning proposes cognitive processing patterns by the sensory and working memory, which is analogous to information students seek informally from their own ICT devices (Mayer, 2019; Mayer et al., 1999; Moreno & Mayer, 1999). Raw information stimulates the sensory memory whereby components are selected and considered in the working memory. This raw information consists of two channels (dual); visual (images) and audio (words, sounds). Mayer and Moreno highlighted the impact of processing written words, spoken words, and pictures. They found it was important to control the sequence, volume, and complexity of visual and audio inputs to prevent cognitive overload and potentiate cognitive processing coordination, resulting in long-term memory schema development. Hence, for formal AL to successfully utilise multimedia, the multimedia message should be designed to prevent cognitive overload. However, because students control their informal ICT affordance requirements, there is no teacher/guide/scaffold to manage the information streams, leading to potential cognitive overload. The Cognitive Theory of Multimedia learning contributes to the previously discussed theoretical framework by highlighting the coordinated cognitive processing of dual-channel information on formal AL and the potential impact when students control the ICT information.

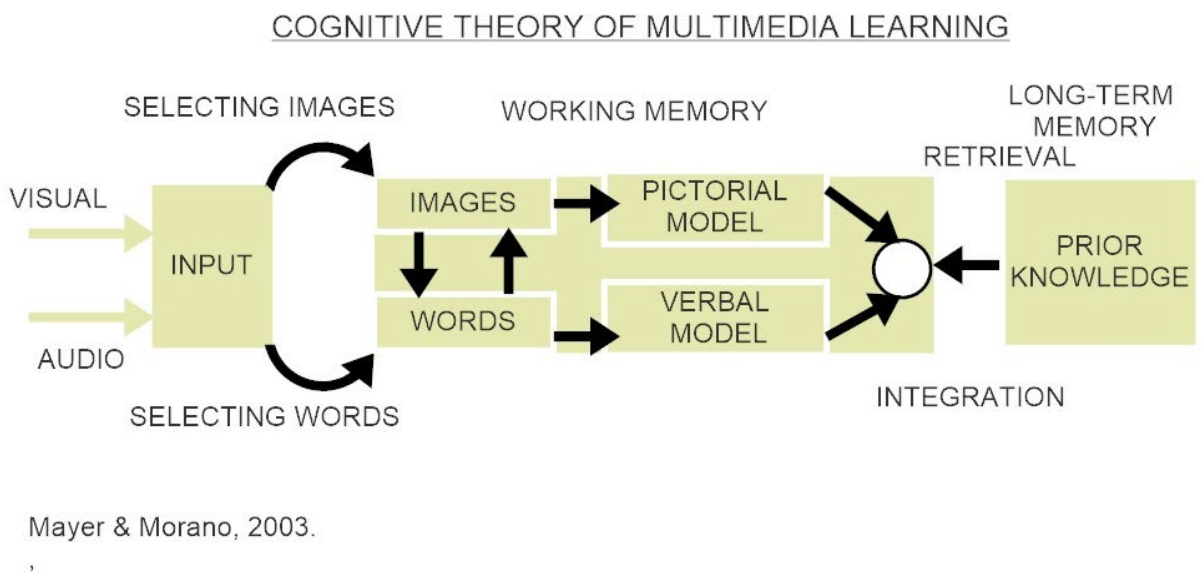

Figure 3-5 The Cognitive Theory of Multimedia Learning, adapted from Mayer and Morano, 2003. (Mayer, 2008, 2014, 2019; Mayer & Moreno, 2003; Moreno & Mayer, 1999) Copyright 2001 by Taylor & Francis. Adapted with permission.

3.3.4 Cognition

To learn is to develop personal knowledge and intellectual skills (Bloom, 1956). Inherent in this learning process is the students are cognitively and actively engaged in their learning (Chickering & Gamson, 1987; Dewey, 1929; Piaget, 1976; Prince, 2004; Vygotsky, 1980; Zull, 2011). To be actively involved requires thinking and exploring one's prior knowledge and how it fits with the information at hand, that is, to be cognitively active. For my research, I call on the revised Bloom's cognitive taxonomy, as developed in the late 1950s, categorizing the cognitive processes as dynamic, hence as verbs (Anderson et al., 2001; Krathwohl, 2002). Figure 3.6 portrays these theoretical cognitive processes whereby the student initially responds to external cues that stimulate recognition and recall of prior knowledge schemas from long-term memory and understanding.

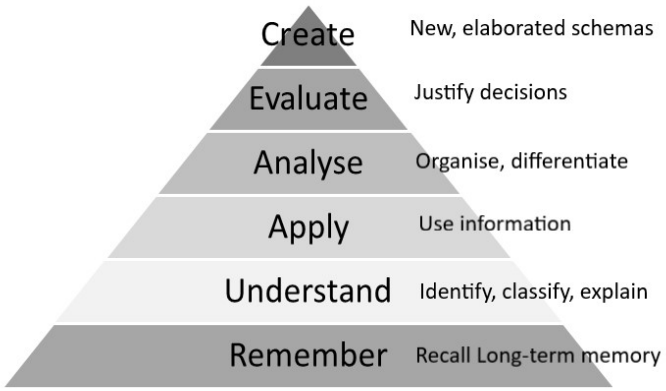

Figure 3-6 Adapted Bloom's taxonomy of cognitive processes. (Anderson et al., 2001; Bloom, 1956; Krathwohl, 2002)

Applying what they already know and implementing this to the situation leads to identifying what they do and do not know. If learning remains at this juncture, the students in a formal learning environment might only be superficial learning and low cognitive engagement. However, more in-depth understanding, high cognitive engagement requires more time and effort to engage with and analyse new information with prior knowledge. After critical evaluation, through checking and judging the relevance to the task or problem (Slavich & Zimbardo, 2012; Hmelo-Silver, 2004; Bloom, 1956), creating new and elaborated knowledge schemas. These cognitive skills are incorporated into the personal determinant of my conceptual framework. Of particular importance is the distinction between the low and high cognitive engagement of cognitive processing from ICT affordances or other learning resources whilst researching through reading, writing, listening, discussing, or problem-solving (Bonwell & Eison, 1991; Bloom, 1956).

3.3.5 Metacognition

Metacognitive knowledge

In addition to cognitively processing information, the student critically monitors their cognitive abilities and strategies by the internal process of metacognition (Flavell, 1979; Zull, 2011). Metacognition is a broad term that includes our knowledge of and our regulation of how we think, in other words, our cognitive processing (Fernandez-Duque, Baird, & Posner, 2000). Metacognitive knowledge develops through reflecting on the way we think and understand the world around us. We develop metacognitive strategies to improve how we learn and self-monitor how our learning efforts are going (Ellis et al., 2014). Embedded in metacognition is the students' self-efficacy. The stronger they believe in their capabilities, the more successfully they perform a task (Coutinho,

2008). For example, determining ‘what is known versus what is not known’ is integral to cognitive knowledge construction. When the learner is confronted with an unknown, a cognitive conflict arises (Mezirow, 1999; Piaget, 1976), stimulating and motivating learning. The interface of new information with prior knowledge and the external factors are dynamic and in continual flux and challenges the learner (Dochy & Alexander, 1995). Consequently, the impetus to learn is achieved by activating prior knowledge, and it is dependent on internal and external factors. Internal factors consist of the learners’ cognition, motivational state, metacognition, and emotional state interacting within a framework of external factors such as rules, rewards (passing exams), and pressure from individuals, groups, or organisations (Ryan & Deci, 2000).

3.3.6 Review of importance of Information Processing Theory

The Information Processing Theories describe the temporal and spatial theoretical concepts of how the brain computes and manages information from the environment. The inherent nature of novice learners' limited sensory and working memory capacities has led to much debate in the literature regarding AL instructional designs. Sweller, Kirschner, and colleagues have argued that AL is an unguided method and results in unwanted extraneous cognitive load (P. Kirschner, Sweller, & Clark, 2006; Sweller et al., 2007). They advocate for teacher-guided learning that they say is commensurate with the cognitive architecture. Additionally, Mayer and Moreno's cognitive load of multimedia learning alerted to the perils of dual audio-visual teaching video formats and recommended controlling both visual and audio stimuli to avoid excessive cognitive load in learning videos (Mayer & Moreno, 2002, 2003; Mayer et al., 1999; Moreno & Mayer, 1999). Therefore, cognitive load is heavily regulated by the educator. Also, the AL educator controls cognitive load in AL through highly scaffolded tutorials and cases (Hmelo-Silver, Duncan, & Chinn, 2007). The longitudinal program and each progressive case are carefully choreographed to build upon the previous cases and learning objectives incrementally (Barrows, 1983; Barrows & Tamblyn, 1980; Hmelo-Silver & Barrows, 2006). Activation and elaboration of prior knowledge are key cognitive processes (Loyens, Rikers, & Schmidt, 2008; G. R. Norman & Schmidt, 1992; Schmidt, 1983; Schmidt et al., 2011). Students who keep pace with these incremental learning steps have ample opportunities to revisit, recontextualise and create new schemas, amend and elaborate on existing knowledge by continual rehearsal and performance in small groups. However, the conundrum with educating contemporary AL students is that the educator is no longer the only source of information. They are no longer able to control the quality or quantity of information. ICT-afforded students are now at liberty to control their information needs through quick access to informal unvetted ICT information. Students no longer have the safeguards of the educator tailoring and supporting their cognitive load. Therefore, there is a real risk that students today might develop superficial long-term memory schemas, as they increasingly rely on ICT affordances to remember for them. AL aims to engage students with new information in the context of biological long-term memory schemas, not ICT memory.

3.4 ICT Affordances and Student Effectivities

The Theory of Affordances provides a lens from which to view learners' interactions with their ICT devices without being influenced by the genre of ICT devices and Wi-Fi platforms. Information Communication Technologies (ICT) is a rapidly growing and progressive field. ICT devices are marketed and adapted continually to appeal to the market. The aim is to sell more ICT devices by appealing to people to buy the latest model. There are myriads of devices, but essentially the perceived uses for learning remain stable. It is these perceived uses that are consistent with the Theory of Affordances (Chemero & Turvey, 2007; Dotov et al., 2012; Gibson, 1977, 1986). Therefore, employing the Theory of Affordances and applying them to ICT enables a relatively stable group of ICT affordances, perceived uses to investigate and align with AL pedagogies. The ICT devices can be upgraded and modified, but the ICT affordances remain relatively constant.

Additionally, independence from technological determinism (D. Chandler, 1995; Oliver, 2011) is an essential criterion in adopting the Theory of Affordances to investigate how students navigate their learning in an ICT-rich environment. By considering the ICT Affordances offers a way of thinking and researching the impact of informal ICT in education, it avoids the technological deterministic trap of the ever-evolving ICT device capabilities and commercialisation.

The other critical associated lens to affordances I use in this research is the concept of student effectivities. Student effectivities and affordances are intertwined and interdependent. An effectivity indicates if the user can use an ICT affordance for the correct purpose. In other words, they need to know how to access, when to access, and to operate appropriately for the task they have set themselves. For example, the smartphone has specific design features that enhance the user's ability to use, such as communicate; this could be seen as an actual affordance. However, the extent to which the user can engage the communication affordances is at the behest of the user and is a perceived affordance. This is linked to the student's abilities, or as termed here as effectivities. The relationship between the ICT affordances and the students' effectivities are pivotal for learning.

ICT devices have become an essential tool in our current society. We use them extensively both socially and at work to communicate with friends, peers, and organisations. We use them to source information about anything at any time and from anywhere. When the internet server drops out, we complain when the internet speeds are not fast enough and when we cannot connect due to incomplete WiFi coverage. According to the Social Cognitive Theory of learning, ICT is an essential environmental determinant for the way we live and learn. In education, irrespective of which pedagogy one subscribes to, the environment determinant of ICT is and will continue to play an integral role in learning. These Human-computer interactions via ICT devices have become indispensable to the majority of our society.

In summary, the use of the term affordance fits within the schematization of the interactions of human behaviour, cognition, and other personal factors and the external environment; Bandura's triadic reciprocal causation model underpins SCT of learning (Bandura, 1986).

3.5 Conceptual framework

The combined SCT and IPT conceptual framework is depicted in Figure 3.7. This will be used throughout my research. As an interpretive study, this framework provides an essential frame of reference upon which to analyse the current literature, contextual factors that impact students' learning, and frame my interpretation of findings.

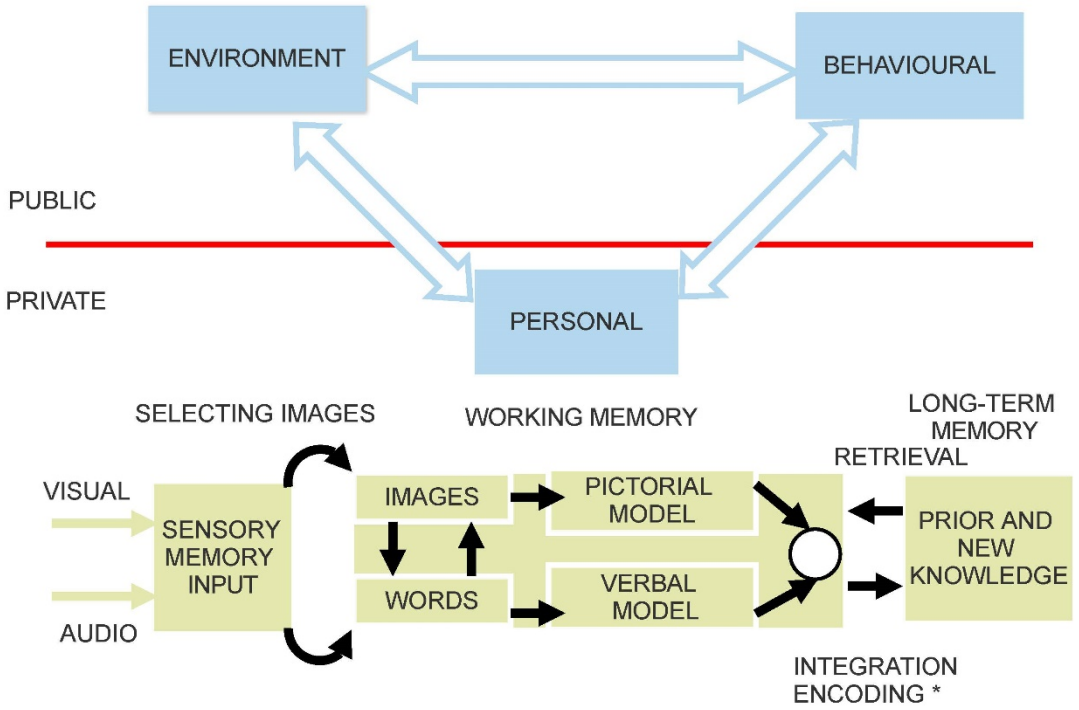

Figure 3-7 Integration of the conceptual frameworks based on the Social Cognitive Theory, Information Processing theory, and the Cognitive Theory of Multimedia Learning.

Each of these theories individually is significant. I have incorporated three compatible macro theories that create a powerful triangulation lens to explore this complex phenomenon by addressing my research questions. The triadic reciprocal causation model, theory of Information Processing system, and affordance theory create a wide macro lens through which to view this learning phenomenon (Samuel, Konopasky, Schuwirth, King, & Durning, 2020). These theories

arise from cognitive and ecological psychology. The basic premise upon which these can be combined is that they are complimentary. Therefore, the combination is a more comprehensive theoretical framework specific for my complex research by merging components. Combining aspects of current theories is not new nor advised against in the literature (Samuel et al., 2020), as validated by Brehaut and Eva. They describe this approach as a “menu of constructs” that enables each theory's critical elements to be expanded and developed into a broad theoretical framework. Amalgamating theoretical components leads to a framework that expands and complements the original theories to produce a more significant construct than one theory alone (Brehaut & Eva, 2012). The result is a wide lens to explore the interaction between formal AL sessions and informal ICT affordance and student effectivity interactions to understand the phenomenon better. The resultant theoretical framework, Figure 3.8, ensures there is no duplication and focuses on expanding the concepts purposefully that could confuse (Bandura, 1986). The aim is to enhance the utility of the selected theories for this research.

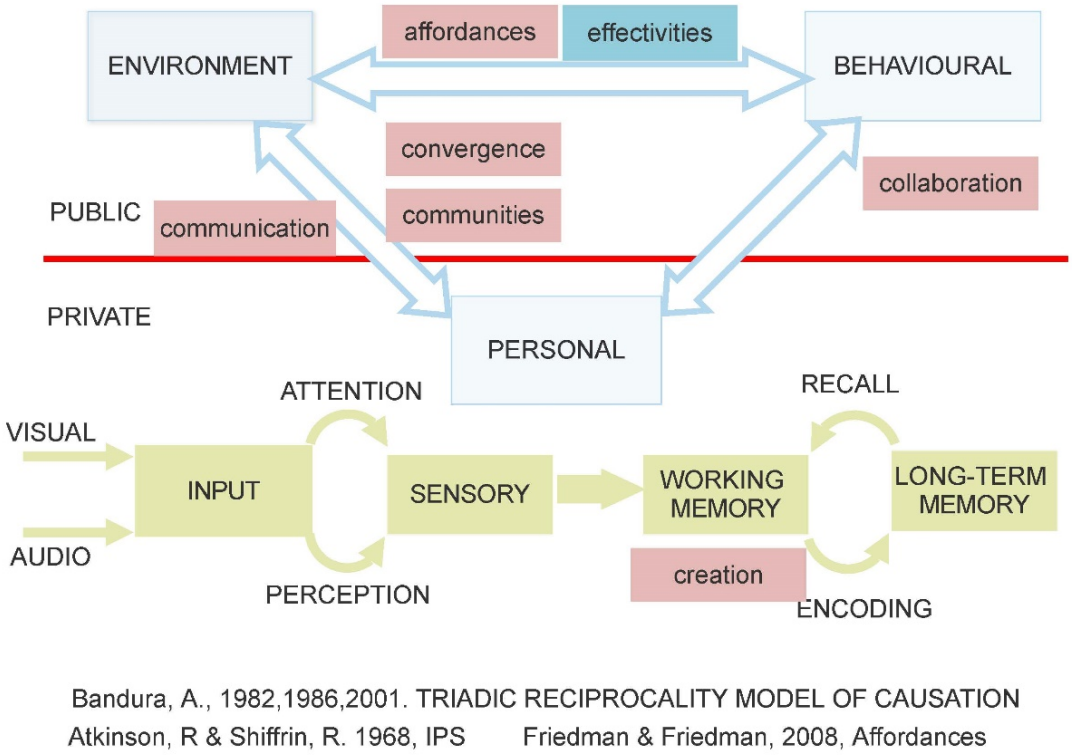

Figure 3-8 Final Conceptual Framework format including the selected learning theories overlayed with the AL tenets and ICT affordances as developed for research presented in this dissertation.

Many complex interactions can shape and direct a student’s path. What the student sees and considers as important or interesting depends on their prior knowledge and experiences gleaned in

their life so far. This has added another dimension to the above framework. The use of ICT affordances now enables students to control their own information needs, supersede the efforts, and construct the educator scaffolds during formal AL sessions. Therefore, figure 3.8 describes the SCT and IPT with the ICT affordances overlayed, and as such, positioning the research aim to determine the students' ICT effectivities and subsequent cognitive and metacognitive impact during formal AL sessions.

4 METHODOLOGY, MATERIALS AND METHODS CHAPTER

4.1 Introduction

The purpose of this study is to explore why and when students access informal Information-Communication-Technology (ICT) affordances and how they utilise ICT (student effectivities) during formal active learning (AL) tutorials (PBL). Subsequently, the impact of ICT on the students' learning process is investigated, focusing on their cognitive and metacognitive strategies. In this chapter, I will position my research ontology, epistemology, theoretical perspective, and methodology with discussions on the associated rationale. Within the research methods, I will provide further explanations to characterise the research learning context, how the data was collected and collated, and the approach to data analyses to explore my research objectives.

4.2 Methodology

4.2.1 Origins of research are naturalistic

Before discussing the ontology and epistemology of the learning phenomenon and the theories I chose to utilise, it is vital to position this research in its origins and the natural world.

My research motivation originates from my experience as an AL (Problem-Based-Learning, PBL) tutor. Over my 14 years of tutoring, I noticed subtle changes in the students' interactions between formal-faculty course information and student-controlled informal information. They increasingly sought to supplement their learning through their ICT device. This interplay is multi-directional between the student, the faculty, and the informal content, each impacting the other. It was around this time when students started bringing their ICT devices into the PBL tutorials that I noticed they were increasingly commenting on the large amounts of information there was to consider. At first, I didn't think this unusual as AL medical students learn through determining what they know and do not know and subsequently formulating learning issues to resolve these unknowns through self-directed learning periods. Students re-contextualise the researched information into the case at hand for the follow up report-back tutorial (Schmidt, 1983; Schmidt et al., 2011; Wood, 2003). The learning aim was to integrate new information with prior knowledge to construct meaningful, memorable long-term memory knowledge (schemas). So, it was not unusual for PBL students to report feeling overwhelmed and swamped with information at times.

However, in 2010, my university imposed a paperless system as a central tenet of their education practice. All information about the PBL and course moved to the online university learning management systems (LMS). At the same time, students were increasingly utilising ICT devices as they capitalised on the available ICT affordances. They did so by taking notes on their devices during the active-learning problem-analysis tutorial, collating their research for learning, and preparing for the report-back tutorial. As a result, ICT devices, mainly laptops, became

commonplace in PBL tutorials. Anecdotally from observations of the teaching process and questioning the students, they described that their ICT notes contained vast amounts of online information. At times, the relevance and accuracy of this information were difficult to assess. Many students were "cutting and pasting" snippets of online information to their notes without processing or 'digesting' the information. It was from this time onwards that changes in the AL tutorials became apparent.

Other tutors were observing similar issues and comments from students. They described that the opened laptops posed a physical barrier to group work as students could avoid eye to eye contact and engagement with peers and tutors. Additionally, the initial problem-analysis phase tutorials (day 1) became increasingly truncated as students searched ICT sources for quick answers to resolve unknowns. The number of learning issues identified was also decreased. The report-back tutorials (day 2) were also shorter in duration. Instead of co-constructing information on the shared whiteboard, students were reporting back information on learning issues by presenting mini-lectures (didactic) - students would read out information from online or paper notes. This was associated with a noticeable reduction in students questioning each other and co-constructing information on the shared tutorial whiteboard. Some students commented they had trouble recalling the relevant information, despite having it in the ICT notes.

Several tutors recommended banning laptops entirely or at a minimum for the problem-analysis phase in AL. However, these changes are not only unsustainable but possibly unwise. ICT affordances have become integrated into our social, educational, and work environment and cannot simply be ignored. Therefore, this research was stimulated by student comments and tutor observations of dilemmas in the PBL process. It is a real-life learning dilemma. As educators, we need to understand this naturalistic ICT-afforded learning setting and how best to use its possibilities and avoid its pitfalls in our educational design.

Therefore, this study investigates when and why students choose to seek information using their ICT affordances and evaluates these usages' types and purposes from the perspective of whether it supports or hampers learning in the AL context. The data gathered will provide an insight into how students are melding their ICT affordances with their specific learning needs and pivotally the role of formal AL in this ICT setting.

4.2.2 Ontology

Naturalistic learning and education are complex phenomena, and logically, there are many aspects to them. Consequently, a flexible ontological and epistemological approach is required. So, it took lengthy deliberations to develop the ontological stance for this research. When researching such a complex setting, it is not possible to start from a single perspective. Instead, multiple perspectives will have to be combined to provide a better lens on the phenomenon of interest. As such, I took a

pragmatic approach to encompass the diverse scope of multiple contextual and cognitive determinants and how they influence students' learning and students' perception of how they learn. These determinants have been discussed in chapter 3. Therefore, my ontological stance is both naturalistic (Lincoln & Guba, 1985) and pragmatic (Dewey, 1929). I have chosen to combine several theoretical frameworks to recognise this research environment even though they individually have ontologically different paradigms.

I will use an ontological interpretive view to interpret the natural AL setting to better understand the meaning of the students' learning behaviours and their observed and discussed interactions with their ICT affordances. This meaning varies depending on stakeholders or individual events. Therefore, these multiple perspectives clarify that there are multiple realities, and consequently, there are numerous ways to interpret this rich and dense data. For this, I need to be ontologically an interpretivist, interpreting the data to make meaning through constructivist epistemology (Lincoln & Guba, 1985). These forms of analyses serve to understand knowledge as a socially constructed phenomenon rather than as objectively defined knowledge. In other words, the environment or context in which the phenomenon is taking place influences the outcomes (Hudson & Ozanne, 1988). Therefore, the ICT-afforded environment the student is learning in, the behaviour of the students interacting with ICT, and the underlying personal cognition and metacognition are all highly variable between students. Indeed, each student responds differently over time and in different places. Consequently, I cannot assume there is one right or wrong way. Therefore, my role as a researcher of this complex phenomenon is to make meaning through understanding students in this environment.

Conversely, however, I am also ontologically interpreting observations from a logical positivist perspective. With the view on evaluating how student ICT interactions would theoretically hamper or facilitate learning, cognitivist theories on knowledge acquisition and learning provide the most informative lens. So, by assuming the nature and structure of memory systems according to established theories, I seek to characterise the students' cognitive processing when engaging with ICT affordances. These theories, the Information Processing Theory of memory (Atkinson & Shiffrin, 1968) and Cognitive Load Theory (P. Chandler & Sweller, 1991; Sweller, 1988) provide an objective scaffold to understand learning.

Therefore, I felt the need to link and interweave the ontologies and epistemologies of these diverse views to address this complex and multifaceted real-life phenomenon in a technical sense. Pragmatically, therefore, some ontological agility is required. I will provide further discussions and rationale to justify the use of these two paradigms.

4.2.2.1 Interpretivist

Learning and educating are complex activities. The diverse constant interplay between personal and behavioural determinants is embedded within the environmental determinants that set the

scene for unpredictable student-derived outcomes. For students, learning is a personal and subjective experience. For the educator implementing a curriculum, learning is about setting up everyday learning environments for students to learn in. For the researcher, exploring how students are learning may provide meaningful insights to inform educators on how to facilitate students learning in the ICT-afforded environment. This illustrates how there are many ways of making meaning within this educational environment.

The process of learning cannot be simply reduced to its individual parts or pieces for isolated study, nor can it be artificially constructed in the form of an experiment. For example, approaching the phenomenon using assessment of learning outcomes will not allow exploration of the process that students undertake to learn. Experimental methods investigating the components of learning will likewise not provide the naturalistic real-life learning process with all its interactions. These are linear views that demonstrate only the endpoint or components of learning, respectively. Hence, they are untenable methods when exploring the *in-situ* learning process. My ontological stance needs to recognise this non-linear dynamic naturalistic research environment with multiple realities as no two students are alike. Nor are two AL groups the same. The complex dynamics between the student(s) and their group cannot be predicted, or better, it happens within the space of bounded unpredictability. Each student has their own prior knowledge and experiences providing their idiosyncratic frame of reference for learning. My research explores the various methods of students' learning and views learning in this real-life complex state with multiple learning theories.

4.2.2.2 Logical Positivist

The paradigm of logical positivism refers to the notion that scientific methods generate knowledge. The nature of reality, as such, is determined by what can be sensed and hence determined scientifically. This perspective might at first seem out of place in this research. But still, the human memory systems' assumptions are pivotal in characterising the cognitive processes and the subsequent limitations. Neuroscience provides rich research to draw upon that describes salient features of human memory and cognitive neuronal architecture. They are logically transferable and generalisable across students when studying cognitive load and the executive functioning of the memory system.

4.2.3 Epistemology - Constructivist

The constructivist learning theories recognise that students learn by making meaning from viewing and combining new information within their prior knowledge. Each learner has a unique 'frame of reference' through which to view the world. These theories acknowledge that learning is maximised when it is pitched at the appropriate level to build upon prior knowledge. The best-known example of this principle is the concept of the Zone of Proximal Development (ZPD) (Tudge & Winterhoff, 1993; Vygotsky, 1930). Others capitalise on the natural curiosity to drive learning through striving to resolve unknowns or disorientating dilemmas (Kitchenham, 2008; Mezirow, 1997, 1999)

because frames of references are individual and unique, as are individual ZPD, which culminates in a complex and, to a certain extent, unpredictable naturalistic environment.

Each student in this research perceives the PBL environment slightly differently. Apart from the shared knowledge and shared understanding, each has unique prior experiences upon which they can create their own meaning and act according to their beliefs and abilities. Essentially, students will be experiencing the same formal PBL environment, but will each uniquely interpret and seek ICT affordances to supplement their learning needs. Therefore, my position as a researcher is to allow the real-life natural PBL learning sessions to take place, unimpeded. Afterwards, I seek the research participants' thoughts and interpretations of their learning.

Furthermore, I will apply the AL tenets of construction of knowledge, collaboration, and contextualisation with the ICT affordances of creation of knowledge, collaboration, communication, communities, and convergence. Hence, a constructivist epistemological research paradigm allows for a diverse research approach to address the research questions. To support this paradigm, a theoretical perspective of interpretivism is adopted.

4.2.4 Theoretical Perspectives: Interpretivism

Interpretivism is closely associated with constructivism. The research participants' actions and views about their formal learning behaviours and environment provides insights into their personal determinants of why they seek informal ICT affordances. The real-life learning setting of AL, Problem-Based-Learning (PBL) tutorials, forms this naturalistic research's initial context.

4.2.5 Methodology

Qualitative and mixed research methodologies can furnish the deep understanding required for this complex learning phenomenon. Qualitative research is an umbrella term for a diverse array of approaches to understanding individuals' or groups' perspectives and lived experiences within the context or environment they are living in (Creswell, 2013; Merriam, 1998).

The context of this research was AL tutorials within a first-year Graduate-Entry-Medical-Doctorate course. The setting was naturalistic in that the students were undertaking their routine problem-based learning (PBL) tutorials in their first year of study. The phenomena being investigated were the students' ICT effectivities and underlying thought processes directing their decisions to use ICT affordances during PBL and the most likely impact on the students' learning according to the developed theoretical framework described in Chapter 3 (SCT, IPS, and AL tenets).

This is a complicated research situation. The interplay between the way students are learning formally (within a group tutorial, with peers) and their informally accessed ICT device under their control results in a complex environment to research. Theoretically, the study could have used a quantitative approach by collecting learning outcomes through test results and somehow

correlating this quantitatively with the amount of ICT use. However, learning outcomes will not provide sufficiently rich information about how the students process and integrate ICT into their learning. Although such information might also be necessary, it is not the focus of my research. It would overlook how students are learning in today's ICT-rich environment and the impact on the teaching design of AL. Quantitative approaches would also potentially lead to a de-contextualisation of the phenomena and to a fragmentation of the environment, rendering the results disjointed and out of context. Such an approach would not do justice to the complexity of the phenomena of interest. The social exchanges between students, tutors, ICT, and the thought processes within individuals lead to a dynamic, diverse, and highly contextually dependent environment. A centre for understanding these complex interactions is understanding why and when individual students interact with their ICT affordances during the AL tutorial ICT (formal) and the individual ICT affordances (informal). Therefore, the student's cognitive and metacognitive processing perspective is sought to enable deep consideration of this increasing student ICT affordance interaction during formal AL university courses.

Qualitative research modes' strengths are typically the result of gathering a diversity of information from the natural AL setting. For example, observation and analysis of students' interactions provide a plethora of rich descriptive information that can be further explored through methods such as think-aloud interviews.

The researchers' roles are pivotal in analysing and interpreting data in qualitative methodologies. The recognition of the methodological considerations of this study requires a discussion on the researcher's chosen paradigm.

4.2.6 Reflection on the chosen methodological approach

The natural learning setting delineates the strengths of this research design. By employing a qualitative methodology, I could unpack, explore and understand the complex learning phenomenon in the students' natural learning habitat. Therefore, I purposefully designed this research to be minimally intrusive for the natural learning setting. To ensure this, I, as a PBL tutor, deliberately withdrew from all tutoring and contact with the GEMD course for the year I conducted my research. This delimitation ensured distance from any perceived role I had and the medical students might think I had. Also, to make sure, I had no prior knowledge of the students as the primary researcher.

The data collection was comprehensive, resulting in the collection of multi-modal data sets, allowing for a robust triangulation of information. However, I recognised biases on several levels. Firstly, to reduce the Hawthorne Effect (Paradis & Sutkin, 2017), I interviewed the tutors after the tutorials to ask if they noticed a change in student and or group behaviour associated with the presence of the cameras. Secondly, as a research observer, I had no prior knowledge or

expectation of the students. Finally, I undertook a multiple iterative analysis approach as explained in the methods section to reduce the risk of first impression bias.

Inherent in my approach is the acknowledgement of my perspectives to undertake analysis. For example, in chapter 4, I described myself as methodologically agile. Essentially, this means I developed a conceptual framework aligned with the ICT and AL affordances to ground my cognitive constructivist intepretivistic perspective (Chapter 3).

4.2.7 Researchers perspective summary

Medical education is complex and continually changing. There are numerous pedagogies employed with many more local variations. As such, ontologically and epistemologically, this study uses a cognitive constructivist interpretivist research paradigm. In this paradigm, there is no one single truth to guide this research. There is no single right way of knowing. Interpretivism embraces subjectivity but cannot be arbitrary. It has to come from a chosen and argued conceptual framework. In the conceptual framework I use for this study, the primary assumption is that learning requires activating, creating and consolidating knowledge in the students' memory systems. Therefore, my position as a researcher is to allow the real-life AL session to take place. Hence, I recognised that I am interweaving the above-discussed ontogenies, epistemologies, theoretical perspectives and methodologies to accommodate the tricky nature of real-life phenomena pragmatically. Learning is not a result of any specific path as it is greater than the sum of the observable parts. Therefore, these situations require methodological agility and grounds my interpretivistic research paradigm through the lenses of my conceptual framework and ICT and AL affordances.

Consequently,this study interprets students' thinking patterns by triangulating data using the conceptual learning theory framework described in chapter 3 and the defined researchers' methodological stance. Therefore, all data will be analysed by triangulating data and applying it to the conceptual framework to support its trustworthiness and rigour.

4.3 Methods

4.3.1 Introduction

The learning setting of this study is ideal for showing the complex interplays between students and the use of ICT affordances in a PBL tutorial when students actively collaborate to construct knowledge and supplement these tutorials with informal ICT use. As such, multiple types of data were collected to acknowledge the complex nature of the PBL tutorial. I will describe the study design and data sets I obtained and subsequent data analysis methods in the section below. Inherent in this design are the ethical considerations and The Flinders University requirements and permission to conduct my research with access to the first-year Graduate-Entry-Medical-Doctorate students.

4.3.2 Study design

The study design consisted of three sections.

4.3.2.1 Section 1 – Medical student cohort sampled demographic and ICT use survey.

I developed and conducted an online demographic and ICT usage survey (10 Questions) to gain an overall impression of the first-year student cohort I accessed for my study. All first-year Graduate-Entry-Medical-Doctorate (GEMD) students enrolled at Flinders University campus in 2016 were invited by email to participate with an introductory letter. [Appendix A]. The email contained an online link to the ten-question survey. The format consisted of simple questions followed by nominal fixed answer responses for the students to select. The first three questions enquired about their age, gender and asked about the prior university degree(s) they had undertaken before entering medical school. The second group of questions sought information about their ICT device usage and how they thought about and incorporate ICT affordances into the learning week. I ensured the questions were written in a simple and understandable format (Krosnick & Presser, 2010) and did not lead the students to a particular answer to maintain optimal neutrality (Lietz, 2010). In this second group of questions, I inquired about the student's metacognitive strategies when seeking ICT affordances to support their learning. The survey served as a brief insight into the students self-reporting of ICT usage during their University learning week [Appendix B].

I did not pilot the survey before sending it to the students as I initially intended to provide a brief overview of the students' cohort. Subsequently, though, I decided to include the survey in my results as the perspective of self-reported ICT usage provided valuable insights to compare with my subsequent interpretations of recorded results.

4.3.2.2 Section 2 – Video record tutorials

First-year GEMD PBL groups (7-8 students plus one tutor) volunteered individually and as a whole PBL group to be video recorded during their routine PBL tutorial. They were provided with detailed information about the research, its objectives, data handling and storage, and their right to withdraw up to 2 weeks after one or two complete PBL case(s) (two 2-hour tutorials) video recordings have occurred. Their willingness to participate was by emailed group consent to me by the PBL group secretary. The total number of recordings conducted was determined by data saturation. Recruitment was sought from established PBL groups to reduce the impact of new group dynamics associated with getting to know each other and each other's learning styles and establishing group learning.

Additionally, students volunteered to supply the Information-Communication-Technology logs of their search histories [Appendix C] from their laptops or tablets or smartphones during the two tutorials.

4.3.2.3 Section 3 Video Stimulated Retrospective Think Aloud (VSRTA)

GEMD students volunteered from the video-recorded PBL to participate in Video-Stimulated-Retrospective Think-Aloud (VSRTA) interviews. Think-Aloud is an established method to obtain information about an individual's cognition (Ericsson & Simon, 1980, 1998). This technique relies on the premise that the human brain processes information into different storage systems, as described in Chapter 3, the Information Processing Theory of learning (Atkinson & Shiffrin, 1968; Shiffrin & Atkinson, 1969). The think-aloud method's validity for what the subject is thinking has been established in various ways, even including neuro-imaging (Durning et al., 2013) and eye-tracking (Guan, Lee, Cuddihy, & Ramey, 2006). There are several methods of implementing Think-Aloud depending upon the research setting. Concurrent verbalisation of thinking was not an option in my study setting (Peute, de Keizer, & Jaspers, 2015). I investigated the students' ICT interactions in their routine PBL tutorial setting, and concurrent verbalisation would distract and influence the natural PBL and ICT interaction processes. Therefore, I decided to retrospectively ask the students to verbalise their thinking during salient events I identified (Jaspers, Steen, Van den Bos, & Geenen, 2004; J. E. Russo, Johnson, & Stephens, 1989; Smagorinsky, 1998). These events, or probes (Ericsson & Simon, 1980), were used to prompt students' recollection and facilitate what they were thinking at the time. After the PBL tutorial cycle had finished, I reviewed all the videos, documented ICT interactions, and the group discussions and activities. Figure 4-1 depicts the resources I used in the characterisation of the events. I specifically focused on the students who had volunteered to participate in the VSRTA interviews.

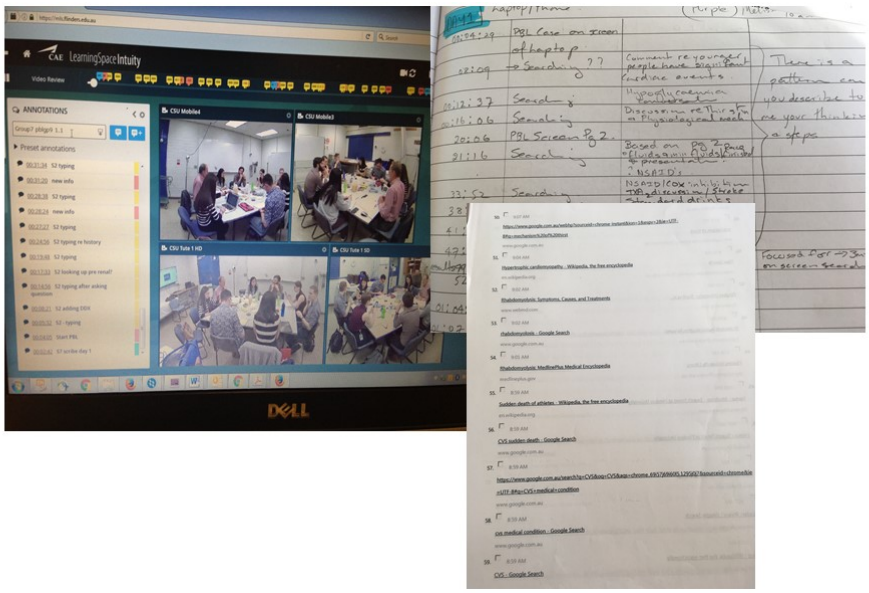

Figure 4-1 Raw data collected.

Events were identified and characterised by viewing each event from the four camera angles. I recorded the student to student and student to ICT device(s) interactions. Events were further characterised by transcribing the group conversations and actions and, if available, the ICT history

logs. The ICT history logs were mainly only available after the VSRTA.

Students were shown the videoed event during the interview and asked to describe their thoughts around their interaction with their ICT devices. Paskins and colleagues phrased this method as ‘getting under the skin’ of primary care consultants when videoed events were shown to them and asked to recall their thinking (Paskins, McHugh, & Hassell, 2014). I prompted videoed students by asking them only to keep talking (Elekes, 2000). The VSRTA provided information about cognitive processing and metacognitive strategies they recollected about each event. The overarching aim was to understand their rationale for accessing ICT concerning their problem-solving methods, cognition, and metacognition processes.

All videos were initially time stamped using the CAE™ video program. Subsequently, the videoed tutorials and ICT history logs were manually aligned with observed interactions with ICT devices and other students and documented. Student interactions with their ICT devices determined points of interest during PBL: these formed ‘events’ to explore during the student Video Stimulated Retrospective Think Aloud (VSRTA). Willingness to participate in these follow-up interviews was subject to an additional consent form [Appendix C]. These interviews were audio-recorded and true verbatim transcribed for subsequent analysis of metacognition and cognition with informal ICT usage.

This design had several strengths.

- The data collected reflects complex social learning interactions in the natural learning setting of formal PBL tutorials.
- I was not present, which reduced the potential for disruption of the established PBL group's normal function. Although PBL tutorials are not routinely recorded, the medical student's clinical skills tutorials are. Consequently, these cohorts of medical students were familiar with being recorded for summative and formative assessment and reflective practice of clinical reasoning and knowledge. This way, the collection of data was as close to unobtrusive naturalistic data as possible.
- The video stimulated retrospective think-aloud interviews that enabled triangulation with data from the online-ICT-usage-survey and the recording of the PBL tutorials to establish and understand the student's personal determinants (private world) learning experience.
- The naturalistic PBL (*in situ*) tutorial setting with no researcher intervention provided a cross-sectional snapshot of one point in time of students' complex interactions with the problem, peers, ICT devices, and tutor.

4.4 Ethical considerations

The primary ethical considerations were the following. First, medical students have limited time to

volunteer to participate in research. Second, there is a need for confidentiality and privacy despite the video recordings, and therefore these were prime considerations in developing the research design. Finally, maintaining the naturalistic learning setting of the formal PBL tutorial was critical to encourage routine PBL behaviours is to ensure authenticity/validity of the data. To reduce the demand on student time, only one case cycle (one week) of tutorials (two, two-hour tutorials) were recorded. All data collection was completed before the next PBL case commenced. Ethically this was important to minimise disruption to the participant's time constraints and promote participants to volunteer. Written information about the study's purpose and time requirements of volunteers was provided with the email invitation. The emails were followed up by invitation to address the PBL groups to answer questions and organise a suitable week for data collection. Recordings of tutorials required all participants to provide verbal consent, individually and as a group. Questions were encouraged and answered either via email or face to face before the recorded tutorials.

After the first tutorial, participants volunteered to participate in the interviews, share their ICT history logs, allow still photos of the group and pictures of the group's board work. The collection of these sources of data required written consent forms. Students were again informed about the purpose of the study, data collection methods, and anonymization of data. Ethics approval was granted for this project by the Social and Behavioural Research Ethics Committee (project 7366) on the 29th July 2016 and the School of Medicine Evaluation Reference Group on the 8th July 2016, both from the Flinders University of South Australia. The research ethics application and the letters of Approval are included in [Appendix D]

Another ethical consideration was made in relation to my role as a PBL tutor in the GEMD programme. I purposefully withdrew from tutoring the year before I started the data collection phase. I had no student-tutor association. However, the tutors I had worked with before. But the only question I was seeking was the PBL group tutors assessment of the impact on the normal PBL functioning of the group in the research setting.

4.5 Context of research is situated in a naturalistic setting

AL is being used at many universities and courses worldwide. Regional variations of AL have arisen according to the physical facilities, academics, and course requirements. Therefore, AL occurs as Problem-based-learning, case-based learning, team-based learning, and many more. Flinders University has been utilising PBL in its graduate-entry medical course since the late 1990s. In my study, I investigated experienced PBL students and tutors in established PBL groups, undertaking the second-semester first-year subjects of cardiovascular and respiratory units of work. Importantly, students, tutors, and their groups had been established for at least four to ten weeks before participating in this research. This is important because it allowed time for the development of students' collaborative learning processes and social systems to develop (Hommes et al., 2014) and thereby reduced any impact of new group dynamics (Tuckman &

Jensen, 1977) and ensured the group was relaxed and comfortable in their PBL learning environment. It was also important to reduce the impact of extraneous factors on student learning behaviours. Tutors were interviewed and asked to gauge the impact of camcorders and PBL room change for the recording of the PBL process. Tutors provided their perceptions of group and individual functioning relative to previous tutorials.

4.6 Participants

4.6.1 The research cohort

Students were from the first year 2016 Graduate-Entry Medical Doctorate (GEMD) cohort (147 students) at the then called The Flinders University Faculty of Health Sciences, School of Medicine, now called The College of Medicine and Public Health. The medical school purposefully assigned students to their PBL group to ensure each group reflects the first-year cohort heterogeneity. For example, gender, age, background, undergraduate degree, and work experience. These attribute distributions are essential to facilitate a diversity of knowledge and perspective during the PBL AL sessions (Azer & Azer, 2015; Fonteijn & Dolmans, 2019).

Students were recruited from the fourth week onwards in their second semester of first-year work and were studying cardiac, respiratory, and renal components of the course at the time of the research. The rationale was to ensure I was sampling established PBL groups with their routine PBL tutor. Figure 4-2 positions the PBL tutorials as a dominant component of the first year GEMD over semesters 1 and 2. Student learning in 2016 was assessed through formative assessments of PBL participation by the PBL tutor in one to one interviews with the students. The final assessment at the end of the semester was via summative written examinations.

Figure 4-2 shows at what stage of the students' course my research was conducted. The group PBL tutor was also emailed to confirm consent to being video recorded.

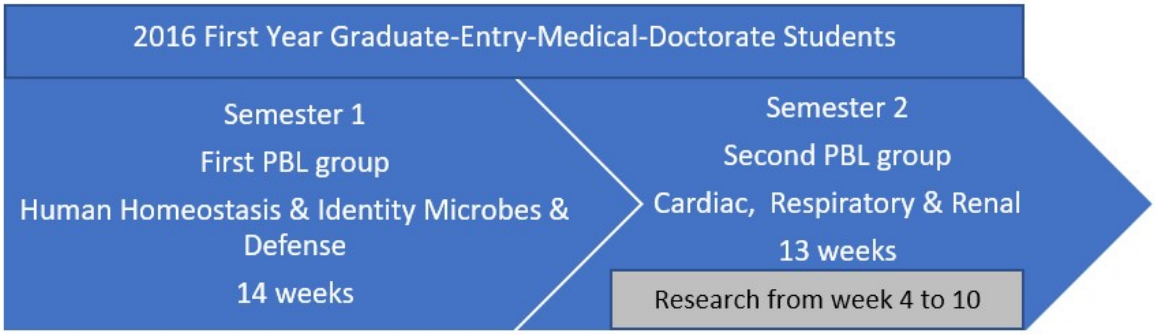

Figure 4-2 2016 GEMD course timeline when students' participated in the research. PBL recordings were conducted over six weeks during the students' established second PBL group in semester 2.

4.6.2 Recruitment

Invitations were emailed to all medical students with a letter of introduction containing information about their contribution, the time required (flow diagram of participant involvement), the project aims, and methods [Appendix A]. Students who responded to the email were followed up by a face-to-face meeting with the group to discuss any concerns, questions and determine mutually suitable tutorials to record. Recording of the PBL tutorials was only undertaken after verbal consent from all PBL group participants, including from the tutor. Only one routine complete PBL case cycle was recorded and analysed to minimise intrusion into the students' established PBL learning environment. No methods of coercion were used to increase participation in the study.

Demographic data were voluntarily provided by an online survey seeking the first-year cohorts' gender, age, prior degree, and ICT usage.

4.6.3 Student Participation

As indicated above, to minimise the time required for students to participate and maximise participation, only one complete PBL case cycle (maximum of four hours) was video recorded. The first tutorial (2 hours) presented the contextually relevant problem that stimulated discussion and identified prior knowledge, and identified areas they did not know or understand. This tutorial is referred to as Day 1, the 'problem analysis phase.' Subsequently, the groups identified and formulated Learning Issues for self-directed learning to guide their self-directed learning (SDL) for the next two days before tutorial two. The second tutorial (2 hours) was also video recorded as students report back the researched learning issues collaboratively to construct and consolidate their knowledge through presenting problems from first principles, clinical relevance, and clinical management. This tutorial is referred to as Day 2, the 'report-back phase.' A total of ten PBL groups (number of total students = 77) volunteered to be recorded.

Video-recorded PBL students were then invited to an individual video-stimulated retrospective think-aloud (VSRTA) interview. These individual student interviews were conducted within three

days of completing the last recorded tutorial to ensure the recorded PBL case was fresh in their minds and reduce interference with the next PBL case.

Signed consent was obtained before conducting the VSRTA interviews, including the provision of ICT-history logs[1] to be collected that documented their ICT usage from their ICT device used during the recorded tutorial. Total student time, outside of the recorded routine tutorials, was 2 hours. The average number of students volunteering for think-aloud was 29% (n=23/77) of recorded PBL tutorials.

4.6.4 Tutor Participation

Tutors were included in the verbal consent process to video record the PBL tutorials along with the students. All tutors consented and were instructed to conduct the tutorial as an everyday routine tutorial but allow the students to access their ICT devices freely. Tutors agreed to a follow-up, face-to-face, semi-structured interview. Three tutors tutored two PBL groups each, while the remaining four tutors tutored one group each—a total of seven tutors across ten PBL groups. Tutors volunteered one hour of their time for face-to-face interviews outside of the PBL setting. Importantly, tutors were asked whether the video-recorded PBL group tutorials were a typical representation of students' PBL learning behaviours than non-recorded tutorials as the impact of camcorders and the knowledge of being recorded could potentially influence student learning behaviours.

4.7 Data collection

4.7.1 Videoed tutorials

PBL tutorials were videoed via two fixed (camcorders for clinical skills recording) and two mobile camcorders in the students' routine Clinical Skills and Simulation Unit tutorial room. A total of four (4) camcorders with 40 hours per camcorder of recordings resulted in 160 hours of video data. Camcorders were placed in the room's four apexes to enable all activities to be visualised. Board work and the individual computer screens were visible to document student ICT device interactions. All videoed sessions were stored on the Clinical Skills and Simulation Unit CAE LearningSpace™. Other learning resources, for example, study notes, were identified and used in the individual VSRTA interviews to remember thoughts and actions associated with the stages of PBL.

An omnidirectional boundary or pressure zone microphone (PZM) was mounted on the ceiling over the tutorial room table to record all conversations. Although medical students are routinely videoed during their Clinical Skills Simulation Unit for practice, reflection, and summative assessment, the

[1] ICT history usage includes own computer, smartphone, tablet, or tutorial room computer (although this was also evident from recording)

presence of camcorders during PBL was new to them. To further minimise any possible intrusiveness from the camcorder use, it was emphasised that the recording has no bearing or relevance to their progress through the course.

Verbatim transcription of events of interest (the basis for VSRTA) in the recordings was undertaken. 10 PBL groups consented to participate.

The PBL room was organised, as depicted in Figure 4-3. It included one fixed whiteboard and one double-sided whiteboard. Another whiteboard was available, but this was not required. The formal PBL material was conveyed through the formal computer and projected onto a 70" television screen mounted on the wall. The students and tutor tutorial desk provided ample room for laptops, books, and other resources.

Figure 4-3 Students in AL tutorial room with resources (both formal and potential informal)

All recordings were securely stored on a dedicated password-protected Flinders University service space in the long term as per the Ethics committee of the University and the College of Medicine and Public Health at Flinders University.

4.7.2 Student Interviews

All student interviews were conducted in their routine PBL tutorial rooms. Signed consent forms were collected and students were advised that they could withdraw at any time. Twenty-three students completed these interviews.

The interviews consisted of two parts that were intertwined to increase the flow and neutrality of

the interview (Table 1):

First, as part of the understanding of each student and their background, they were asked to explain their learning approach, study patterns, and how they documented their learning for learning and exams.

Second, the VSRTA was conducted: Students were shown short sections of the video from the recorded PBL tutorials and asked to verbalise what they were thinking retrospectively. These events consisted of several identified events from the Day 1 problem-analysis phase and the Day 2 report-back phase.

Table 1 Interview overview with Video-Stimulate-Retrospective-Think-Aloud plan.

Flow and process of VSRTA student interviews and associated questions	**Prompts**
Introduction	An information sheet accompanied all consent forms as to these interviews. However, it was explained that this interview asks direct questions punctuated by VSRTA. The procedure of showing the video and asking to talk out-loud their thoughts, any thoughts, was explained and encouraged.
Students preparation for Day 1 PBL	all students were initially asked *"how do you prepare for Day 1 problem analysis phase of PBL?".*
Think aloud first tutorial: events were marked on the CAE video from Day 1 problem analysis phase.	Identified events were contextualised into the time and place of the PBL to help situate the video clip.
Self-directed learning:Independent study between tutorials and how they prepared for the second tutorial.	Students were encouraged to explain their learning approaches – this is the self-directed learning component of PBL.
Think aloud second tutorial: events were marked on the CAE video from Day 2 report back phase	Identified events were contextualised into the time and place of the PBL to help situate the video clip. Statements such as: Please tell me what your thoughts were here? Please keep talking, were frequently used to support the student
Previous degree and experience. Any other comments.	Students usually provided the answer to these questions without being prompted. However, if they did not offer, I asked them directly.

4.7.2.1 Student interview question component

During the VSRTA, I punctuated the interviews with questions that I consistently asked all participants. The aim was to "break the ice" before the VSRTA. Questions in Table 1 sought information about how students prepare for the problem-analysis and report-back tutorials and their previous degree(s) and experiences. Finally, students were asked if they had anything else they wanted to add. These questions were conducted informally and did assist in the flow of the VSRTA.

4.7.2.2 Student video stimulated retrospective think-aloud interviews

The video-stimulated-retrospective-think-aloud (VSRTA) interviews were used to assess students' systematic approach to problem-solving, to provide insight into their cognitive and metacognitive processes. I reviewed videoed PBL tutorials as soon as possible after the completion of the students' report-back tutorials. Initially, I reviewed and identified areas of interest when student-ICT device interactions occurred, which I will term “events.” Secondly, I documented the group interactions surrounding these events, which included both verbal and non-verbal contributions. The events were then video tagged to locate and replay during the interview quickly. Interviews were conducted between 4 hours to 3 days after completing the report-back phase (ending the case, final) tutorial. Students were asked to reconstruct their thinking at the time of the event. I provided prompts such as "what were you thinking" when interacting with their ICT device during the tutorial. I also prompted them to "keep talking." To assist their recall, I situated the events with the context in which the event occurred, for example, the topic of conversation. The main feature of the VSRTA interview was to encourage the student to "keep talking" through prompts and assisting contextualisation of the points of interest.

Students were provided with a description of how to undertake the VSRTA, but no further practice runs were undertaken. This was deemed superfluous because GEMD students are familiar with think-aloud during the clinical simulation and skills testing. VSRTA interviews took between 45 to 60 minutes.

4.7.3 Tutor interviews

I also interviewed the tutors from the participating PBL groups to ascertain if and to what extent the PBL tutorials' recording had altered the PBL group's performance. The tutors were explicitly asked, “was the videoed PBL group performance in keeping with previous non-videoed tutorials?” and the interviews were conducted as soon as possible after the report-back tutorial. This ranged from hours to one week afterwards. All interviews were audio-recorded and were true-verbatim transcribed. Seven tutors consented to these interviews; 3 tutors tutored two groups, with all tutors from the 10 PBL groups interviewed.

4.7.4 GEMD first-year cohort demographic and ICT usage Survey

An online 10 question survey was developed and implemented utilising the Flinders University MNHS Limesurvey^{TM} Tool. All first-year medical students enrolled in 2016 were invited and sent the online link to the survey via their Flinders University email address. Consent to participate was through the completion and submission of the questionnaire.

The survey was designed to provide descriptive information about the cohort of students invited to participate in my research (Table 2). 38% of students participated.

4.7.5 Student ICT history logs

All participating recorded PBL students were asked to log their internet history usage during the recorded PBL tutorial. Students provided either snapshot of their internet history from their smartphones or emailed their history from their laptops or tablets. ICT history logs were aligned with audio and activity transcription of recorded PBL tutorials. They formed important cues for 'events' that included crucial extra information to align with the student VSRTA interviews transcripts. Connecting to the University Wi-Fi in the study room was problematic, with only 26% of students connecting. To gain a more in-depth insight into the students thinking, I conducted the ICT history searches and documented the sites and information students obtained (Table 2). Of this cohort, 65% volunteered their ICT logs. Eight students provided their ICT logs from the PBL sessions.

4.7.6 Collaborative Board work

All participating groups provided images of their collaboratively constructed board work for the problem analysis tutorial (day 1) and the report back tutorial (day 2) (table 4.2). Students routinely take photographs of their co-constructed board work. Nine groups volunteered and forwarded the board work photos to me.

4.7.7 VSRTA and ICT logs and Board work

The students who provided their ICT log and participated in the VSRTA interviews produced a rich data set that allowed for thorough, in-depth analyses of resources used and their learning styles. It provided unique opportunities to gain insight into students' cognitive and metacognitive processing thinking (Table 2). They proved particularly informative in addressing the research questions.

Table 2 First-year 2016 GEMD Students' participation and data collected from an online survey and PBL recordings with subsequent VSRTA interview, ICT history logs, and board work.

First-year GEMD cohort	AL - PBL Groups			
	PBL Tutorials	VSRTA interview	ICT History Logs	Board-Work
Online - Survey	Video PBL, activities logged & events identified	Verbatim transcribed	Images/document	Images
140 students 25% responded	10/18 groups (77 students)	23/77 students	8/23 students	9/10 groups

4.8 Analysis methods

4.8.1 Introduction

Qualitative research requires the researcher to make sense of the data through a deep understanding of the data and the situation it is derived from. The researcher has to be the critical tool for analysis, as unlike in quantitative research, there are no standard approaches to describe and summarise the data. Additionally, there are no standard approaches like inferential statistics to draw inferences. In order for any reader to follow and critically appraise this process of sense-making of the data, the use of a theoretical framework is indispensable. My theoretical framework has been described in chapter 2 extensively, and it provides a unified lens applied to the research design and the analysis of the data. Figure 4-4 depicts the flow of analyses undertaken.

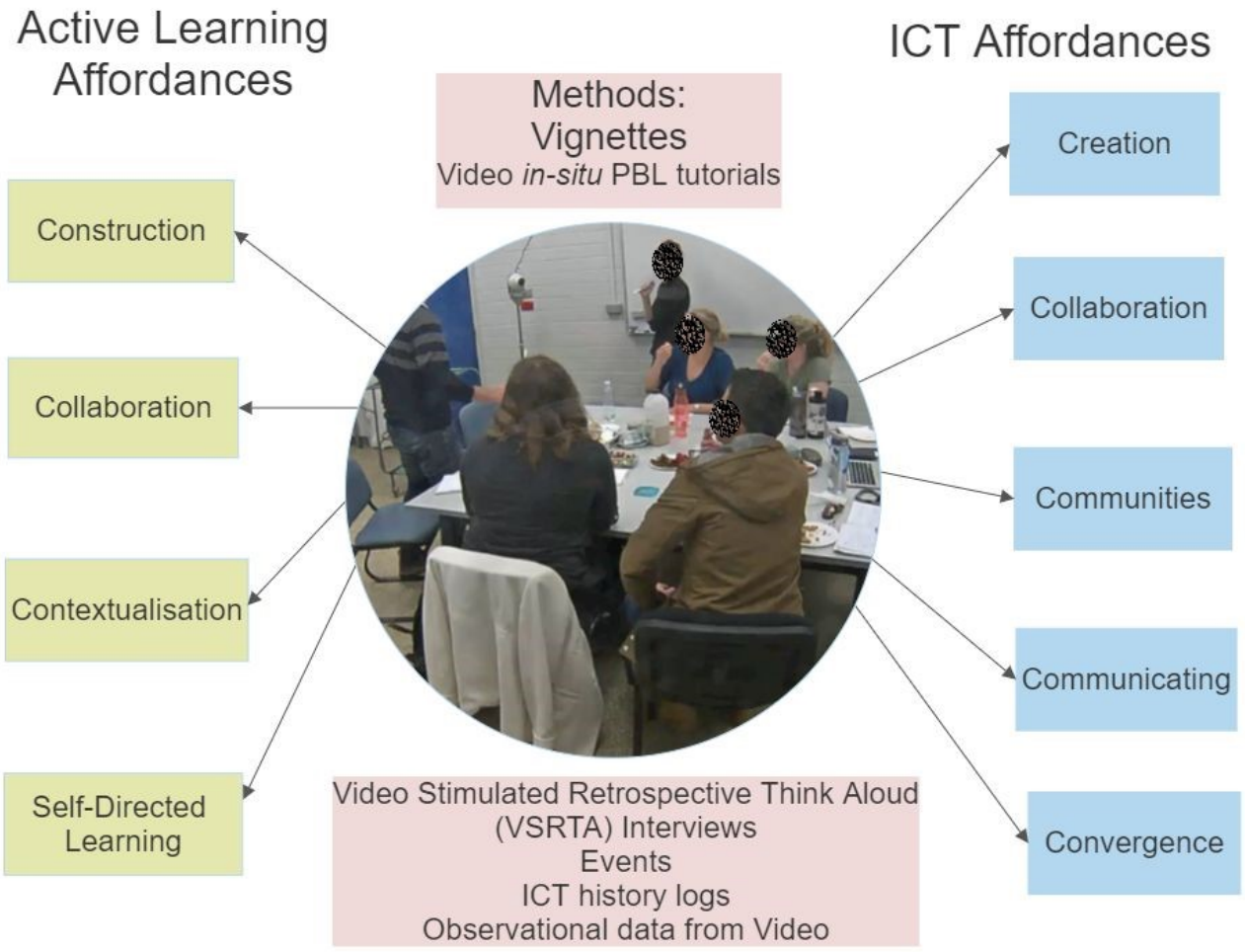

Figure 4-4 Data sources linked with the ICT affordances and the AL affordances and the methods.

4.8.2 Initial review of data

The initial review of the data consisted of viewing all the videoed PBL sessions from the four camcorders, documenting and analysing them to form field notes of discussions, key learning prompts, interactions with ICT, and peers. These field notes were recorded and included my initial observations to identify potential 'events' during which students interacted with ICT. After the completion of the PBL cycle, students provided their ICT history logs. The ICT history logs formed a critical component of the data gathered as they objectively documented the individual students' online times, websites visited, ICT collaborations formed. I compared the information in the ICT history logs with my observations of their face-to-face collaborations. All these activities were matched in time on the CAE ™ recording program. Hence, I matched the time of ICT interactions, the ICT history log with my observational data. Four camcorder views of the PBL were instrumental in determining these 'events of interest.' These consisted of identified learning opportunities or other distracting stimuli that prompted the student to seek ICT during the PBL. The videos from the four camera angles helped identify ICT activity on laptop screens, smartphones, and tablets of all students.

Additionally, they allowed me to identify the degree of face-to-face engagement with the PBL group to

determine the level of collaboration and co-construction of knowledge. The initial review of data was completed between 2 hours to 3 days after completing the report-back PBL session. This component was critical to set up for the interviews.

4.8.3 Interview transcriptions

All interviews were de-identified and verbatim transcribed, a confidential professional transcriber [Appendix C], before being uploaded to NVivo 12 Pro ™, a qualitative textual, video, and pictorial data analysis software. Initial thematic analysis identified basic themes and recorded them. These themes were organised according to the theoretical framework overlayed with the five ICT affordances (creating, communicating, collaborative, convergence, and communities) and the three AL tenets (constructive, contextual, and collaborative learning). Using the lens of the conceptual framework, the students' subsequent ICT effectivities were determined and analysed as to whether their use of ICT affordances leads to better or poorer learning. Other themes identified were matched with the students' learning approaches associated with their thoughts on how they learn.

4.8.4 Event characterisation

Each 'event' of high student ICT device engagement was identified and characterised by reviewing and documenting all four camera angles that were time-matched with the group's face-to-face activities and the PBL processes. Time stamping was a critical method to align all the data points to reflect the same point in time. I transcribed the group discussions before, during, and after the 'event' for comprehensiveness and 'event' contextualisation. Of particular contextual importance was what initiated the 'event', how the students responded, and the associated collaborative interactions, discussions, other ICT interactions of other students in group and board work. This information was used to re-familiarise the students back into the PBL tutorial setting before showing them the videoed segment during the VSRTA interviews. All VSRTA interviews were verbatim transcribed and textual analysed using NVivo Pro 12 ™.

4.8.5 Vignettes

Descriptive vignettes based on events that included the ICT history logs provided additional data to gain insights into the students' thinking. These VSRTA interviews were verbatim transcribed and were used to write descriptive vignettes that matched, through time stamping, with the NVivo thematic analyses of VSRTA's, CAE™ and written field notes, ICT logs, board work, and the event characterisation transcription. Included in these vignettes were the additional information and insights from these ICT history logs. I ran the same searches as per these logs, using students' keywords, and I navigated to the same websites to assess and review the content. The aim was to judge the calibre and relevance of the information sought. Additionally, I checked the recorded PBL to specifically look for how the information was shared, such as reading out directly from the website or if they did share the information with their group. The aim was to assess the degree to which the ICT information found was shared with and contributed to the groups' co-construction of the groups' shared understanding and knowledge.

4.8.6 Review of the research objectives

Table 3 contextualises the research objectives with specific research questions and align them to the overall research methods as presented. This research was not linear. The methods described formed my laboratory (the student learning environment). I aligned my multiple lenses to interpret this complex environment by viewing and understanding the student perspectives of ICT on their learning behaviours. Therefore, I re-convened the research objectives in the discussion and conclusion. Thus I gained an understanding of the phenomenon through a cognitivist intepretivistic frame of reference.

Therefore, the following result chapters address an incremental increase in depth to which all research objectives were investigated. Commencing from a superficial survey to in-depth VSRTA triangulated with student ICT history logs, to probe the students' effectivities to align ICT affordances with AL affordances for learning according to the research objective.

Table 3 Research objectives with research questions and research methods employed.

<table>
<tr><th>Research objective 1</th><th>Research Questions</th><th>Method</th></tr>
<tr><td rowspan="3">To understand the informal ICT affordance-seeking behaviour and subsequent student effectivities for learning during formal AL tutorials.</td><td>i. Are typical PBL groups routinely using informal ICT affordances to supplement formal PBL tutorials?

ii. At what stages during the PBL process are students seeking informal ICT affordances?

iii. What sites are students navigating to during PBL tutorials?</td><td>Tutorials were videoed then transcribed for thematic analysis using NVivo 12 pro. All interactions with ICT devices, peers and whiteboards were noted in a field notebook for subsequent individual think-aloud interviews. All data was uploaded to Nvivo. Events were identified that represented high ICT engagement.

Students were asked to record their history of internet usage during PBL sessions.

Ethics approvals were obtained from SBREC and the School of Medicine evaluation committee.

All consents from students and tutors in PBL groups</td></tr>
<tr><td colspan="2">Analyses</td></tr>
<tr><td colspan="2">Analysis - This involved transcribing VSRTA interviews with students who have participated based on identified events. I determined the selection of events when students had high ICT engagement. These points in time were then triangulated with the field notes, peer-to-peer interactions and whiteboard use. This information formed the basis for the video-stimulated-retrospective-think-aloud interviews.

The seven jump method was used to identify PBL stages

Particular attention was related to metacognitive strategies [no metacognitive scales were used] to address the active learning trigger of not knowing and comparing and contrasting to just-in-time information.</td></tr>
</table>

Research objective 2	Research Questions	Method
To explore the level of alignment between the formal AL tenets with the students' abilities (effectivities) to manipulate their ICT affordances to benefit learning.	i. What is the level of face-to-face collaborative interactions during PBL compare with level of ICT affordances usage during PBL sessions? ii. How is information being shared during PBL? Compare ICT information and students activating prior knowledge and independent research between tutorials. iii. Are students collectively working through information? a. Communication b. Collaboration c. Knowledge creation/construction d. Contextualisation of information **e.** Convergence	Tutorials were videoed then transcribed for thematic analysis using NVivo 12 pro. All interactions with ICT devices, peers and whiteboard noted for subsequent individual think-aloud interviews. Students were asked to record their history of internet usage during PBL sessions. The group tutor was interviewed to determine if the research room impacted the normal PBL tutorial function.
	Analyses	
	Analysis - This involved transcribing VSRTA interviews with students who have participated.	
Research objective 3	**Research Questions**	**Method**
To gauge the interaction of and student dependency on ICT affordances during the AL process and the subsequent impact of these on students' cognitive engagement.	i. Are students relying on ICT affordances for cognitive help throughout PBL? Just in time information or any time information. ii. Are lower-order cognitive skills of remembering, understanding, and applying occurring and at what PBL stage? iii. Are higher-order cognitive skills of analysis, evaluation (reflection) and creation of knowledge occurring during face-to-face group time, ICT interaction, or between tutorials? iv. Are different ICT sites sought during low versus high cognitive times during PBL tutorials? **v.** How are students assessing the trustworthiness and relevance of informal ICT information?	Recorded tutorials were used for VSRTA individual interviews. Students were asked to record their history of internet usage during PBL sessions.
	Analyses	
	Analysis - This will involve transcribing think-aloud interviews with students who have participated. Cognition: Blooms cognitive skills Just-in-time: ICT judgement: Information Problem Solving evaluation	
Research objective 4	**Research Questions**	**Method**
To evaluate the impact of	i. Are typical PBL groups routinely	Tutorials were videoed then transcribed for analysed

<table>
<tr><td rowspan="3">informal ICT affordances on cognitive load regarding the individual student and the group's information processing system.</td><td>using informal ICT affordances to supplement formal PBL tutorial?

ii. At what stages during the PBL process are students seeking informal ICT affordances?

iii. What sites are students navigating to during PBL tutorials?</td><td>using NVivo 12 pro. All interactions with ICT devices, peers and whiteboards to be noted for subsequent individual think-aloud interviews.

Students were asked to record their history of internet usage during PBL sessions.

The Tutor interview question of the impact of my research cameras were also considered.</td></tr>
<tr><td colspan="2">Analyses</td></tr>
<tr><td colspan="2">Analysis - Involve transcribing think-aloud interviews with students who have participated.

This involved documenting during the video recall think-aloud interviews and individual study habits and patterns</td></tr>
<tr><td>Research objective 5</td><td>Research Questions</td><td>Method</td></tr>
<tr><td rowspan="3">To explore the overall influence ICT affordances have on the students' learning strategies and ICT's impact on the development of metacognitive strategies for self-directed learning and lifelong learning essential to AL methods.</td><td>i. What learning strategies are students utilising across the PBL process?

ii. Do ICT affordances accessed during PBL or students who anticipate access after tutorial impact on the willingness to participate during the tutorial?</td><td>Tutorials were videoed then transcribed for analysis by using NVivo 12 pro. All interactions with ICT devices, peers and whiteboard were noted for subsequent individual think-aloud interviews.

Students recorded their history of internet usage during PBL sessions.</td></tr>
<tr><td colspan="2">Analyses</td></tr>
<tr><td colspan="2">Analysis - Involved transcribing think-aloud interviews with students who have participated.

Metacognition strategies identified during interviews. No formal validated metacognitive scales were sought as this was beyond the scope of this research.</td></tr>
</table>

5 RESULTS CHAPTER

5.1 Introduction to Results Chapters 5, 6 &7.

The results I will present in the next three chapters consist of data from a survey, direct observations, interviews, and student Information Communication Technology (ICT) history logs. The data have been aligned and triangulated to address the overarching research objective of this study, namely, to understand how students are utilising and learning when accessing ICT affordances during their formal Active Learning (AL) tutorials. As such, large volumes of qualitative data were generated from multiple sources that were then analysed according to the ICT and AL affordances in the context of chapter 3 theoretical framework of learning. In order to make sense of and present this diverse but interconnected information, I have chosen to present the results in three consecutive chapters. By doing so, I seek to logically set out a linear format in which each chapter builds upon the previous one(s), leading to a comprehensive analysis of how informal ICT and formal AL affordances align or misalign with respect to effective learning. Figure 5-1 pictorially represents this organisation and the flow of the result chapters with the inherent questions to be addressed.

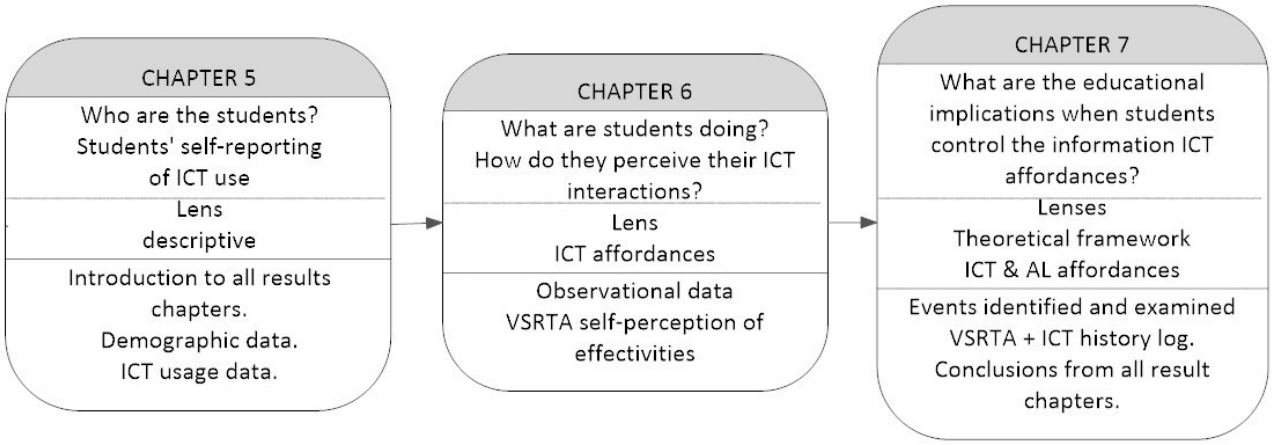

Figure 5-1 Overview of organisation of the results chapters.

Chapter 5 will introduce the first-year GEMD student cohort to gain an overview of 'who the students are' by describing their background and generic ICT uses. To investigate this, I developed a short voluntary online survey (Chapter 4) that provided me with demographic information and background information about the students' self-reporting on their ICT usage during an average university week and the formal AL tutorials. The overall rationale was to obtain a general overview of the student cohort characteristics and how they perceived their own routine ICT usage. Therefore, this chapter consists of descriptive information from the online survey about the study cohort that is used to supplement the qualitative information of the subsequent chapters.

Chapter 6 explores 'what the students are doing' and 'how they apply their ICT know-how to navigate

using ICT affordances in their formal AL environment' and which rationales they have for this. Thus, I explore the students' perceived effectivities. For clarity, I have divided this chapter into two sections. The first section presents the observational data from all four video cameras that recorded different views of the AL group's interactions at the same point in time. Using four different camera perspectives provided me with an overview of the student's interactions with their ICT device(s), and I could generally view the ICT-device screen switching and activity. First, all interactions students had with their ICT device(s) and resources of choice during both the problem-analysis and report-back phase tutorials were documented. This information highlights the learning environment that the students routinely set up and controlled during the AL tutorials. Second, 23 students from the observed PBL sessions participated in a Video Stimulated Retrospective Think Aloud (VSRTA) interview. These interviews explored the salient events of when these students interacted with their ICT device(s) and with their AL group as identified through the video observations. Short video segments were played to each student to stimulate their thinking that aimed to prompt them to retrospectively describe the reasoning behind their choices to engage with ICT at those moments. The aim was to identify and understand their effectivities from the students' perspective that they perceived to be essential whilst accessing the ICT affordances of learning, as described in Chapter 3. I interpreted these interactions through a cognitive and metacognitive lens in the context of the ICT affordance themes of collaboration, communication, communities, creating, and convergence.

In the final result chapter, chapter 7, I will describe and interpret the educational implications of how students use and control the informal ICT affordances during formal AL educational settings. For this, I have further explored the observable student behaviours and the VSRTA interviews described in chapter 6 and combined this with the extra data obtained from the ICT history logs these students provided. These ICT history logs offered a unique and valuable insight into the students' ICT actions to match their assessment of their thinking and why. As a result, rich vignettes were constructed that encompassed and triangulated all the data from the same point in time that consisted of the different sources related to the identified events. I interpreted these rich, complex data sets using the conceptual framework of learning and the ICT and AL affordance perspectives. At the end of Chapter 7, I summarise the major themes and significant results from all three results chapters in preparation for the discussion and conclusions.

5.2 Introduction Chapter 5 'The student cohort.'

Thirty-five (25%) of the 2016 first-year Graduate Entry Medical Doctorate cohort 2016 (n=140) completed the online LimeSurvey ™ survey. Figure 5-2 outlines the type of information sought from the students. It consisted of two broad areas, as explained in Chapter 4. The first sections asked general student demographic questions, and the second set of questions inquired about the ICT devices used and self-reported reasons for ICT usage. The intention is to highlight important aspects of the students' self-reporting of ICT device interactions and their perception of how they integrate ICT affordances for their learning. As such, I do not draw generalizable conclusions to the larger medical student population. Therefore, the numbers are reported 'as is', and no inferential statistics are performed.

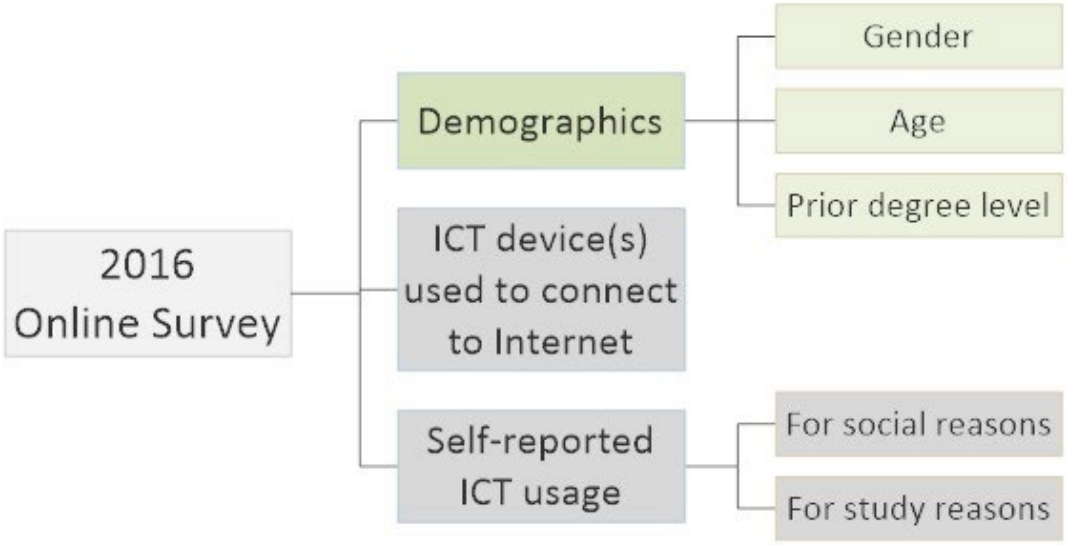

Figure 5-2 Descriptive information collected from a voluntary online survey of 2016 first-year GEMD students

5.2.1 Who are the students?

Demographics of participants

Demographic information collected included the students' gender, age, and prior degree(s) as described in Table 4. The ratio of females to males was equal. The majority of students being between 20 to 30 years of age. 83% of the students had completed a minimum of a Bachelor' degree level, in keeping with the Graduate Entry Medical Doctorate requirements for entry into medicine at the Flinders University of South Australia. Bachelor's degrees varied from science (pure or medical) or Arts or Law. The remainder of the students had completed a further study with Honour's degree, and one had completed a Masters' degree.

Table 4 Demographic information regarding the students who completed the voluntary online questionnaire regarding their ICT use.

Variable	Features	Responses (n = 35)	Percentage (%)
Gender	Female	17	48
	Male	18	52
Ages	20-24	15	42.8
	25-29	14	40
	30-34	5	14.2
	35-40	1	3
Education Highest Degree achieved before medical school	Bachelor	29	83
	Bachelor Honours [2]	5	14
	Masters	1	3
	PhD	0	0

[2] Bachelor Honours Degree is a one-year qualification taken after an undergraduate Bachelor degree. The student researches under the guidance of an academic supervisor. Assessment is by submission and pass of a written thesis, oral presentations, and other written work.

5.3 ICT device(s) used to connect to the Internet.

Students were asked to list which ICT device(s) they use to connect to the internet.

Question 5.2: Which of the following devices do you use to connect to the internet?
Check any that apply

- Computer tablet (eg ipad)
- Desktop computer at home
- Desktop computer at University
- Laptop
- Smart Phone
- Other

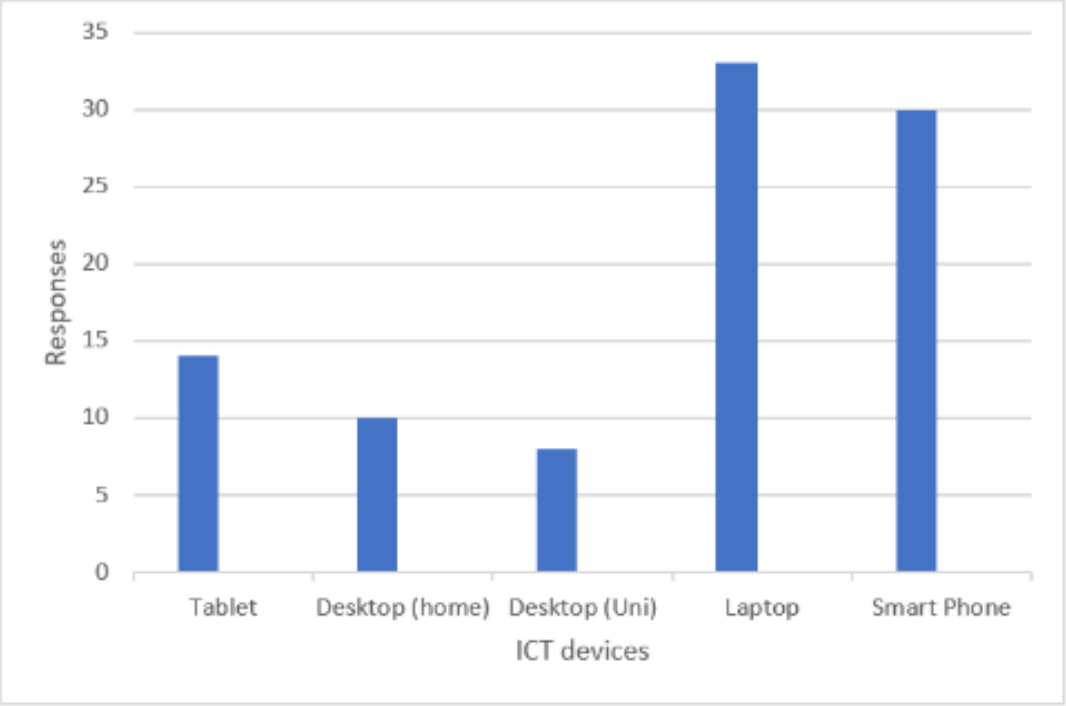

Figure 5-3 Number of ICT devices used—survey question 5.2 and results.

Students indicated that they utilised several ICT devices to connect to the internet. They predominantly preferred portable devices, such as laptops (n=33), smartphones (n=30), and tablets (n=14), for this (Figure 5-3). All students who used the university desktop computers (n=8) also used other devices. Therefore, there were no students who relied solely on university computers. From the responses, it became clear that only 9% of the students used a single device to connect to the internet routinely. The majority of students used two or more devices. 43% of students used two devices, 17% used three, and 31% used four devices to access the internet. All students owned a personal ICT device to access the internet. Further insights into how students incorporate and juggle multiple devices will be explored in

conjunction with the other data sources, and it will be discussed in the following results chapters.

5.4 Students' ICT access

The next question addressed students' reasons for internet access during a typical university week, including their AL tutorials and associated lectures and sessions. This question asked them to consider the balance between study and personal reasons for ICT access.

Question 5.3: On a typical weekday, do you access the internet

- A great deal more for study
- Quite a bit more for study
- Somewhat more for study
- About an equal amount for study and personal reasons
- Somewhat more for personal reasons
- Quite a bit more for personal reasons
- A great deal more for personal reasons

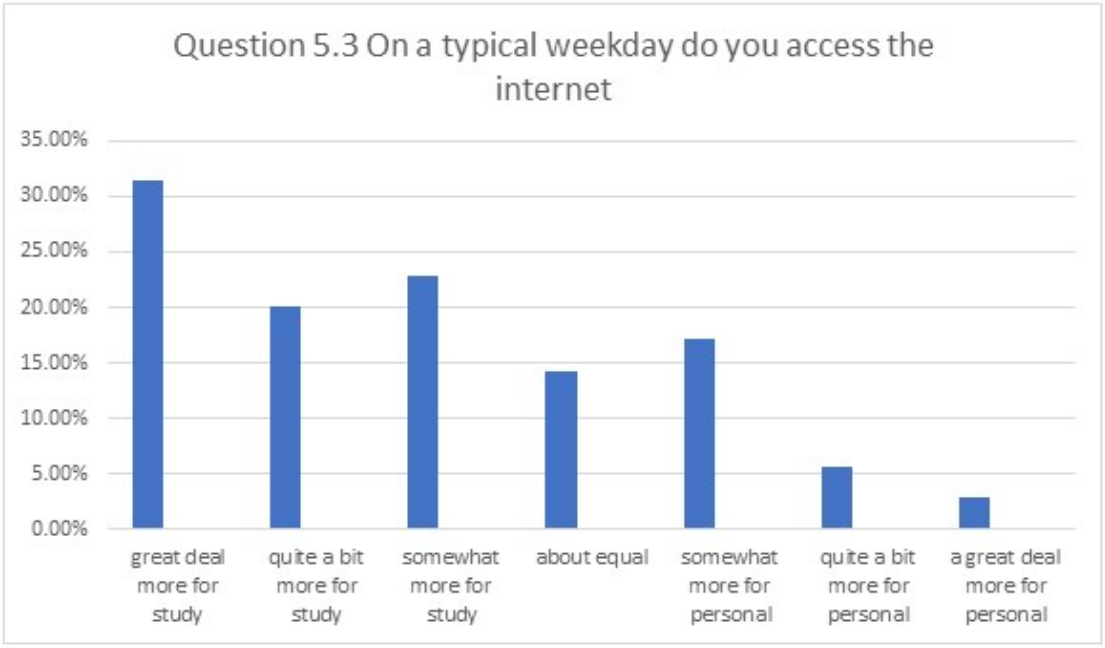

Figure 5-4 Weekday access ICT – survey question 5.3 and results in percentages.

Combining the categories of 'a great deal more for study' through to 'somewhat more for study' totals 65% of students who indicated using ICT more for study than for personal use during their university week. 15% reported they use ICT equally for both study and personal. The remaining 22% reported using it more for personal (Figure 5-4). Under the caveat, self-reporting may be vulnerable to perception bias, but the data indicate that students perceived they predominantly use ICT for their learning during the university week. This will be explored further in the following results chapters.

5.5 ICT use during formal active learning tutorial?

Next, students were asked to reflect on their ICT usage but now more specifically on their reasons for accessing the Internet during their PBL tutorials.

Question 5.4 During PBL do you access your smart phone/computer to
Check any that apply

- ☐ check social media, emails
- ☐ check my information before I share it
- ☐ check information presented by other students or tutor
- ☐ search for information to help PBL group understanding
- ☐ search for ideas related to the problem
- ☐ search for new information for PBL group
- ☐ Other _____

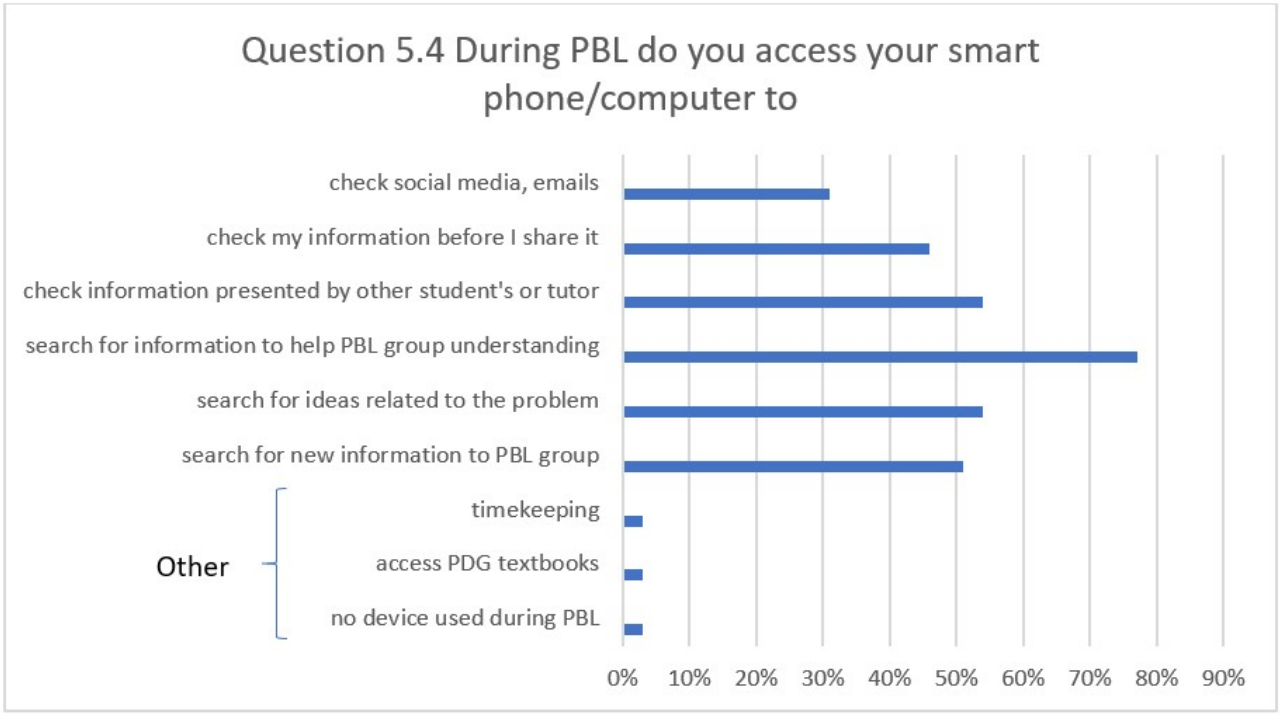

Figure 5-5 Why students accessed ICT during PBL tutorials - survey question 5.4 and results.

Most students reported using ICT for PBL tutorial processes. Students either used ICT to check their own knowledge (46%) or that of the other students or the tutor (54%) as shown in Figure 5-5. Such use likely does not contribute much to the PBL learning process as it entails just-in-time fact-checking. This may reduce the students' individual levels of uncertainty rather than develop their own or the group's AL. The amelioration or reduction of uncertainty through engaging with ICT affordances would potentially run

counter to the AL tenets. One of these holds that the trigger of uncertainty drives group discussions, which in turn leads to group knowledge. This too, will be discussed further in the next chapters, especially in chapter 7.

Nevertheless, most ICT uses were attributed to supporting the PBL group process, such as searching for new ideas to add to the discussion (51%) or searching for information to help group understanding (78%). Against this background of students focusing on the PBL, 31% of students indicated that they accessed social media during the PBL session. However, it was not clear whether this was communication related to the PBL case or totally unrelated. Whether these students were interspersing their PBL searches online with their non-related personal activities online is explored further in the VSRTA interviews.

A small percentage (3%) of students stated they accessed their ICT device to search PDF textbooks for information during the PBL tutorial. Whilst only a small percentage of students alluded to use of PDF textbooks in the survey, the additional data of the VSRTA revealed that the practice of searching, collecting, and storing of PDF textbooks was more widespread.

5.6 Online study groups

This question was designed to determine the prevalence of student's using their social ICT know-how in their learning environment.

Question 5.5 Do you participate in online study groups? -tick as many as relevant
Check any that apply

- ☐ Yes, I select my own group members from anywhere online
- ☐ Yes, our PBL group has formed one
- ☐ Yes, I'm a member of a group outside of my PBL group but in the same course
- ☐ Yes, set up by others and actively participate
- ☐ Yes, but only because others in the group set it up
- ☐ No, I prefer face to face groups
- ☐ Other _____

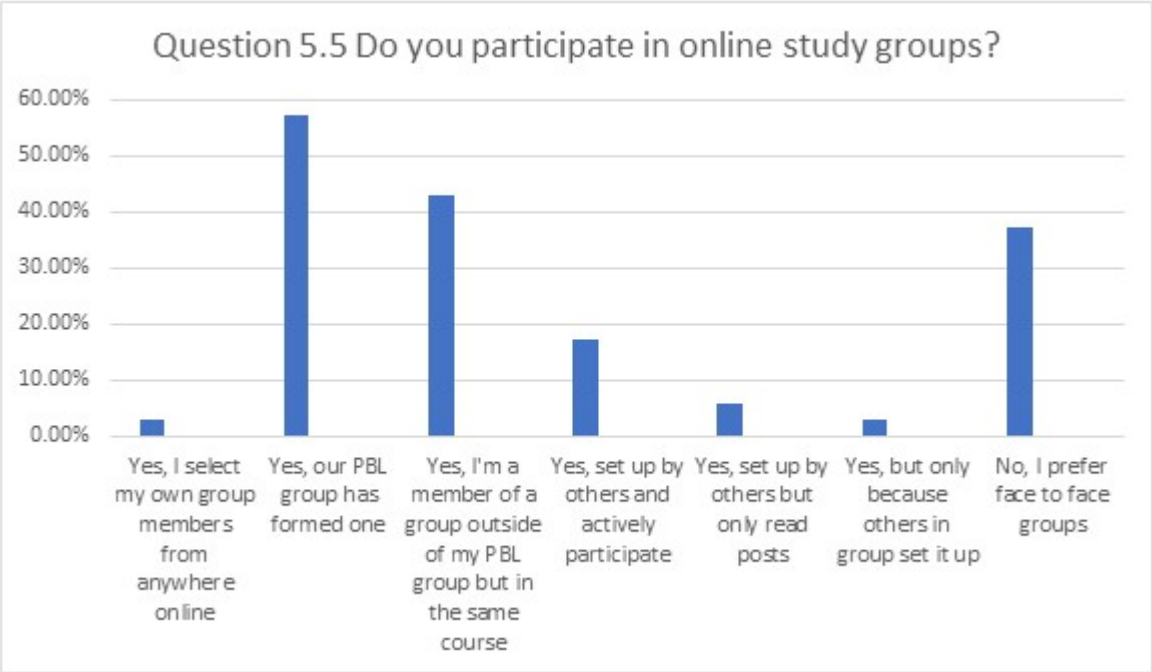

Figure 5-6 Online study groups(s) formed – survey question 5.5 and results. Students ticked as many as relevant

All PBL groups routinely created online collaborative spaces to provide potential collaborative opportunities during PBL and self-directed study times. Tutors were not invited to these online collaboratives. Figure 5-6 shows that students participated in three types of online groups. The first and most often used is with their current PBL group. The second group consist of self-selected peers from within their year level and or people from outside their year level or university. The latter essentially meant forming groups from anywhere, online. Memberships to these groups were not mutually exclusive; students often belong to multiple online study groups. Despite belonging to these groups only, 17% reported that they actively participated in them. Also, 37% of students stated they preferred face-to-face study groups over online groups. This finding of belonging to multiple online collaboratives was explored further during the VSRTA.

5.7 ICT use for a hypothetical problem, question, or unknown.

The importance students placed on accessing ICT affordances during the formal AL tutorial was investigated through a series of questions. These questions asked what students would do when they were, hypothetically, confronted with a problem, a question, or an unknown. Students' potential metacognitive strategies were listed as options as described in figure 5.7. In an educational context, a 'problem' describes a matter or situation proposed for academic discussion; hence, it needs to be resolved or understood. Therefore, defined as *a thing that is difficult to deal with or to understand* ("Problem," 2021). The problem is used to contextualise, and motivate the student in PBL (Azer et al., 2012; Barrows & Tamblyn, 1980; Hmelo-Silver, 2004; Schmidt, 1983). A 'question' describes *a sentence, phrase or word that asks for information* ("Question," 2021) and which is key to stimulate collaborative discussions and increase participation in the PBL (Barrows, 1983; Dahlgren & Öberg, 2001; Graesser &

Person, 1994). An ‘unknown’ describes *not known or identified ("Unknown," 2021)*, and, as such, creates a cognitive conflict that underpins and drives the development of learning issues based upon what they know and does not know for self-study (Blumberg et al., 1990; Van den Hurk, Wolfhagen, Dolmans, & Van der Vleuten, 1999).

Question 5.6, 5.7 and 5.8 (combined)

When presented with a (5.6) problem, (5.7) question or (5.8) unknown do you immediately

	Yes	Likely	No
Reach for your ICT device	☐	☐	☐
Think key words for search engine	☐	☐	☐
Wait until you have ICT access to check response	☐	☐	☐
Have a go at working through	☐	☐	☐
Ask someone	☐	☐	☐
Other	_____		

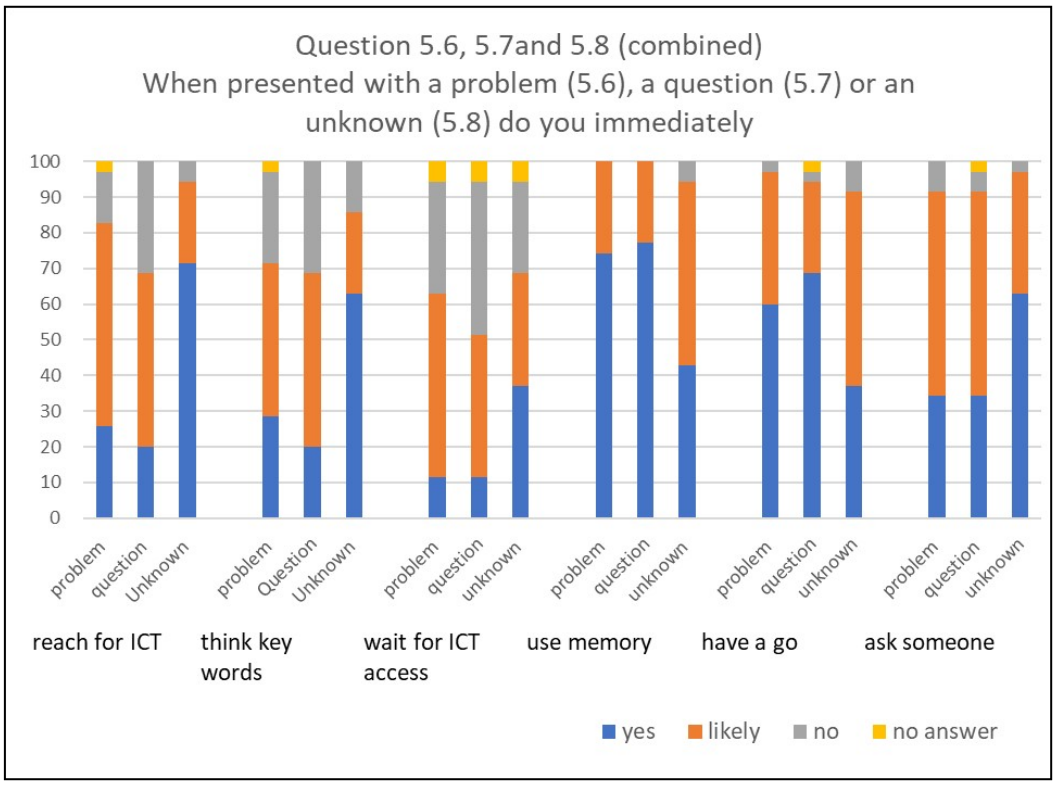

Figure 5-7 Metacognitive responses when confronted with a problem, a question, or an unknown – survey question 5.6, 5.7, 5.8. All responses are percentages.

When students were asked what their immediate response would be when confronted with a problem or question, as per Figure 5.7, 74% stated they would engage their biological memory to think of possibilities, with 77% saying that they were likely to do so. Many acknowledged they would or likely would attempt “having a go” at working through the problem or question. Interestingly, far fewer students in the problem (25%) and question (20%) category stated they would reach for their ICT device for answers. In contrast, 57% were ‘likely’ to reach for their ICT device with a problem, with 48% likely to respond to a question. This demonstrates that students also contemplated and made conscious

decisions about whether or not to reach for their ICT device for help despite activating their prior knowledge during problem-solving and questioning. These decision-making episodes are not trivial. They are likely to add extraneous cognitive load and potentially lead to a decrease in cognitive capacity to problem solve or consider questions in the course of the AL process.

Interestingly, the inverse evident when students were responding to an 'unknown.' In this situation, 71% answered they would predominantly reach for their ICT devices with 63% considering keywords to navigate their ICT device. The remaining 23% responding they were "likely" to think ICT and keywords simultaneously. Nearly all the students intended to use or were considering using ICT as their metacognitive strategy when confronted with an 'unknown.' Interestingly, a third of these students said they definitely "would wait" until they had internet access, with another third saying they were "likely to wait" until they had ICT access to resolve the unknown. But it is important to note that the traditional method of resolving an unknown by asking someone was also prevalent. Also, 62% of students said they would ask someone or 34% said they would likely to ask someone to help resolve an unknown.

Essentially, students sought external memory stores to resolve an unknown and sought internal biological memories to address problems and questions. ICT enables access to rapid, private, and extensive information sources at our fingertips to turn to for answers anytime and anywhere. This series of questions highlighted students' metacognitive strategies that I will describe further in the subsequent result chapters.

5.8 Students' view of the impact of ICT affordances.

The final question relates to students' perceptions of the impact ICT information sourced during the PBL tutorial has on the PBL co-construction process on individual and group knowledge.

Question 5.9 Does accessing the internet information during PBL by you or by others in the group

Check any that apply

	By me		By others	
	Yes	No	Yes	No
• Improve understanding	☐	☐	☐	☐
• Increase group discussion	☐	☐	☐	☐
• Increase board work	☐	☐	☐	☐
• Decrease board work	☐	☐	☐	☐
• Decrease willingness to discuss	☐	☐	☐	☐
• Decrease understanding	☐	☐	☐	☐
• Make it a learning issue	☐	☐	☐	☐

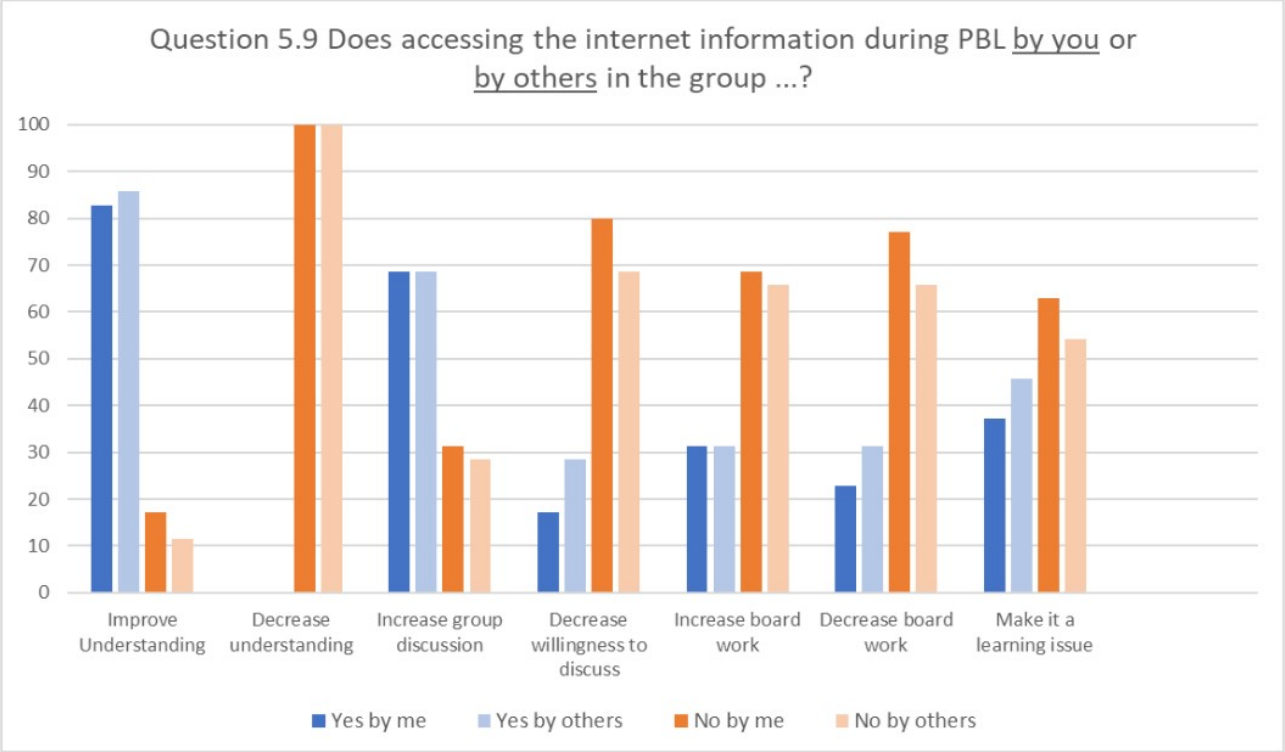

Figure 5-8 Students' use of ICT information assessed during AL tutorial. Survey question 5.9 and responses. The order of the alternative responses are adjusted for clear visualisation of the responses

Students' perception of the importance of ICT access and use during PBL demonstrated the responses for whether self or others sourced information did not influence the students' perception as a significant factor in the PBL process. Figure 5.8 reflects the paired responses from question 5.9. 83 % to 85% of students agree that ICT information accessed during the PBL increases their understanding. The inverse question of whether ICT information would decrease understanding was answered with 'no' by 100%. Therefore, most students perceived that accessing ICT by either themselves or others during the PBL tutorial increases their understanding of the tutorial, and the remaining 17 – 15% were therefore neutral. Additionally, there was no perception by self or others that ICT impacted the willingness to discuss.

It was difficult to assess the students' perception of the board work. One-third of students felt it increased board work, while two-thirds stated it did not decrease board work. Overall, students said there was no increase in board work, yet ICT decreased board work. Therefore, these results indicate that the students might not have a measure of board work with or without ICT being present.

'Make it a learning issue' was also interesting. Students were slightly more inclined to use the ICT information shared by others during the PBL group in making a learning issue than when the information was sourced by themself. The resolution of finding information by themself could provide these students with a better sense of knowing rather than relying on other students in the group interpretation of ICT information. This raises the issue of trust and will be explored in chapter 6.

5.9 Chapter 5 summary

This chapter reported the online survey results that 25% of the 2016 first-year GEMD students at The Flinders University participated in. The first section reports demographic information that showed equal gender distribution, and students were of similar academic level. The second part focused on the students' self-reflections on the role of their ICT device use at university. Students assessed the impact their, and others' ICT access has on the PBL tutorial process and, as such, revealed several findings that are summarised here.

Students consistently sought ICT affordances to reduce unknows about their own and others' knowledge in the PBL groups. Thus, by solving unknowns quickly indicates ICT affordances are potentially truncating the AL-intended role of unknowns.

Inherent in resolving or reducing unknowns is that ICT availability leads students not to trust their own knowledge and feel the need to check their knowledge before sharing. Moreover, they are inclined not to trust what others in the group are sharing. They use ICT to judge the accuracy and relevance of information and, in doing so are relinquishing critical thinking skills of questioning and interpreting to the internet.

Students are routinely accessing the internet on multiple ICT devices and, additionally, are members of various social media groups, all about their learning. Therefore, students are juggling several ICT devices and searching online, hence are attempting to multi-task. Even more importantly, they seem to be 'multi-attentioning' whereby they repeatedly divide their attention between the AL physical group process and their ICT multiple uses.

Most students reported they used ICT affordances to support the PBL process through developing their own digital library. They used the ICT affordance of convergence. By 'convergence,' I mean that they sourced, selected, collated, and stored information for access anytime irrespective of where they physically are and any ICT device available. The use of and collection of PDF textbooks was alluded to in these survey responses.

Students metacognitively thought of and reached for their ICT device when confronted with an unknown. Whereas when students were asked a question or problem, they predominantly sought their biological memories first. However, there was a blurring of these results as many students answered they were likely to use ICT affordances in these situations. It suggests that when students encounter a situation that requires memory or cognitive effort, they feel comfortable with a more or less two-pronged approach of using biological memory and ICT.

As discussed in the literature review, online surveys undertaken by the students are routinely used to obtain quantitative data for statistical analysis to determine ICT benefits for students' learning. In my study, I have used the online survey as a descriptive background for the in-depth educational assessment of the impact ICT has on students AL. Therefore, the findings of this survey will be

integrated with the results of the other analyses to add meaning.

In summary, I found this albeit small survey has supported the literature in that the students believe their use of ICT is appropriate and supports their learning. Therefore, chapter 6 will now delve deeper into using video-stimulates-retrospective-think-aloud interviews to explore what students think when seeking ICT affordances during AL tutorials.

6 RESULTS CHAPTER

6.1 Introduction

Chapter 5, subjectively reported using a small survey tool, that students assessed ICT as a valuable learning tool. However, in Chapter 6, I seek a deeper understanding of the student effectivities, ICT affordances by including observational data and the interpretation of the video-stimulated-retrospective-think-loud (VSRTA) interviews from the videoed PBL tutorials. In part 1, I briefly review the PBL tutor assessment as to whether my research procedure impacted the normal flow and dynamics of the routine PBL tutorial. Part 2 will address student interactions with their Information Communication Technology (ICT) device(s) during the problem-analysis and report-back phases of the two PBL tutorials recorded. This part is purely a collation of the number of ICT devices and other resources the students used during these recorded tutorials. The final piece, part 3, explores students' recollection of why they sought to use their ICT device(s) at that point in time. The student/ICT device interactions formed the basis for identified 'events' replayed to the student during VSRTA interviews. I asked them to think aloud and describe their thoughts and reasons that led them to use their ICT device. Additional information from the student ICT interaction and student-to-student and group interactions during the tutorials were aligned and used to contextualise the events. Subsequently, the students' ability to capitalise on the available ICT affordances for learning (their effectivities) are presented and explored by applying my theoretical learning framework to assess if these ICT-student interactions are most likely to promote or hamper AL. The final section will contain a summary of the salient findings in preparation for chapter 7. Figure 6.1 situates the flow of this chapter.

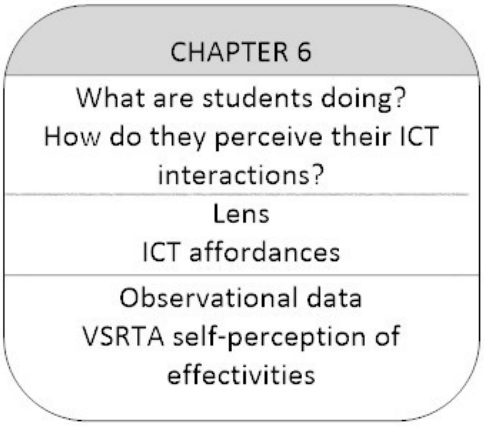

Figure 6-1 Chapter 6 overview of data and analyses.

6.2 The impact of research procedure on PBL dynamics

The research procedure focused on reducing interference from me, the researcher, while collecting the PBL tutorial videos. I was not in the tutorial room for the tutorials. Students were also familiar with the

PBL tutorial room as they are routinely video recorded during clinical encounters for their reflection and assessment. The only question included in this thesis, from the tutor interviews, was to evaluate the impact of the research environment on the routine functioning of the PBL tutorials. Tutors predominately stated that the research procedure did not impact the PBL groups. Overall, my research was not influencing the PBL routine functioning that would likely affect the data's veracity.

6.3 Observation of ICT devices interaction during AL

In this section, I present my observations to identify the number of ICT device(s) and learning resources (hard copy textbooks, notebooks) students interacted with during the researched PBL tutorials. As such, I was able to gain more information about students' self-reported multiple ICT device usages, as described in chapter 5. The observed cohort consisted of 77 students divided into 10 PBL groups (55% of the first-year cohort). In addition, I analysed all videos for student interaction with ICT devices and other resources. But in this section, only the numbers and types of ICT devices used are presented.

In PBL, each case or problem is dealt with in two phases: one problem-analysis phase and one report-back phase. In the problem-analysis phase, students are introduced sequentially to the PBL case. It was during this problem-analysis phase that some students had technical problems connecting to the university internet. Students focused their attention on manipulating their mobile data from their smartphones (hot spot) to connect it to their laptops or tablets to gain internet access or directly use their smartphones.

I have used proportional Venn diagrams to present these results of the number of ICT devices and resources students used during the problem-analysis and report-back tutorials. Figure 6.2 shows the students' device use during the *problem-analysis* tutorial, and Figure 6.3 shows this during the *report-back* tutorial. These results confirm the self-reported multiple ICT device usages from the chapter 5 survey. However, students are also using traditional learning resources such as paper, pen, and hardcopy book resources all at the same time. In fact, some students were juggling three different informal learning resources and engaging with the formal PBL group and the formal PBL content presented to the group on the tutorial room computer screen. This formal content concerns the faculty/university content sanctioned and delivered on the learning management system (LMS). In contrast, the informal content reflects the students' information they source to supplement their learning during the tutorial by accessing their ICT device(s) or analogue resources.

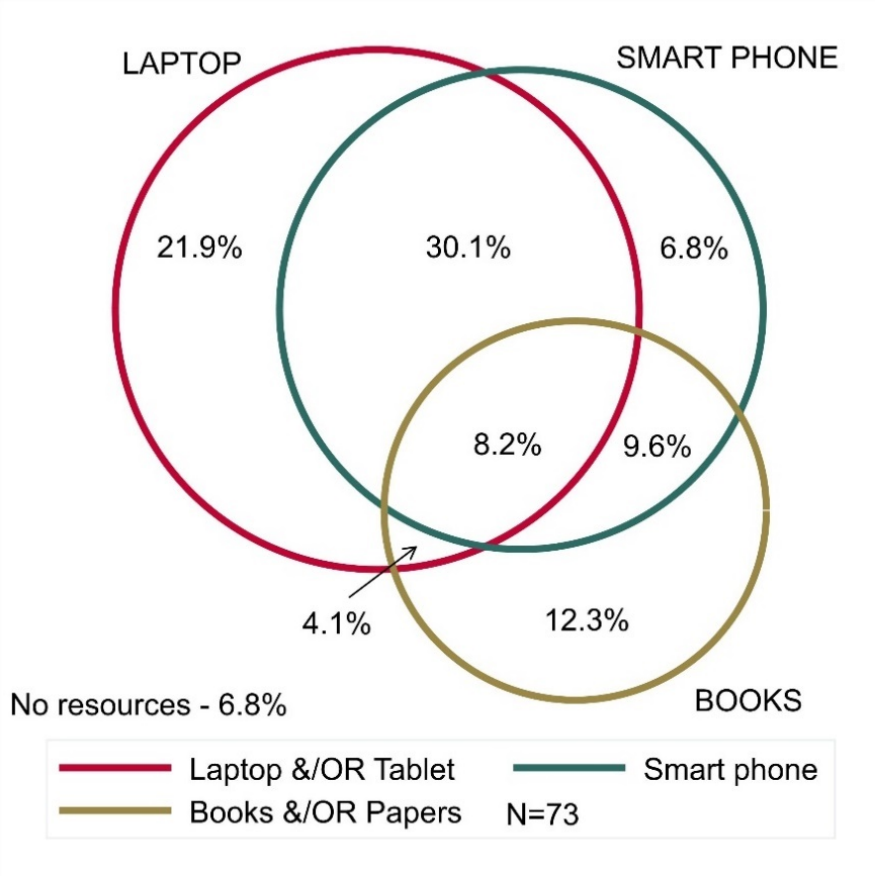

Figure 6-2 Number of resources students used during PBL problem-analysis tutorial. Proportional Venn diagram -10 PBL groups.

Figure 6.2 highlights that while the majority used at least one of their ICT devices, 6.8% had no learning resources (no ICT device, textbook, or notebook), and 12.3% had only textbooks or paper resources. The focus of my study was on student and ICT interactions during PBL tutorials. Therefore, students who did not use ICT devices were excluded. The majority of students utilised one or several ICT devices during the problem-analysis phase, with 8.2% using all three informal resources (laptops, smartphones, and books/paper resources). Smartphones, in combination with laptop/tablet, were employed by 30.1%. However, this number may be an over-representation of the usual situation, because as stated before - some students could not access the Internet via the university internet and decided to hot-spot to ensure internet access. 21.9% of students relied solely on their laptop/tablet. Although all formal PBL material was displayed online via the tutorial room computer and screen, most students still decided to connect to the Internet.

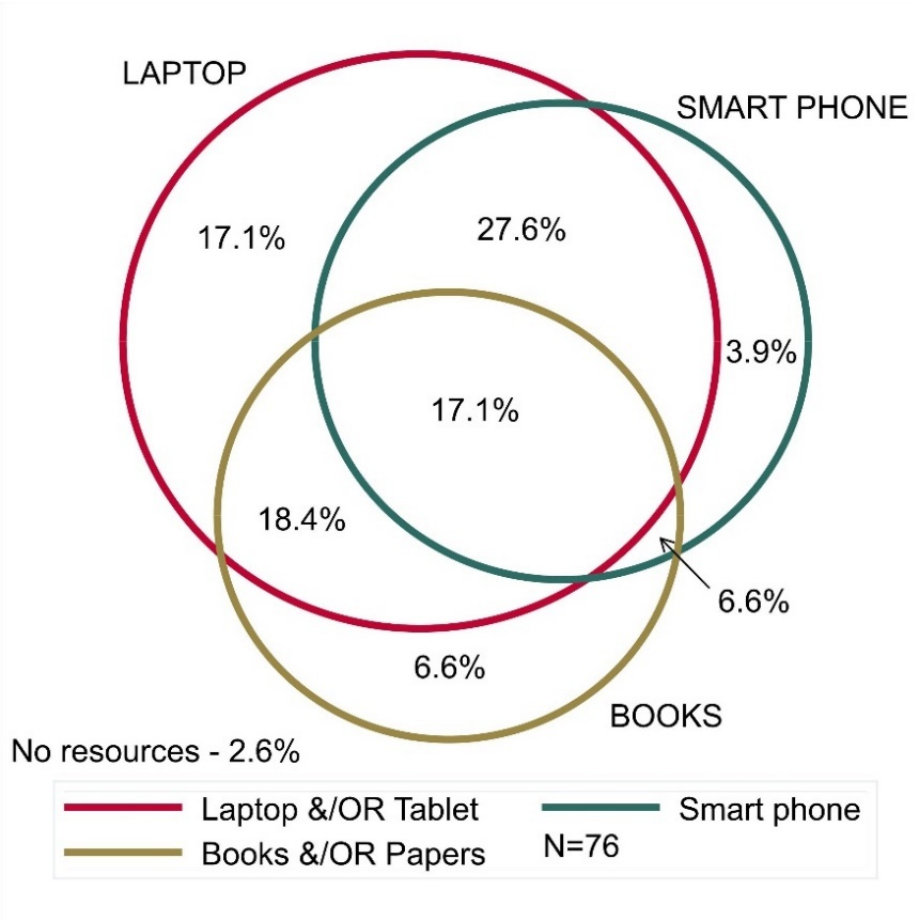

Figure 6-3 Number of resources students used during PBL report-back tutorial. Proportional Venn diagram -10 PBL groups.

The second PBL tutorial is where students report-back by sharing and discussing what they have learnt during their self-directed-learning (SDL) period. Their SDL period reflects the student diversity of experiences and prior knowledge that each student uses to select resources from formal and informal ICT and non-ICT information sources.

With this in mind, it was evident that more students attended the report-back phase with more resources. For example, 17.1% of students relied on laptops or tablets alone, and 3.9% relied solely on their smartphones (Figure 6.3). Additionally, the number of students using laptops/tablets in conjunction with paper resources increased over four-fold from 4.1% (Figure 6.2) during problem-analysis to 18.42% (Figure 6.3) during report back. Overall, students not using any informal resources decreased from 6.85% in the problem-analysis phase to 2.6% in the report-back phase.

Table 5 summarises the total percentages of students who had laptops/tablets (Figures 6.2 and 6.3 red circle total) in the tutorial room, which was higher during the report-back tutorial, 80.2%, compared to the problem-analysis tutorial 60.3%. There was a doubling of all three resources used from 8.22% during the problem-analysis tutorial to 17.11 % during the report-back. The smartphone usage remained constant,

but there was an increase in the use of books and paper notes during the report-back tutorial. These findings are not surprising because, as a whole, students tend to bring more self-directed learning work for presentation and discussion to the report-back tutorial on their laptop/tablet and paper.

Table 5 Differences between the resources used during the problem-analysis and report-back tutorials. The percentages from Figures 6.2 and 6.3.

	Total percentage of students who had Laptop/tablet	Total percentage of students who had Smart Phone	Total percentage of students who had Books/Paper	Total number of students who used all resources.
Problem-analysis	**60.3%**	**54.7%**	**34.2%**	**8.2%**
Report-back	**80.2%**	**55.2%**	**48.7%**	**17.1%**
Difference between Report-back & Problem-analysis	**19.9%**	**0.5%**	**14.5%**	**8.9%**

In summary, students supported their AL tutorials with up to two ICT resources plus one traditional resource (paper/books) available. They expected to have access to the internet throughout the tutorials. When students did not have access to the internet, they sought alternatives through hotspot access to the ICT device they wanted to work on. In addition to accessing and engaging with informal ICT resources, the students also engaged with the formal PBL case, recommended resources, collaborative group discussions, and the co-construction of the groups' knowledge on the shared tutorial board. So, students were attempting to manage multiple information resources during the formal AL sessions synchronously. In order to explore this complex interaction between ICT affordance, student effectivity, group dynamic, and PBL case, the VSRTA interviews provide an insight into students' cognitive processing.

6.4 Students' VSRTA: ICT device(s) seeking behaviour

6.4.1 VSRTA Participants

Twenty-three students from the above ten PBL groups consented to participate in VSRTA interviews. The group of students volunteering consisted of 61% male and 39% female from various academic backgrounds (Table 6). Previous degrees ranged from one bachelor's degree to three bachelor's degrees, with students predominantly originating from science-based degrees.

Table 6 Demographic data of students who participated in the VSRTA interviews.

Student	Gender	Previous degree(s)	Student	Gender	Previous degree(s)
G1S1	F	Bachelor Laws and BachelorCommerce	G5S4	F	Bachelor Medical Science
G1S2	M	Bachelor Arts, Bachelor Science, Bachelor Science Honours	G5S6	M	Bachelor Bio-Medical Engineering
G1S3	M	Bachelor Medical Science	G6S3	M	Bachelor Bio-Medical Science
G1S7	F	Bachelor Medical Science, Bachelor Medical Science Honours	G6S6	M	Bachelor Arts, Bachelor Education
G2S1	M	Bachelor Science, Bachelor Science Honours	G7S2	F	Bachelor Medical Science
G2S3	F	Bachelor Science	G7S7	M	Bachelor Science
G3S3	M	Bachelor Health Science	G8S3	M	Bachelor Computer Science
G4S5	F	Bachelor Bio-Medical Science	G8S6	F	Bachelor Applied Science Physiotherapy
G4S6	M	Bachelor Science	G9S2	M	Bachelor Clinical Science[3]
G4S7	M	Bachelor Science	G9S3	F	Bachelor Sociology
G5S1	M	Bachelor Medical Science	G9S4	M	Bachelor Para-Medical Science
			G10S2	F	Bachelor Medical Science

6.4.2 VSRTA and identified student effectivities, 'events', with formal and informal ICT affordances.

In this section, I present and discuss the combined observational data from the recorded PBL tutorials with the associated VSRTA interview data to better understand when and why students used their ICT

[3] Bachelor Clinical Science [undergraduate entry programme into MD]

devices. The analyses of the VSRTA interviews led to identifying recurring themes. These themes helped characterise student abilities (effectivities) to detect and capitalise on the available informal ICT and AL affordances that impact individual and group AL. Initially, I started with seeing AL tenets as the central prescriptive characteristics that define AL. But now, I have shifted to viewing them as affordances because AL environments (the PBL tutorial) provide students with a setting conducive to learning if and when they choose to engage with it. Therefore, in the remainder of this chapter, I will describe and discuss the five major themes identified from the 'events' from the PBL learning environment of ICT and AL affordances.

6.4.3 Theme 1: Student expectation of being connected during PBL tutorials.

Students expect to always have immediate access to fast, reliable Internet throughout the PBL tutorials. This expectation was evident when most students, upon entering the PBL tutorial room, automatically connected to the free university internet server in preparation for the PBL tutorial to commence. Students said it was a habit and a necessity, and thus, they were not able to make it more explicit.

> *"Just feel like I need it on just in case I need it; it's a **habit"**. (G5S4)*
>
> *"Absolutely had [internet] access". (G6S3)*

Yet, some students had problems accessing the university internet in the research tutorial room. Initially, I had assumed that all students would be able to access the internet without further issues. However, this situation provided a unique research environment that revealed behaviours that I would otherwise not have seen. It created a dilemma for many students as it exposed their dependence on the internet. Most students went to great lengths to ensure free internet access. Their resourcefulness was evident when they created internet links (hotspot) between their smartphones and computers. They decided not to waste time and rely on their smartphone directly when they required internet access and used their laptop for notes, identifying a preference for ICT devices for particular uses.

> *"I wasn't able to get internet access, but I was hotspot using the phone." (G5S6)*
>
> *"My phone has access to my 4G internet, so I use that, and that allows me to look up things [if necessary].". (G3S3)*
>
> *"I didn't have Internet on my laptop, so I was using my phone". (G2S3)*

However, some students persisted but continuously failed to connect to the university internet and became quite frustrated. They did not attempt to use alternative ways to connect despite having their smartphone present. G1S1 tried fifteen times to connect in 10 minutes during the initial problem-analysis phase of the PBL. In the interview, G1S1 admitted they became disengaged from the PBL tutorial, but they persisted nonetheless.

> *I have to admit my listening to the actual discussion in the group kind of phased out at that point because I was more just focusing on 'refresh, refresh, refresh; let's try and get this working' so you kind of have half an ear open to what's going on around you but not as much as you usually would.(G1S1)*

The rationale for persisting was that this student felt underprepared for the tutorial as they had not viewed the formal online learning material. Interestingly their persistence to gain the Internet potentially placed them even further behind by preferencing the internet connectivity important over the face-to-face PBL time in the problem-analysis tutorial.

For other students, establishing communication between their ICT devices was problematic.

> *"I was trying to hotspot my phone to the iPad and it wasn't working… wasn't working, I was trying to get onto the system, and I thought I'll just leave it." (G6S6)*

It quickly became apparent that students expected to have access to the free university internet services during PBL. If they did not quickly access the internet, they either manipulated their other ICT devices successfully or unsuccessfully or gave up. Therefore, highlighting student differences in abilities, or inabilities, to use their ICT devices to gain internet access. Essentially, students need and expect to have an internet connection at all times. This is an example of where the need for ICT affordances can interfere with the face-to-face AL affordances.

6.4.3.1 Need to be 'connected.'

Further analyses of the VSRTA transcripts identified several reasons for this 'need to be connected' during the PBL tutorials.

First, there were several personal reasons students cited that were identified that enabled them to fulfil their family or work obligations during the formal PBL session.

> *"I like to be contactable if there's – you know, once in the past, about four weeks ago, my son passed out at school." (G5S4)*

> *"Sometimes I might get texts from work or something like that and I might just quickly make sure that there's nothing urgent going on". (G8S3)*

Another reason cited was that the university required students to check their emails regularly.

> *"Particularly in this course you receive about 50 emails a day and the school (Medical school) wants us checking emails every hour". (G2S1)*

Maintaining contact with others outside of their PBL group was important for students with families and is understandable. On the other hand, though, the need to be contactable for work and checking university emails hourly raises the question of why they could not wait for 2-hours for the tutorial to finish? One student commented that because of the technology, you are contactable at all times, so why not use the available ICT affordances.

> *"…because I think it's important in our [interconnective] world to be contactable all the time because you are contactable all the time realistically". (G2S1)*

In Figures 6.1 and 6.2, I have shown that most students were contactable either by their laptops or

smartphones or both. Although they seemed to negotiate these intrusions, for example, by muting inbox alerts, they would still be aware of a new message. Nevertheless, they would briefly look and decide on a response when an email, social media post, or text arrived.

> *"My girlfriend was messaging me, and it was me telling her, Cool. I'll talk to you after the PBL". (G2S1)*

> *"Like my light will be flashing and it's a message or it's an email and I'll just look at that quickly, make a mental note about it and let it go. I don't usually reply to them at that point". (G2S3)*

These brief periods occurred throughout the PBL for most of the students. From an attentional focus perspective, regular intrusions are likely to be limiting the effectiveness of the AL process, and these short interruptions potentially disrupt thinking, listening, and engaging with the face-to-face group.

6.4.3.2 Cognitive escape

Generally, students are focused on using ICT for their PBL. However, there were instances where students used ICT as a cognitive escape from PBL. At these times, students found PBL to be tedious, and they became bored. So, they decided to take a mental break by engaging with the ICT device.

> *"I would say that I do sometimes use my phone in PBL. Sometimes I get bored in PBL" (G2S1)*

> *"I was messaging my boyfriend and that was a complete little zone out and so … It's two hours of PBL and sometimes you just zone out". (G1S7)*

> *"I think I was just on Facebook…Yes that's just me being distracted". (G7S2)*

Or as a cognitive escape from listening and participating in the group discussion.

> *"..quieter moments in PBL when I don't - what they're talking about I don't need to listen to very attentively, but if there's points where it'll come up where I don't understand something properly I'll just like stop using it and I'll listen or I'll listen and I'll type so I can remember what they said". (G2S3)*

> *"..find the reporting back can be quite repetitive and dull, because I've already covered these topics so many times throughout the week. That's why it's scrolling on my phone, that would have just been personal use of the Internet. I'm just absentmindedly, while listening to the reporting back, and listening out for key words. If I did hear something that was unfamiliar, then I would stop my personal use of the Internet, pay more attention". (G7S2)*

> *"I'd already done that LO and I'd already had a relatively good handle on the classification and I knew that the pedantics of the classification weren't really that relevant so at that point I tuned out and I was reading some news". (G8S3)*

These are examples of students seeking external cognitive escapes and who view this behaviour as a normal part of their PBL environment. They stated they could listen and quickly return their focus to the group when they heard something they did not know or were interested in. They were confident in this situation and did not perceive any problems. However, the biological information processing system has

limitations, as discussed in Chapters 2 and 3. External information is first detected, then selected by attentional focus, and then processed by working memory. Both have inherent temporal and spatial limitations. The attentional focus would be split between the several sources of information, resulting in a decreased ability to focus on any one source in detail. There would be a dilution of selecting relevant information for the working memory, limited cognitive load capacity, and reduced long-term memory activation. Therefore, when students state they can listen and, at the same time, scroll and read online, it demonstrates limited of understanding of how they learn. Yet, they continually split their attention between the face-to-face group and their ICT interactions. Essentially, there is a decrease in cognitive capacity to focus and select information and a bottleneck of information in the working memory. The students' assumptions that they could manage this situation is doubtful and will be discussed in more detail in chapter 7.

6.4.3.3 Access to free services

Students were forthcoming in expressing their desire to obtain free services from the Internet. They were discerning in what they paid for and what they did not pay for. For example, they would reject sites or applications that required payment

> *"It's free because it's through Google sites … I'm very good at finding free resources …". G10S2*

> *"Because I'm at university you can actually sign up with a university email, with like the .edu, and it will give you access to the full thing for free".G10S2*

However, some students did pay for programs they deemed essential such as voice recognition or spaced repetition applications. The remaining applications selected were based on being free for all or selected services, typically organisation programs such as Habitica app ™. One student, G10S2, was very considered and discussed their need to have all programs compatible.

> *"I can't use One Note because my voice [recognition] program isn't compatible with it; I tried… There's a program that I use called [Lucid Chart] which is just a flow chart maker that's online so I can use my voice program to put it in and then just move - like use my mouse to put the boxes in… [it is a] free version". (G10S2)*

This student also had created extensive online searchable digital notes, which I will discuss in chapter 7. The majority of the other students interviewed stated they used free-form-information gathering programs, such as One Note, to collate their digital notes. However, these notes were unsearchable, creating limitations in using these programs for their learning. I will present and discuss this further in this chapter.

The notion of having free access to knowledge resources on the internet was consistent throughout the VSRTA interviews, which went hand-in-hand with the expectation of having free internet access throughout the PBL tutorials. Essentially, students are free to select their learning resources independent of the educator, and they do so. In fact, the internet has nearly everything a student would require for their course and more. Yet, students do not have free personalised access to an educator who can guide

them on how to access, judge, and apply ICT information. This concept has ramifications for all educational institutions will be discussed in chapter 8.

To summarise this first theme, students always had expectations to be connected to free online services and search engines, download free applications, and access the university's online services throughout their PBL tutorials.

6.4.4 Theme 2: Reduction of Unknown and reduction of uncertainty relationship.

The second theme I report on differs from the students' expectations of always being connected to the internet. Students were uncomfortable with uncertainty and sought quick resolution by accessing the internet anytime, anywhere, including during the PBL tutorial. In other words, students tried to avoid suffering uncertainty and behaviourally manipulated their learning environment to ensure they always had immediate, fast access to the internet.

Herein lies a conflict with the affordances of AL. AL scenarios are intentionally written to be ill-defined. As such, they encourage students to activate their prior knowledge, brainstorm a wide range of ideas, and then share them with the group. Students are unsure of or do not know create group discussion to flesh out what is known and not known. The unknowns identify their collective knowledge gaps. Students are expected to write unknowns as learning issues that form the basis for the groups' self-directed learning plans and reported back in the following tutorial. Therefore, 'the unknown' is a powerful learning trigger intrinsic to AL, but it creates a feeling of uncertainty. Uncertainty is not pleasant but serves as motivation to resolve. This way, AL motivates students to research and spend time understanding and reducing uncertainty. The availability of ICT affordances can quickly reduce this uncertainty. But this also creates a dilemma or conflict between the students' learning and AL affordances' intended role.

6.4.4.1 Think google

It was evident that when students encountered something they did not know or were uncertain about, such as 'the unknown' in the AL learning trigger, they thought of google first.

> *"Google. One hundred percent of the time it'll just be open a tab. I'll even type the question into Google sometimes… 'what is blah, blah?' and it'll just like pop up an answer for me in that nice little summarised box on the top and I'm going 'thank you Google'". (G1S7)*

> *"… Google images - it's a really good resource of just trying to find like a really nice diagram". (G10S2)*

> *"I'll often just go to a Wikipedia page just to confirm what I'm thinking". (G7S2)*

Individual students accessing informal ICT affordances, such as Google or Wikipedia, during PBL were quickly and timely obtaining information to reduce their uncertainty. They thought of google first rather than spending time to search through their long-term memory or to confirm their thinking. It was important

to understand what the students did with this information.

6.4.4.2 Just-in-time information

Some students used ICT-sourced information to enhance their groups' understanding of the PBL case and facilitate discussions. They are using ICT for just-in-time information. Students explained they like to look up information at the time they needed it rather than in a preparatory way.

> *"During the PBL I hate if something is said and if everyone kind of looks at each other, no, no idea, okay well … can do at least a quick search, "oh! that's what it's referring to, easy", I'll look at that more during the week".(G6S3)*

The students sought just-in-time information to mitigate the frustration of not knowing or of facing uncertainty. By having ready access to ICT, they also avoid the cognitive effort of having to commit information to their biological memory. Hence, students experienced that resolving an unknown or uncertainty is always available and re-iterates the student need to ensure they have ICT connectivity during PBL.

ICT allowed students to conduct 'quick searches'' and provide just-in-time information that resulted in them not having to wait for this information. In other words, access to ICT can quickly resolve the AL trigger and negate the need for further effort into research and study. Herein lies a conflict with AL. Students do not have to suffer uncertainty. In fact, students seek to resolve the PBL case rather than use the AL affordances to devote time and effort to understanding the intended learning objectives of the PBL case. Rarely is solving the case the goal of AL.

Students did not perceive this as a problem as they saw a quick resolution as finding relevant information when they required it. They sensed they could save time in the PBL and Self-Didertec-Learning phase and as such, deemed just-in-time information essential for themselves and the group co-construction of knowledge. Students made judgments as to the relevance of the information.

> *"… I think that was one of those things that came up that is kind of peripheral to the case but not a central problem, which is the kind of thing that we would usually look up in PBL. Things that are more central to the case we would actually go away and do deeper research on but, yeah, any of these peripheral issues that we can just quickly look up and discuss we would kind of Google straightaway. So I think I was just trying to look up kind of what caloric input the patient would be getting from these six stubbies of beer a day, just so that then you can look it up, you can mention it, you can talk about it and what kind of an impact that has on the patient as a really quick discussion point". (G1S1)*

G1S1 did share this information with the group. Although not all 'searched' just-in-time information was shared with the group, most were kept for private individual use. When exploring the reasons for not sharing, students had a range of explanations.

They did not think it was relevant.

> *"Like it's not LI [learning issue] worthy kind of thing so it's just like a very minor thing*

that you just need to know, kind of thing, so I just wanted to look it up and clear it up". (G9S2)

They thought the group already knew the information.

"So they are quite familiar with pharmacology and even some of the drugs but this is completely new to me. I don't really want to interrupt like the flow of the conversation sometimes, so I just look it up on my own". (G9S3)

Or they searched for information based upon their learning style and did not consider it essential to share with the group.

"So essentially every time I have a question, I'll Google it, pretty much. Sometimes I don't even ask the group. I'll just do it myself". (G7S2)

Or they couldn't follow the group discussion and sought ICT to provide immediate answers.

"If they say something that I just don't know or I've never heard of that word before, that's immediately going to be looked up on my iPad. I'll quickly type it down get a definition because if we start discussing something that I don't understand the definition of and they get too far into the discussion and I don't know what it is then I'm going to fall behind the discussion". (G3S3)

These comments highlight that accessing ICT during PBL resulted in students making assumptions about their fellow students' learning needs. In doing so, they ignored the AL affordances of collaboratively constructing a shared understanding leading to a more memorable and deeper understanding and subsequently developing better knowledge. Other factors that were ignored were the opportunities to learn by questioning, listening, and then rehearsing the information, which cognitively facilitates the individual development of long-term knowledge schemas and life long-learners. Consequently, students chose to engage with the ICT affordances and failed to engage with the learning benefits of face-to-face AL affordances. If just-in-time information is shared with the group, it can lead to a deeper understanding of the case's unknown components and further the discussion, thus promoting deeper understanding.

Not all students failed to share just-in-time ICT information. In some groups, the students had developed group ground rules associated with ICT use during PBL. Students would ask their group if they wanted them to look up this information.

"We ask the group before … so should we just look it up?" (G1S2)

Also, formal ICT resources are sought to supplement the group understanding during the context of group discussion.

"I didn't actually search the Internet, I was looking up - we'd had a practical the Monday prior and they'd talked about it at the practical and I couldn't remember the name". (G5S4)

Even though these students were conducting group-directed ICT searches, the group did not pause their discussions. During which time, G1S2 and G5S4 were focused on their ICT device for several minutes

before re-joining and sharing the information found. There were no group rules to accommodate this situation. Consequently, students who undertook group-directed ICT searches missed components of the ongoing discussion and, in doing so, missed learning opportunities.

Students were unaware of these learning opportunities and the AL learning trigger role for their learning. As a result, they were oblivious to how the misuse of ICT affordances in the AL context is likely to hamper their knowledge development. In fact, students were prepared to reduce their cognitive effort into working through uncertainty as they had ICT connectivity. Yet, they genuinely did not know they were seeking a resolution to an unknown that could have facilitate their learning. Resolving uncertainty is a shortcut that likely does not lead to better understanding, but in some situations resolving an unknown can lead to knowledge.

6.4.4.3 Memory check

Searching the internet to supplement the group's co-construction of knowledge depended upon whether the information was timely found and resulted let to subsequent discussions. When students were confronted with an 'unknown' aspect, they displayed an array of responses. The internet often served as a memory check for what students understood and thought. Often, students conducted several quick google searches to resolve their uncertainty.

> *"I just googled that. I think I googled something like immuno-complex in nephron rheumatic fever. Just some basic key words, just to confirm my thoughts to make sure that I was thinking of the right thing and not thinking of something else and yes, get some more information about it". (G7S2)*

As G7S2 said, they wanted to make sure what they were thinking was correct. This implies that they preferred to use the internet to confirm their thinking rather than 'take the plunge' and openly discuss their ideas with the AL group.

Other students conducted searches to fill in missing information before they shared it

> *"Yeah, I mentioned it and I was like 'oh I can't remember the name of it' so I quickly Googled the name of it to then be able to give it to them in another gap". (G10S2)*

> *"Yeah because I wasn't sure whether it was what I was thinking of so I just looked it up to make sure it was correct". (G9S2)*

Interestingly G9S2 was uncertain what they were thinking and referred to the internet for help. Many students were uncertain about their depth of knowledge or their knowledge perse and resorted to the internet for confirmation and help.

Access to the internet was intended to reduce students' level of uncertainty, with some sharing their findings. However, many did not. Several reasons emerged for this behaviour.

> *"I don't really want to interrupt like the flow of the conversation sometimes, so I just look it up on my own". (G9S3)*

They did not want to interrupt, or the group discussion had moved on. In these instances, the student kept the information to themselves.

> *"Because I'm from a non-science background and they're all from science backgrounds, … so they are quite familiar … but this is completely new to me". (G9S3)*

Also, many students perceived that others in the group already knew or understood, and so they did not want to share for fear of potentially being seen as not knowing. It was evident that students misconstrued the focus of AL as solving the problem and knowing the answers rather than the intended cognitive effortful process of exploring the problem and creating questions to probe their own and others understanding of basic underlying principles.

6.4.4.4 Checking others and trust

Students not only checked their thinking, but they also checked what their peers were saying.

> *"I just wanted to look up and make sure that what he was saying was correct". (G9S2)*

> *"…was saying that the value could be different and I don't think that it was different so I wanted to look up the equation because I wanted to see if it was exactly the same and that it had just been omitted and then I couldn't find anything. I hunted for an equation but a lot of people - there's a few different ways of calculating it and then I found it but I didn't find any explanation about what the 1.73 metre squared actually meant. After a while I just gave up because there's no point wasting PBL time not engaging with the conversation if I'm just going to sit there and search, Google search for 30 minutes trying to get the right answer". (G9S4)*

AL groups can afford each student a diverse array of peers allocated by the faculty to form a face-to-face learning relationship. However, not all students utilised these AL affordances. Some preferred to ask their private online learning communities and accessed them while they were with their formal PBL group. These students communicated with friends in other groups or universities. They also sought distant ICT knowledge communities and collaboratives such as Wikipedia or others through google searches.

For example, one student did not trust the proffered information by formal PBL group members and sought clarification during the tutorial from outside of the PBL group. Instead of questioning the PBL group, this student used social media to contact a friend in a synchronously running PBL group who they trusted and valued their opinion over the face-to-face PBL group.

> *"I find everything that every member of the PBL says, I will fact check … S7 had said something which I disagreed with, so I was Facebook messaging a friend to confirm whether he had found the same thing, or something different". [in synchronous PBL group]". (G7S2)*

When asked why they did not question their own PBL group, the response was for fear of disrupting the group dynamics.

> *"… don't know if it comes across as doubting someone or whether that's good for a group dynamic". (G7S2)*

Despite individually resolving the issue by communicating with a Facebook friend, the pertinent information was not brought back to the discussion group. The problem was left unresolved as this student did not share their concerns or information. Instead of asking questions to clarify misconceptions, G7S2 decided not to embarrass the student and hence messaged their friend. G7S2 missed an essential learning opportunity for developing strategies to question and discuss cognitive conflicts with others. Discussing and questioning information are desirable clinical medical practice skills when working with peers and patients with opinions and different knowledge levels. However, because my aim in this study focuses on the information processing system and the cognitive impacts of ICT affordances, the social determinant of learning is beyond this study's scope.

6.4.4.5 Overview theme 2: reduction of unknown and uncertainty

Figure 6.4 summarises the student effectivities as found above during an event whereby they were confronted with an 'unknown' or with 'uncertainty.' The 'unknown' is pivotal in AL as it stimulates interest and motivates time and effort to explore develop understanding. The blue component of Figure 6.4 describes the AL process that leads to deeper learning through construction, collaboration, and contextualisation of meaningful, memorable long-term memory schemas. In addition, when just-in-time information is shared and contributed to the group discussion, it can enhance the discussion and promote group collaboration.

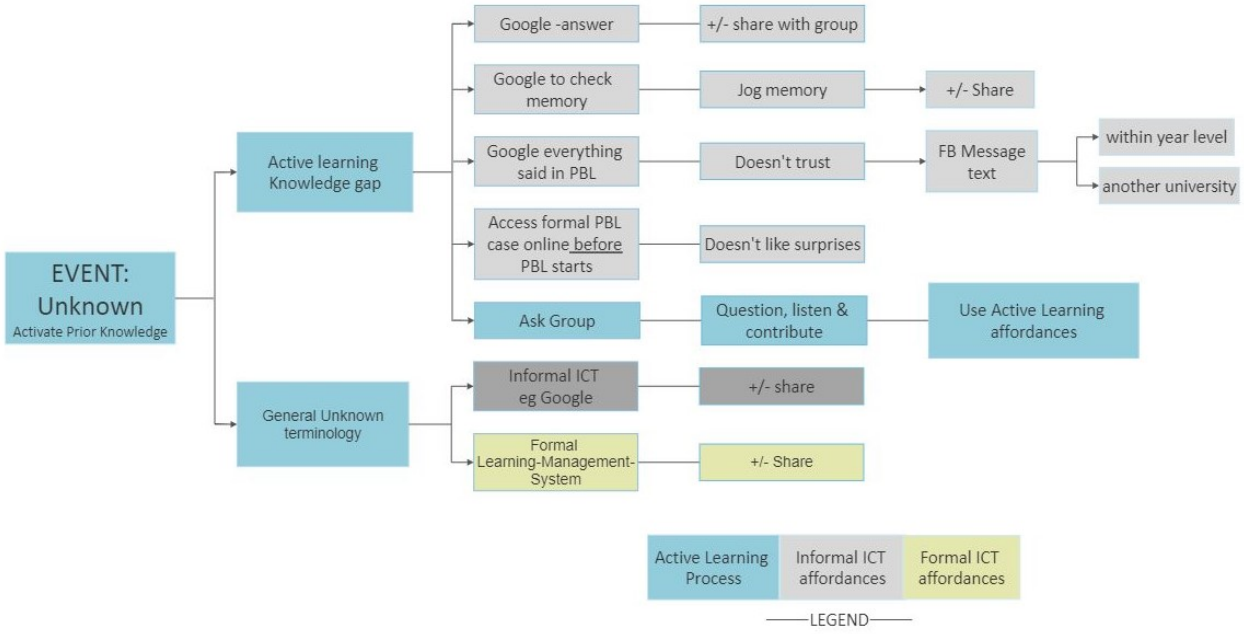

Figure 6-4 The unknown: Student effectivities during active learning tutorials when confronted with an 'unknown.'

However, when students sought informal ICT affordances of communities of knowledge (in grey) to resolve the unknown quickly, they were at risk of truncating their thinking and, if shared, discussion time. The resultant reduction in the groups' collective and individual cognitive effort led to less face-to-face group discussion. The quick superficial resolution of the unknown, also potentially led to fewer learning issues based upon the groups' learning needs.

6.4.5 Theme 3: Students creating informal learning environments using ICT affordances

As previously reported, most students stated they habitually connect to the Internet to prepare for the PBL tutorial and expect to have free, fast, reliable Internet throughout the PBL tutorial. Another theme that clarifies why students feel the need to have the Internet is to create learning environments beyond formal face-to-face interactions. The students select these groups through controlling who joins and are based on individuals who share similar social needs and points of view. They form personalised informal learning environments.

In this study, all PBL groups employed social media applications to collaborate and form groups outside of the formal PBL group. They created several private Facebook groups with associated Messenger groups. Students did not invite educators (group tutors) to join these groups. The reason being that they saw these spaces as private and for the students only.

Students were often members of past and present PBL Facebook groups, friends within their year, entire first year, and entire course level.

> *"The PBL groups are run by the PBL groups, there's a year level Facebook page as well where the entire year level is a part of it. Then there's a med school group that the entire med school is in". (G9S4)*

Additionally, G7S2 commented,

> *"Our group has a Facebook page just because we all find FLO (University LMS) a little bit clunky and we don't really check the notifications of FLO. Whereas Facebook, we all have it in our personal life. It's always in our face, essentially. So we're all seeing notifications for it". (G7S2)*

Students preferentially adapted their everyday social media platform of Facebook for their educational needs. Unlike the university Learning Management System (LMS), Facebook was familiar in their lives already, and as such, it did not require additional learning on how to navigate. The student effectivity of communication through Facebook for PBL was essential to the individual student and the group.

Facebook served as a repository for posting the group's board work generated during tutorials and for organisation during and after the PBL tutorials. They communicated general information about timetabling, meeting times, and other housekeeping issues. Members contributed or used the site as much or as little as they wanted.

One use consistently mentioned was for the report-back tutorial organisation. Groups conducted learning objective polls on their group Facebook page. They posted the objectives, and students selected the learning objective(s) they wanted to present during the report-back tutorial. They adapted their familiar social media platform, Facebook, for their learning.

> *"I'd seen polls before on Facebook but I'd never used it for study. It was always like I*

had never actually made my own poll before". (G2S3)

The pre-planning of who would be responsible for each learning objective promoted the flow and organisation of the face-to-face tutorials and AL collaborative group process. In one instance, a student was absent and posted their Learning Objective research on Facebook to be presented by a fellow student.

> *"He had posted his LO presentation on Facebook. He did that on Thursday and he posted this diagram that you can see which we've brought up on Facebook and then he had a bit of a blurb about It".(G7S2 comment on G7S6 who was absent in report back tutorial)*

For this event, the Facebook page was shared with the group on the tutorial screen. Therefore, G7S6 maintained their collaborative, positive interdependence with the group by ensuring they participated and honoured their responsibilities to the group learning, even when absent.

However, the drawback was that not everybody learnt and prepared all learning objectives actively, so they relied on other students' learning rather than their own interpretation and understanding.

In summary, student effectivities in using informal ICT communication and collaboration was observed across all groups in this study. The social media platform of Facebook was preferred over the formal LMS for group ICT communication as it was already familiar and in everyone's life. The students created their own sharing economy through multiple tiers of Facebook groups, Messenger, and google docs. The degree to which students used social media for AL collaboration construction of knowledge was beyond this study's design. However, students commented it was predominantly a sharing platform for information about the PBL case, associated sessions, and social matters. These student-developed online learning spaces were not investigated further but could potentially augment the tutorial flow if used in alignment with AL affordances.

6.4.6 Theme 4: Levels of ICT communication.

Setting up online communication avenues enabled students to communicate with multiple stakeholders quickly. Stakeholders included their current and previous PBL groups, friendship groups, and year and course level groups. These virtual connections afforded students to have ready access to various learning partners, no matter where they were in the world.

> *"… so I sometimes do ask my peers through Facebook about certain questions or certain parts of the book that I'm reading that I don't understand, I just take a picture, send it through Facebook and they will just - if someone understands it or anything they will just reply immediately and 'okay, this is how it is' and stuff like that so it's really useful. We can quick communication". (G5S6)*

The immediacy of using social media was an essential feature. Students communicate with their learning peers for cognitive support, and ICT afforded them the ability to communicate detailed information.

> *"…have a couple of other Facebooks that's with other medical students as well from*

> *other PBL groups because we have our PBL group as well so some of them are still posting and stuff, like basically 'oh our tutor mentioned about this and it's a very useful thing' so we just post it in a link or something". (G5S6)*

Interestingly, students quickly disseminate experiences and information from one PBL group to another by having multiple stakeholder groups.

Notably, most students had ICT affordances in their lives through social media and were continually alert to incoming messages.

> *"In our generation … lives are very integrated into handheld technology … If my phone buzzes I check it because I hate it if people don't reply to me when I send them a message". (G2S1)*

But there were other partners such as local or global special interest groups that link like-minded individuals together.

> *"I disagreed with, so I was Facebook messaging a friend to confirm whether he had found the same thing, or something different". [in synchronous PBL gp] (G7S2)*

I have previously cited this quote from G7S2, but it is relevant here as well. This student had predetermined who they were going to trust by creating Facebook groups with trusted friends. The likely implications of selecting like-minded groups are that students are not exposed to different ways of viewing or interpreting problems, as seen in G7S2. In this instance, G7S2 communicated with their friend in a synchronous group during both of their formal PBL tutorials. They perpetuated their own ideas and thoughts by associating with someone else who had the same view. While ICT affords an enormous volume of information, students can limit what they see and believe through searching and interacting with the knowledge and information ICT communities.

Therefore, creating informal ICT learning communities and communicating online with whom the student deems suitable or likes creates their own social media and collaborative learning bubble. In fact, they are potentially decreasing their exposure to people who disagree with their way of thinking. In the previous theme, students used ICT to reduce their uncertainty. In this theme, communication with multiple stakeholders, students regulate their exposure to dissenting views and disorientating dilemmas. Dissonance and disorientating dilemmas are essential aspects of AL that drive collaborative interactions through discussion, which in this instance, is truncated or ignored by communicating within tailor-made social bubbles of like-minded people.

The final category in ICT communication is that of students communicating with themselves. I have already presented how they use online applications such as spaced-repetition and gamification apps whereby they set up reminds to test themselves with questions they have written. Or they are reminded to review a particular chapter or YouTube clip suggested during PBL. Therefore, ICT affordances play an essential role in allowing students to organise all aspects of their learning environment independently of the faculty and university's offered formal learning resources and infrastructure.

6.4.7 Theme 5: Student organisation.

Students specifically adapted and organised their learning environment by utilising the ICT affordance of convergence during the PBL tutorial. The formal PBL case and associated resources (laboratory results) were often said to be easier to read on personal ICT devices than on the tutorial screen.

> *"I had the PBLs like on my screen. I just do that because sometimes it's hard to read so pull up the [lab] results it's hard to see [on tutorial screen] so I just have it on there". (G9S2)*

Students also had the flexibility to scroll between screens case information independently of the PBL group.

> *"They [the group] were flipping through it [the case screens] and I wanted to go back and have a look". (G6S6)*

They could read ahead or return to a previous screen independent of the rest of the group. They set their own pace independent of the group.

Some students had laptops or tablets with writing stylus pens, which they used to annotate online copies of the PBL case as the group discussion progressed.

> *"So I sit there with the case notes and as we go through it they come across and I put in the important bits from that case note. (G2S1)*

Here is an example of an ICT affordance of convergence by digitally handwriting comments directly onto the PBL case. Therefore, students controlled the PBL case presentation flow, independent of the group, and directly annotated a digital copy of the PBL case for later study. They were organising their learning environment within the formal PBL tutorial for themselves. However, it also restricted group collaboration and cohesiveness as students were literally not being on the same page.

6.4.7.1 Organisation of own notes

Students were very considered in how they collected, documented, and stored information for learning. They extensively used word processing programs (Microsoft Word ™) or free-form information gathering programs, such as Microsoft OneNote ™. Many students had discussed during the VSRTA how they adapted their organisation of notes and methods of notetaking from undergraduate. They found handwritten notes were too messy, disorganised, and not amenable to additional information as they progressed in the medical course. The high volume of information students perceived they needed to note and learn in medicine was cited as the reason for needing such a program. They listened to their peers and near-peers, and many switched to digital notes.

> *"I just create a Word document for that week and I'll start - like I'll put the key info, hypotheses, questions or investigations and I just find it easier to type. I find it quicker to type along when we're writing everything up rather than writing it out by hand in PBL, plus if you want to add things in it's easier to just add it in on a Word document". (G1S2)*

“I've had people like talk about it a lot and say like 'oh computer notes are really good'. People are using One Note where in One Note you can embed PDF files and everything as well into - while you're making your notes”. (G2S3)

The free-form information gathering programs (OneNote ™) had extra features to Word -processing programs. These digital forms of information are readily embedded into digital notes at any phase of the students' learning and remain neat. Students considered neat notes as being necessary. For example, students can quickly and easily add videos, audio files, images, PDF files, and segments cut and paste from websites or screenshots from textbooks. OneNote's other common feature was that digital notes can be easily linked to spaced repetition applications (such as Anki ™) and used to test their recall of information. So, OneNote ™ is an ICT convergent software program but can only converge with the same company's compatible software. Students had extensive subject libraries of digital flashcards that are periodically present questions and test their knowledge.

“I use AnkiApp, which is like a flash card app. You can download it onto your computer and you can make flash cards, so you put like a picture from a textbook and then type a question about the picture, or like any question, and then you put an answer in and then when you - you make a deck for each week. I might make, depending on how much content there is, like 100 questions based on like anatomy and physiology just from the notes that I've made. Like I'll re-read over my notes and then make questions for myself so I find that pretty useful as well”. (G1S2)

Another use considered was of gamification applications (such as Habitica ™) that turn to-do lists into a game to be completed, including rewards.

“I use a task manager called Habitica - it's like 'habit - I-C-A' and it's a [gameification] of your tasks that you have to do in your life, of your to-do lists, your daily tasks and things that you'd like to make habitual, make a habit out of”. (G4S7)

G4S7 creates their to-do list on this application during PBL

“Towards the end of this class or part way through I used Habitica to just add a task … because [Name] suggested that we go and listen to the lung cancer lecture on Armando … and yeah, I did, I did actually listen to it before the next PBL and very clear that [Name] had as well because I could see her notes and everything that she was saying was directly from that You Tube video, which was quite funny”. (G4S7)

The linking of digital notes to capitalise on the features of spaced-repetition and gamification applications was, for many students, invaluable to their learning. Some of which they paid for, but others used the free versions. Students also actively sought free, easy-to-use, and specifically designed digital notetaking programs to gather and store information. To be organised and have digital notes available on any ICT device was attractive to time-poor students. So the functionality of the program(s) they used was critical and was weighed against the potential costs. For example, Word processing programs are designed to create, edit, and create a final product for printing. With the extra features mentioned above, the Onenote program can save a diverse array of digital note formats as folders of work determined by the student.

“Everything's all kind of categorised based on the week and the LO number, the lecture notes and the name of the lecture and then any practical notes and supplementary notes; it's all there and I can just find it straightaway. It's kind of really up to my efficiency in terms of study”. (G3S3)

Organisation of digital notes and resources depended upon student effectivities to navigate the ICT affordances specifically for learning. Interestingly students were prepared to change how they had undertaken study in their prior degrees and adapted to the massive volume of study material in medicine.

6.4.7.2 ICT search engine and ICT library hierarchy of use

The organisation of resources was paramount for students' preparedness to participate in PBL and conduct self-study. Students used ICT to create, organise and manage their ICT library. Yet when students needed to find information, they all utilised the search engine ‘Google’ upon encountering an unknown or question during the PBL sessions, and many commented they prepared for the formal sessions by 'googling', *“Good starting point”. (G1S1)*

Google snippets on the first search engine results page were judged for relevance and guided where to search next. The most trusted community of information was Wikipedia. Students consistently commented that Wikipedia provided an overview of current information upon which they used to search further. Then they would then look at google images for flow diagrams and YouTube if they needed further explanations. Free medical sites were viewed and trusted before moving onto the library databases, which required log-in details. Figure 6.5 depicts the flow of ICT resources students use.

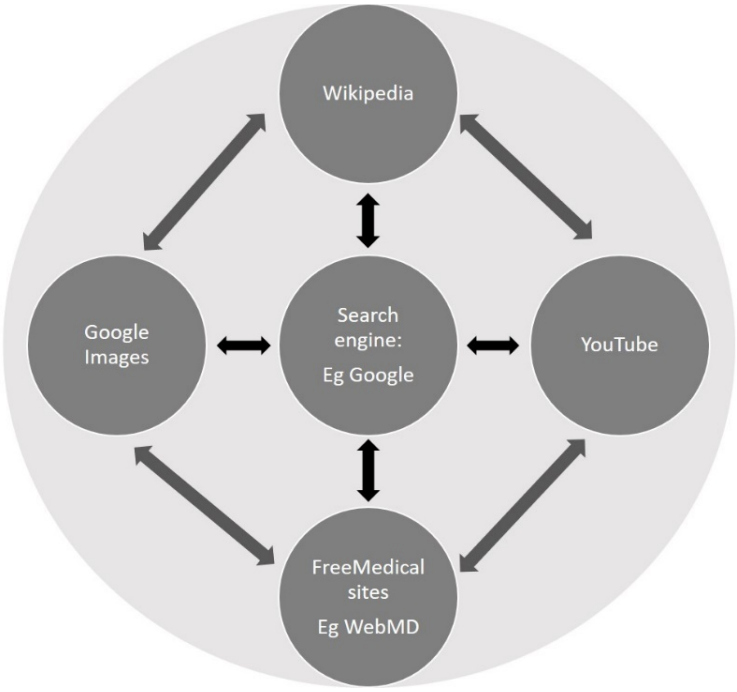

Figure 6-5 Student's ICT use of search engines and ICT resources during the PBL tutorial demonstrates ICT communities, and collaborative knowledge preferred.

Some students commented they utilise peer notes that have been posted on year-level Facebook pages for them to upload. These notes consist of all the PBL cases with notes and diagrams compiled from previous medical students' generations. The near-peer notes are passed down from year to year and adapted and edited by each new cohort of students. Similar to free online encyclopedias such as Wikipedia created and edited by volunteers. Students used this informal ICT near-peer community notes to guide the information required to pass the depth and direction of information.

After students used search engines, almost all VSRTA students reported using PDF textbooks stored on their ICT device and iCloud. They spent time and effort developing a comprehensive online library. The number of PDF textbooks ranged from thirty through to hundreds. Students supplemented their PDF copies with hard copies, mainly because they found screen reading for complex issues difficult. Only one student stated they only used textbooks borrowed from the library. Most students preferred PDF textbooks for their research during PBL and the learning objectives. The physical library served as a reservoir to access the hard copies of books when and if they wanted to read from printed versions.

During PBL sessions, students accessed a range of online resources and stockpile the bookmarks for the report back PBL and to review after the formal session.

> *"I remember he (Lecturer) showed us an image in his lecture and that's what I was trying to look for, but this wasn't bookmarked". (G5S1)*

Students behaviourally strived to collate these sites and have them available during their learning phases, including PBL tutorials. But the limitation, as demonstrated by G5S1, was that the student had to remember to bookmark them and quickly be able to find them on their ICT device. Bookmarks included Google searches with associated sites opened, PDF textbooks, formal lecture material, and their own or peer notes. The bookmarks served to remind students to review and use as a guide for their study.

> *"My computer at the end of the week is so just a million tabs, of the notes, a lot of them will be other people's notes or just an up-to-date article or just lots of things that I've had up that I've been using that I don't want to get rid of yet".(G7S7)*

However, many students commented that they usually did not have the time to review them. Eventually, they ended up deleting them.

About half of the VSRTA student cohort regularly moved from informal ICT knowledge communities and collaboratives of knowledge to online university and clinical databases such as clinical decision support websites (UpToDate). However, only a few looked at sites relevant to their countries, such as Best Practice and electronic Therapeutic Guidelines (eTG, Australian). The rationale varied as to the usefulness of these sites in first-year medicine.

> *"I use Up to Date quite a lot, which has a pretty good overview of everything related to one condition, … Mainly the things I end up bookmarking are the Up to Date articles because I find those are most relevant". (G6S3)*

Figure 6.6 shows the hierarchy of resource usage during self-study and formal PBL sessions. All students interviewed expressed this hierarchy of searching. The student who only used hard copies of textbooks still followed this hierarchy of searching. They would firstly google the term or question, read predominantly the Wikipedia page. Judgments were made about relevance and trustworthiness. Wikipedia was used for broad concepts and starting points and followed up by edited medical sites such as UpToDate or Best Practice. The use of online textbooks was minimal as they preferred to use their PFD textbooks. However, students accessed online databases to source recent articles or review articles on topics they were interested in.

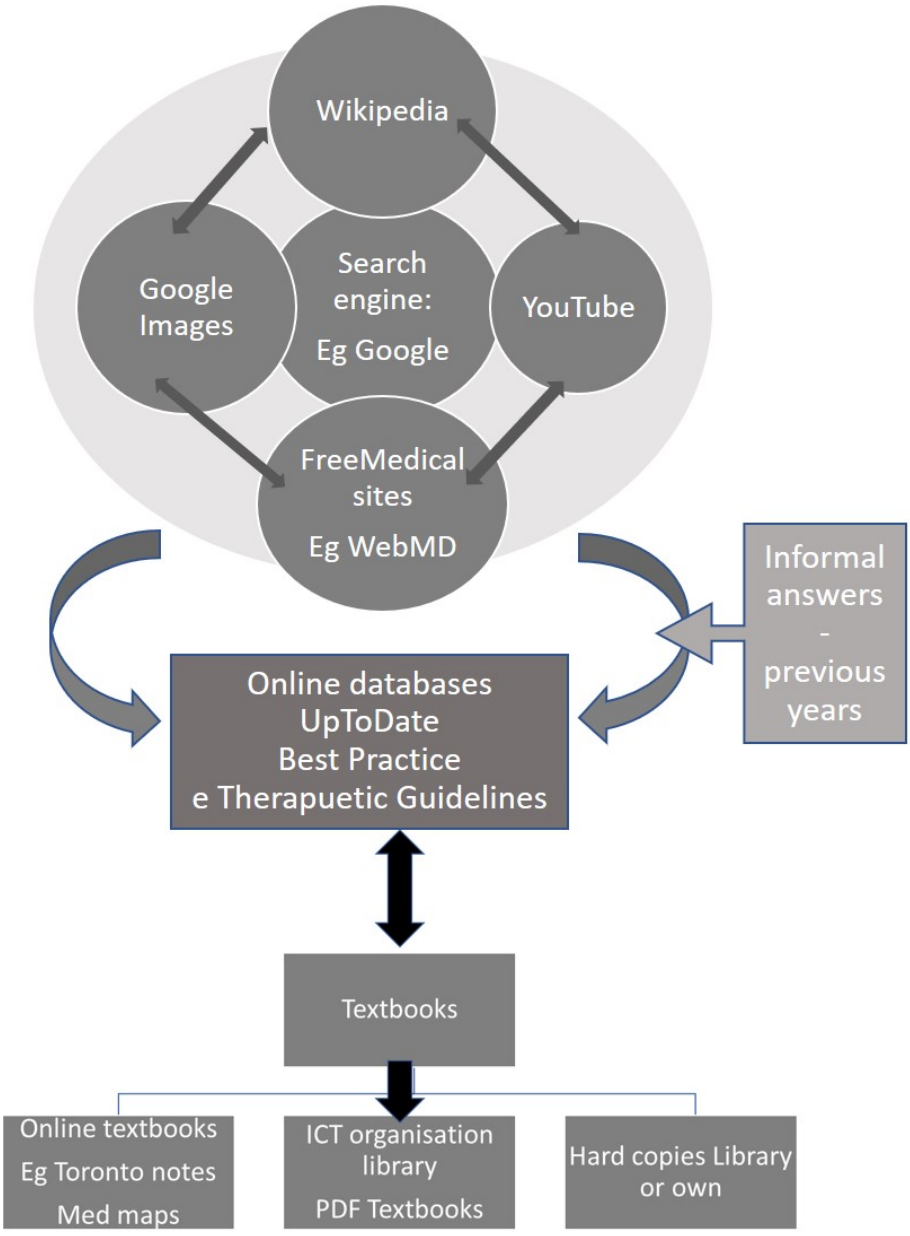

Figure 6-6 Hierarchy of learning resources used by first-year GEMD students during self-study and formal PBL sessions.

Again, students behaviourally orchestrated their learning needs by manipulating the ICT affordances of communities and collaboratives of knowledge. Time constraints, the volume of information to learn, and the course's fast-moving pace were cited as reasons for this high organisation level. However, despite this high level of organisation and information procurement, students could not search for specific

information when required during the PBL tutorial. Additionally, they had devoted much time and effort to organising the notes that the information to be learnt was not necessarily learnt. During the PBL, the time taken in attempting to search these notes took their attentional focus away from the face-to-face group and essentially reduced their interactions with the AL affordances. Therefore, students would use ICT search engines instead of their own electronic notes.

6.4.8 Limitations of student effectivities: Learning for biological memory

Students utilised their ICT affordances to access online knowledge communities to select their learning partners with whom to communicate and collaborate. Thus, they created their own sharing information economy. However, when it came to learning, remembering and understanding, students found handwriting the best strategy to consolidate and construct their knowledge.

> *"I find handwritten notes excellent for memory, and retaining knowledge, but poor for organisation and efficiency, especially if you want to go back and add things in, and then referring back to them. It's just really hard to find what you're looking for". (G7S2)*
> *…*

Therefore, ICT devices were only used to collect important information to learn later.

> *"I've got a few exercise books, as well, which is just my scribble of handwriting notes out. In terms of having the electronic notes, I find that they're a point of reference. Almost like building your own encyclopaedia, and then the handwritten notes I have is just for memory and recall and all that type of stuff". (G7S2)*

Almost all of the VSRTA students recognised that handwriting and drawing diagrams were associated with forming strong, memorable long-term memories. ICT was a vehicle to assist in their learning, but students found it difficult to remember and connect information if they did not handwrite it.

> *"… (have notes) on my computer but I don't learn anything until I handwrite it as well - so I just double the work". (G1S7)*

> *"I think for me it comes back to I have to handwrite it. So I really just like to be able to handwrite and scribble and draw diagrams, and strangely enough I remember where everything". (G6S6)*

> *"I really do believe that handwriting stuff is linked to your memory". (G7S2)*

Only very rarely would students view learning merely as a collection of facts that need to be memorised. These students utilised ICT to store and organise their notes, but more importantly, by having the notes electronically, they could link them to space-repetition applications to build up flashcards.

> *"I'll take electronic notes from textbooks. Generally, I'll take notes from multiple sources and I won't generally cite the sources; I'll just have it as like a compilation of information, similar to what people would hand write. I did hand writing last semester and I found that this (electronic notes) is more effective because I turn it into flash cards, digital flash cards, so I just find it's easier if it's already in electronic form".(G8S3)*

G8S3 changed from handwriting specifically to digital notes to enable the development of online flashcards. This change in learning strategy was to accommodate the available ICT affordances. In doing so, he used ICT as an external metacognitive tool to create, organise and format multiple-choice questions rather than rely on the more cognitive effortful learning methods of handling the information in several formats. The spaced-repetition algorithms thought for him by repeating questions based upon standard data determining when forgetting will occur. Essentially, ICT was relied on for what and when learning should happen, not the students learning needs.

Additionally, in this instance, the ICT affordances promote rote learning rather than the effortful AL for understanding. Therefore, catering to students who prefer the rote style of learning and converting others. However, this was not evident. Other students who used spaced-repetition applications commented their learning was enhanced when they included the writing of flow diagrams with a rationale to underpin the information. G10S2 utilised flow diagram applications for this purpose. These students contextualized and constructed diverse schemas to form strong, memorable long-term memory structures during the PBL tutorial and self-directed study. However, those students who stated they had everything electronically stored and collated on their ICT device and used spaced repetition applications relied on rote learning information with minimal elaboration to understand information. All students are motivated to pass exams and other course assessments. Therefore, it is natural for students to find learning methods that best enhance their learning outcomes. However, when ICT is misused for rote learning only, it can be detrimental to and misaligned to the fundamental AL affordances.

6.5 Chapter 6 summary

In chapter 6, I presented the results from direct observations from first-year GEMD PBL tutorials. Students used multiple ICT devices during both problem-analysis and report-back tutorials and books and paper resources. However, students' ICT device usage doubled in the report-back phase as opposed to the problem-analysis phase. This increase in ICT device use is possibly due to students electronically storing their SDL research.

VSRTA interviews focused on student interpretation of what they were thinking during identified ‘events’ whereby they interacted with their ICT devices during PBL. Textual analyses revealed five themes.

Firstly, students expect to have access to free internet services to automatically connect in preparation for their PBL tutorials. They were frustrated when access was not forthcoming and preferred to gain ICT access over the AL affordances of face-to-face interactions. The reasons for needing ICT access varied. Predominantly it was out of habit that they connected. But they were used to having access and relied on the internet to quickly seek information. In some instances, they used ICT as a cognitive escape from the boredom of the PBL tutorial.

Secondly, students sought ICT as relief from not knowing, unknown, and uncertainty. Students thought of search engines first when confronted with these issues instead of activating their long-term memory. In

these instances, ICT nullifies the AL learning trigger of the unknown that motivated students pre-ICT to seek understanding through collaborative discussions and SDL research. By thinking ICT first, students were reducing the time taken to think and recall information, or if they did remember information, and were reluctant to share until they had checked with ICT to ensure they were correct. They were using ICT to reduce uncertainty and find information about unknown aspects of the PBL case. Students did not have to wait for their SDL phase to resolve these dilemmas. The subtle difference of resolving a simple unknown during PBL, as in just-in-time information, can facilitate discussion and lead to learning. But only if the information is shared with the group. However, the reliance on ICT to resolve uncertainty and complex unknowns does not encourage students to activate or trust their memory. Therefore, checking ICT when uncertain does not promote learning but increases dependence on ICT for their knowledge. Inherent in this issue were students were uncomfortable at proffering their knowledge or understanding unless they checked it first, as they wanted to be correct. They were protecting themselves. Hence, students used ICT to avoid being uncomfortable with being uncertain. Yet, uncertainty without ICT can lead to the teasing out of information into meaningful long-term memories. Without this, it is debatable if the long-term memories are added to and reinforced. Interestingly, students were unaware of the AL implication of resolving uncertainty or unknowns quickly. They could only see this as a bonus to their learning and not as a serious disadvantage.

Thirdly, students were adept at creating their own social knowledge economies by setting up multiple tiers of social media applications. All groups in my study had set up a group Facebook page, Messenger, or google docs. These online spaces focused on the group disseminating the groups' co-constructed tutorial work by posting photographs of the board work. They served to communicate with each other regarding interesting information. Students also organised their face-to-face tutorial flow to save time and ensure quiet students had an opportunity to present.

Fourthly, students utilised ICT affordances for communicating with themselves, with their peers, friends, distant people from all around the world. They set up trusted invitation-only social media bubbles in the form of Facebook groups. These groups consisted of like-minded members. The risk here is that students are protecting themselves against cognitive dissonance by reducing opportunities for their understanding to be challenged by other students with differing views. Therefore, the AL affordance of collaboratively working in small groups is ignored. ICT applications are incorporated to help students learn information, such as spaced-repetition apps, and form learning habits, such as gamification apps.

The final theme of organisation was extensively found throughout the VSRTA interviews. Students devoted considerable time and effort to develop their digital notes and library. However, when students required the information they had stored, they had to rely on their biological memory. Their ICT notes were unsearchable, and they had to rely on remembering where they had stored the information before finding the information. Therefore, it was easier and quicker to use online search engines. Most students were oblivious to their digital notes' learning shortcomings, and most returned to the tried and tested learning methods of handwriting. However, some students mistook their ICT note creation as their

learning. Also, ICT affordances enabled and promoted rote learning over the more cognitively effortful AL. This is a problem in students who were struggling to cope with the volume of information and who also did not reflect or have insight into the pitfalls of learning purely through rote learning. Therefore, ICT served as an organisation tool for students to collect and store information neatly. But when they wanted to understand the information, they handwrote information and developed diagrams for meaningful long-term memory development.

In Summary, students rely on ICT affordances for multiple reasons, some associated with their learning others to organise their learning space. Students utilised their ICT affordances to access online knowledge communities to select their learning partners with whom to communicate and collaborate. Thus, they created their own sharing information economy. However, when it came to learning, remembering and understanding, students found handwriting the best strategy to consolidate and construct their knowledge. The next results chapter will investigate further by triangulating the students ICT history logs with the VSRTA interviews and observational data.

7 RESULTS CHAPTER

7.1 Introduction

In the previous two results chapters, I presented the medical student year cohort views on ICT affordances (chapter 5) and the observed student interactions with their ICT device(s) during the formal PBL tutorials. The observed ICT interactions were followed by individual students' Video Stimulated Retrospective Think Aloud (VSRTA) interviews to identify and characterise the thinking behind the students' effectivities (Chapter 6). In this chapter, I focus more deeply on the students' cognitive and metacognitive processes in the subset of students who also provided their ICT device history logs from the observed PBL tutorials. This allowed me to triangulate between observations, VSRTA and the time-matched logs of ICT to identify ICT device interaction events for analysis providing further insight into the students' effectivities and resultant learning and thinking.

Figure 7.1 situates this chapter and briefly describes the vignette analyses according to the chapter 3 conceptual framework. In this chapter, identified 'events' were supplemented with the students' ICT history logs from their ICT devices, thus forming a deeper understanding of their behaviour and thinking.

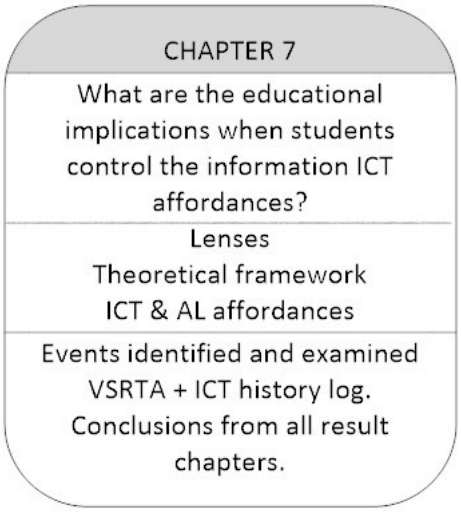

Figure 7-1 Chapter 7 organisation overview.

7.1.1 The Participants

Eight students provided their ICT history logs, participated in the VSRTA interviews and consented to their actions and interactions during their formal PBL to be videos, recorded, and transcribed. This cohort of students was anonymised further by allocating random names and genders, which protects students' identity, and assists in the flow of writing and readability of the vignettes. Table 7 provides a list of the participating students' relative student backgrounds and the categories allocated to the events.

Table 7 Background of students who provided ICT history log and the events explored during VSRTA interview.

Student	Previous degree(s)	Events
G3S3 Blake	Bachelor Health Science	Convergence of memory; Multiple resources
G4S7 Kyle	Bachelor Science	Contextualisation; Split attentional focus
G6S6 Parker	Bachelor Arts Bachelor Education	Co-Construction of Knowledge
G8S3 Ryan	Bachelor Computer Science	Transactive memory; Control of Intrinsic Cognitive Load
G9S2 Avery	Bachelor Clinical Science[4]	Collaboration; Communication; Communities 1. Prior Knowledge and ICT affordances 2. Missed Co-construction opportunities
G9S3 Brooklyn	Bachelor Sociology	
G9S4 Logan	Bachelor Paramedical Science	
G10S2 Charlie	Bachelor Medical Science	Transactive Memory; ICT Convergence

7.1.2 Vignettes

Short descriptive vignettes were developed based upon the identified events, relevant parts of the VSRTA (transcripts), PBL group observational data (videos), group board work (photograph), and the ICT history log (word document). These events are, therefore, the unit of analysis in this chapter. I chose to use vignettes describing ICT interaction events as the unit of analysis because this was considered the most meaningful way of bringing information together from the array of data sources. I then identified what ICT affordances the students accessed and whether they could successfully incorporate them into their learning. Evaluation of the vignettes led to understand how students used and selected their effectivities to negotiate these ICT affordances for their learning and the resultant impact on the formal AL affordances. (Table 8)

Each vignette commences with a short review of the student's background to situate and enrich the events' interpretation. I then triangulated all data to understand how effective students were learning in this ICT-afforded and AL-afforded environment, culminating in diagrammatic overviews of the students' effectivities to access and utilise the ICT and AL affordances followed by an analysis using the conceptual framework of the students overall learning, as summarised in table 8.

[4] Bachelor Clinical Science [undergraduate entry programme into MD]

Table 8 Vignette criteria, interpretation, and summary.

Vignette		**Interpretation**		**Summary**
Identification and Event criteria: Student interacting with ICT device,	**Vignette information:** Stage in PBL active learning cycle Event description ICT devices used Student background	**ICT affordances** Creation, Collaboration, Communication, Communities Convergence	**Active learning affordances** Construction Collaboration Contextualisation	**Conceptual framework** Theoretical insights from integrating analysis of the event, ICT and AL affordances, and overview of learning according to the conceptual framework

7.2 Blake (G3S3) Vignette: Convergence of memory and multiple resources

EVENT

This event occurred during the identification of key information of the new PBL case. The word Haemoptysis was used followed by a description of frequency, amount, and colour. The tutor questioned the group. Blake and the group commented, but then Blake transitorily removed themself from the group discussion to google 'types of Haemoptysis' and possible causes. Figure 7.2 positions this event in the AL cycle. The group continued to brainstorm possible differential diagnoses whilst Blake remained engaged with his ICT device.

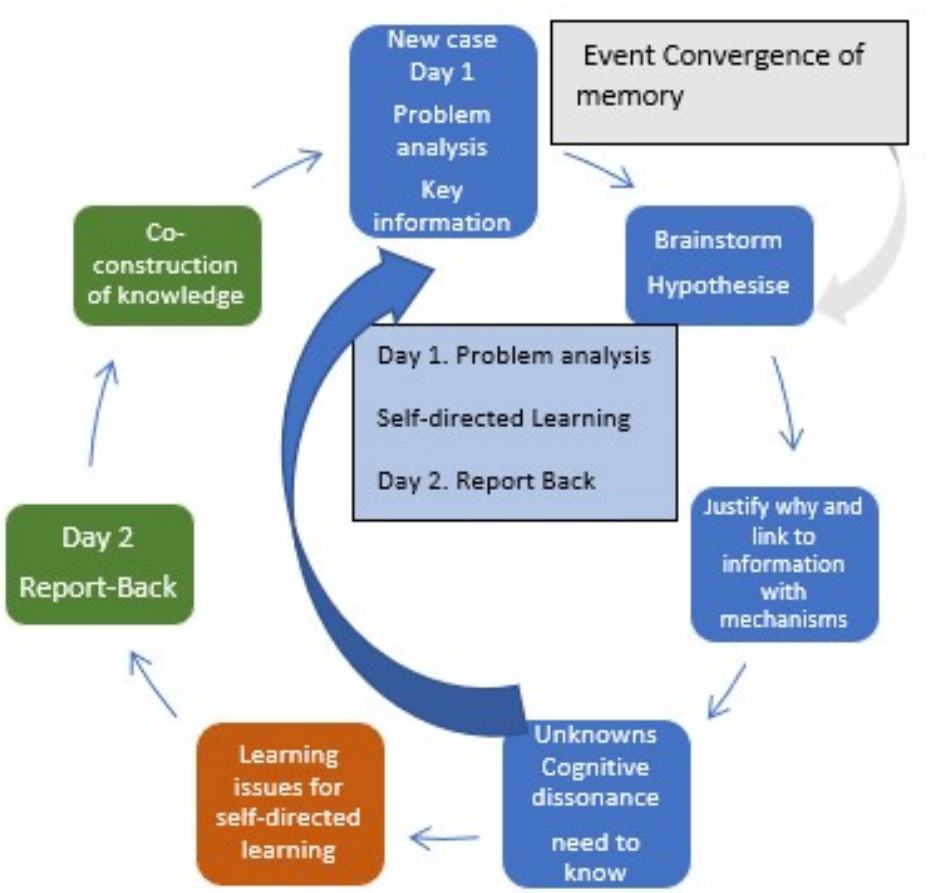

Figure 7-2 Active learning cycle: Convergence of memory event occurred during brainstorming and hypothesising differential diagnoses for 'haemoptysis.

Blake conducted several google searches for 'types of haemoptysis.' He then opened a Search Engine Result, which was an online 'Canadian Standard First Aid Course' resource site. He scrolled and read this site before attempting to open another site, but this was not accessible.

> *"I just looked up a standard web page, just typed 'causes, test and treatment' … know more about the different types because … at that time I'd forgotten the different types. I knew there was like spotted or streaked and they can mean different things". (Blake)*

Subsequently, Blake opened his hardcopy Oxford clinical skill book and looked at clinical signs of lung tumours.

> *"I only got this (book) recently I've found it particularly useful in kind of just finding if there's a certain condition in a case I'll look it up and it will tell me what symptoms and signs are relevant".(Blake)*

He punctuated his ICT iPad searches with smartphone searches (no smartphone history log was available) and with searching and reading the hardcopy book. As a result, he was frequently switching his attentional focus between his multiple resources and attempting to listen, question,

and participate in the face-to-face AL group.

7.2.1 Background

Blake described a considered approach to how he learnt and gathered information. The lecture notes, research, and private study were all handwritten. He associated the handwriting of his notes with the formation of long-term memory.

> *"I feel that my learning is much better derived from actually writing things". (Blake).*

These handwritten notes were achieved by ICT convergence of functionality with the ICT device that enabled him to handwrite on the screen '*an iPad, it also has like a stylus thing, so I have handwritten notes that are on here (Blake).'* Blake also recognised that his ability to recall information was enhanced through understanding and rehearsal of information.

> *"…so I put it in my own words and my own understanding and that usually helps me a lot. I don't understand it if I just cut and paste it. I actually just look at it and write it down myself or do my own version that summarises my own understanding because I've always been a believer that you have your own understanding of something and someone else's understanding might not always help so...".(Blake)*

Inherent to Blake's learning approach was to have neat and organised notes. The use of ICT markedly assisted this as he predominately had his notes online, and these were organised using compatible ICT applications with their ICT programs.

> *"..the app I use, it kind of integrates with [name of application 'aveno'] and that allows me to not only put my written notes on, it allows me to cut and paste pictures and stuff and put different kind of prac notes on there. …I wrote … all my LOs were handwritten and my lecture notes as well, but the prac, I sat down and wrote all of that". (Blake)*

During the PBL tutorial, information was being discussed with many ideas proffered. Blake typed up new information from group at these stages, cut and pasted diagrams from searches conducted during the tutorials, and deleted non-relevant information according to the discussion flow. He used different colour fonts to keep track of information generated by the group.

> *"Everything in black is what I've written beforehand and then green will be kind of supplementary notes". (Blake)*

He was very strategic in how and where he organised information to be learnt. This would have required a continuously high cognitive load and continual self-discipline to maintain.

However, searching through his digital notes for specific information required Blake to recall the unit of work in the topic occurred in also in which week it happened. This recall strategy was attempted during the VSRTA interview but was unsuccessful. Blake organised his ICT notes according to the curriculum flow and each weekly PBL case. His ICT effectivities, abilities, to rapidly search his digital notes relied on his memory as to where the information was stored rather than the information itself. Therefore, rendering his digital notes quickly unsearchable and prone to failure.

7.2.2 Interpretation:

While short in duration, this event typified Blake's pattern of interactions throughout both problem analysis and report-back tutorials. The student cycled between listening, conducting online searches on his iPad and or smartphone (no log provided), and reading his hardcopy Oxford book. Blake also attempted to participate in the group actively. In interpreting the identified event, the background provided vital insights into Blake's personal and behavioural interactions with their ICT affordances during learning.

In this Haemoptysis event, the ICT affordance of Communities and Collaboratives of Knowledge were accessed to find the types of haemoptysis to identify a potential diagnosis for the case at hand. This was contrary to the tenets of AL that promote learning through understanding, not by simply solving the case. Blake had '*forgotten the different types (of haemoptysis)'*, implying that he had once known or encountered them. He jogged his memory by forming an ICT transactive memory relationship with the ICT knowledge collaborative. Blake's ability to write concise keywords demonstrated he had sufficient prior knowledge and effectivities to engage with and navigate the ICT affordance. Regardless of his intention to learn, he only had time to glance at the ICT Search Engine Results (SER) and briefly opened one and failed to open another SER.

Additionally, he continually switched his attention between resources, his ICT device, and his hard copy book, further decreasing his learning time and adding to cognitive load. He was unlikely to have integrated the newfound information with the case into meaningful, memorable long-term memory. His learning under these conditions was therefore sub-optimal. In this event, the brief ICT affordance encounter with the ICT knowledge collaborative led him to fixate on the most likely cause for haemoptysis in this scenario, lung cancer. Blake then used the answer of 'lung cancer' to navigate his other resource, the book. Figure 7.3 shows the range of differential diagnoses hypothesised by the group along with the summation of their assessment of the likelihood for each differential. The group was actively discussing these hypotheses whilst Blake was focused on one specific differential of lung cancer. Blake missed practising the critical thinking process to discern between these diagnoses.

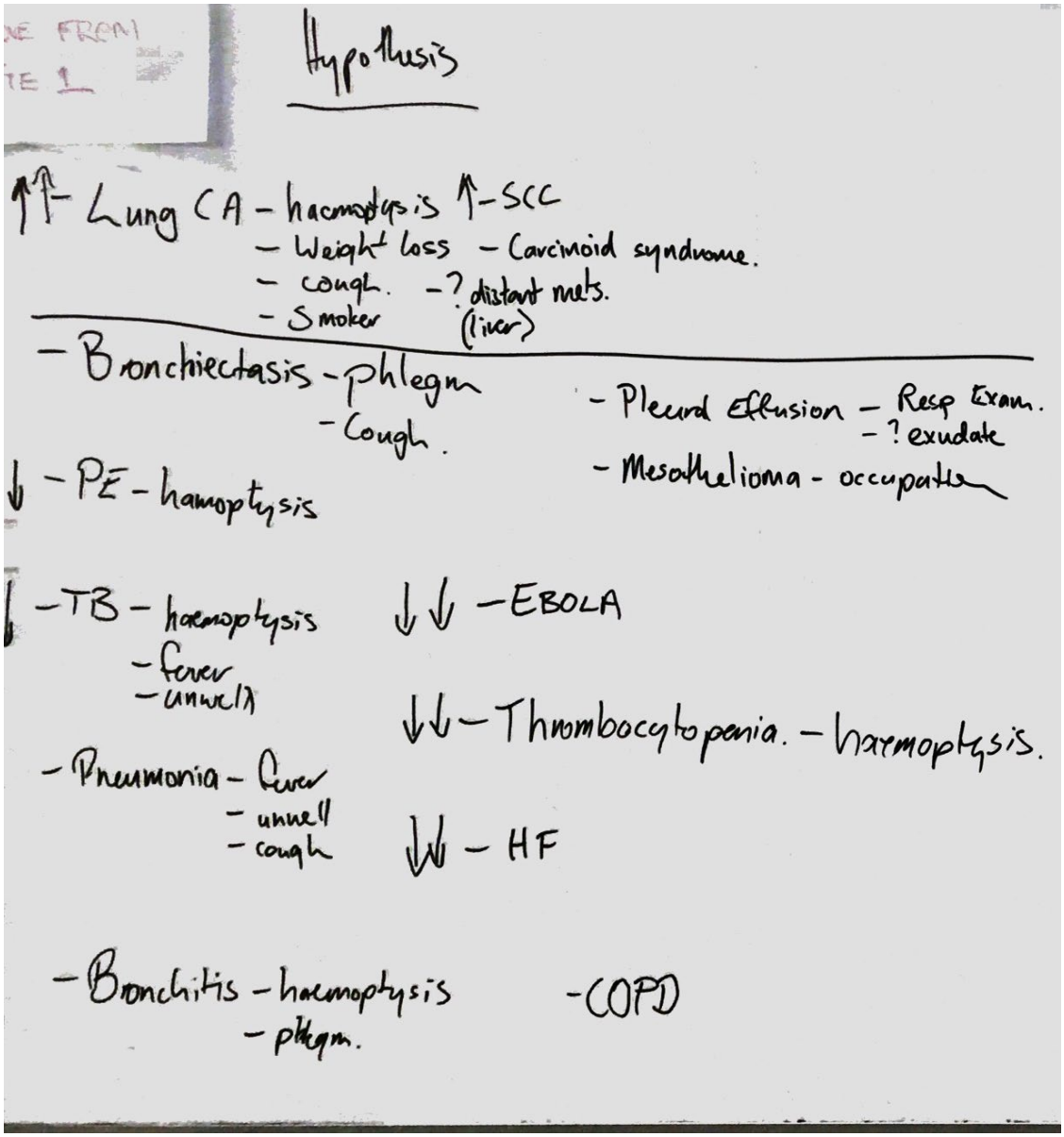

Figure 7-3 Co-constructed board-work of hypothesised differential diagnoses, uring the problem analysis tutorial. Photo was taken at the end of the problem-analysis tutorial.

Blake was not capitalising on and did not appear to understand the learning benefits of the face-to-face AL affordance of elaboration. Therefore, by directing his individual learning efficacies towards ICT and a book to seek an answer, he denied himself the opportunity for constructive and collaborative learning. He was using ICT affordances as means of convergence of memory of ideas to communicate with other resources, but not that of the group.

These AL affordances of constructive and collaborative learning opportunities were repeatedly missed throughout both tutorials. Blake preferred to continually transition attentional focus and task-switch between resources and, briefly, the group. As a result, Blake compromised his ability to learn because of a focus on quickly finding the diagnosis. Therefore, he robbed himself of the opportunity to learn using the face-to-face AL affordances. These transitions are likely to have increased unwanted and unhelpful extraneous cognitive load.

7.2.3 Summary

Blake had unintentionally constructed complex, self-imposed ICT-based systems that were perceived to help to learn. Essentially, Blake directed cognitive energy to switch between and searching for several resources rather than directing it towards his learning. In reality, Blake had unintentionally created an unnecessary increase in extraneous cognitive load.

Formally constructed instructional designs strive to reduce extraneous cognitive load by controlling unnecessary cognitive demands unrelated to learning. Yet Blake imposed upon himself a high extraneous cognitive load at the expense of his learning. Figure 7.4 describes the complex transitioning of attentional focus between his resources. These self-directed efficacies of using the ICT affordances continued throughout the AL PBL tutorial. Blake focused his ICT and AL effectivities on searching for one specific answer to explain the PBL case at the expense of considering other possible causes. AL does not promote answer-driven learning but is designed to motivate students to explore all possibilities and underlying mechanisms. Blake utilised the ICT affordances superficially to find this answer as he entered only one SER, but it was doubtful if he had time to fully consider the content to make an informed judgment about the information's credibility. He did not realise he had missed the purpose of the AL affordances in front of him. In this regard, Blake did not participate fully in the group brainstorming of ideas and did not attempt to elaborate on why the other ideas brainstormed might be necessary to investigate. Consequently, the central collaborative interaction for Blake was between his ICT searches and book. He used ICT affordance of convergence by ICT memory to help his memory to use his other resource, the book.

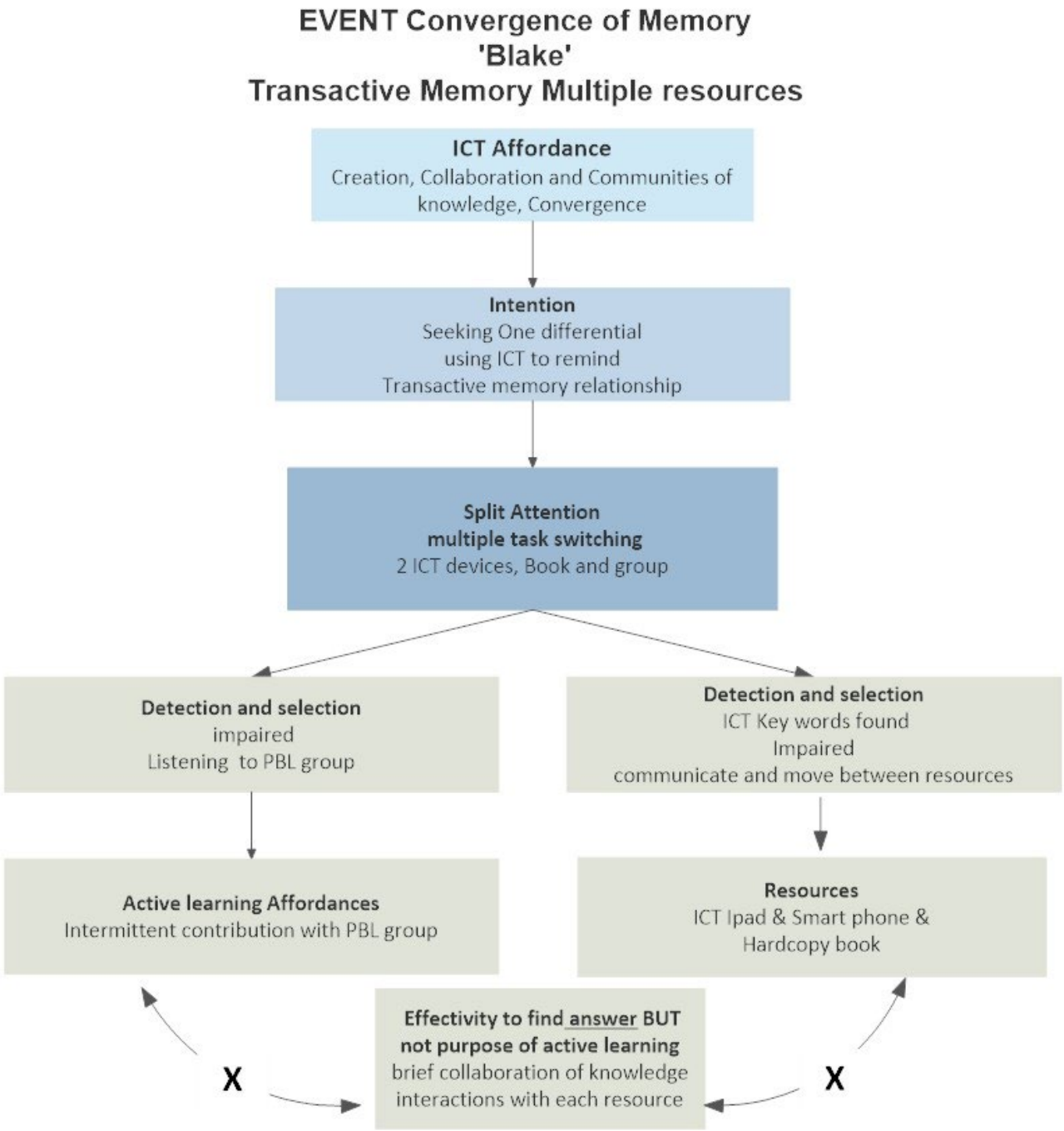

Figure 7-4 Convergence of memory shown as Blake's effectivity to use ICT affordances and AL affordances during the formal active learning PBL tutorial.

Figures 7.4 and 7.5 represent the first in a paired series of figure styles developed for this chapter (except for the group events). The first figure of the series portrays ICT and AL affordances' flow to incorporate the students' effectivities and underlying cognitive processing from data triangulation. I specifically analysed the data for the ICT affordances of collaboration, communities, creation, convergence, and communication for alignment to the AL affordances of construction of knowledge, collaboration, and contextualisation. Therefore, ICT affordances must be perceived or detected by the student before they use them for their learning. That is, the student's intended use of ICT initiates their ICT interaction which is highly dependent upon the students' abilities to apply their prior ICT knowledge to the AL environment

appropriately. Inherent in the process is a shift of attentional focus from the face-to-face to their ICT, which incurs cognitive costs. Subsequently, the student divides their attention between the face-to-face AL affordances and personal ICT affordances. Importantly, in this process are the students' abilities (effectivities) to navigate ICT and AL environments to detect and select relevant resources.

The second figure of the series consolidates the analyses according to the conceptual framework (Chapter 3). In doing so, pictorially represents the students' ICT effectivities' consequences of appropriately accessing and using ICT affordances for knowledge construction and life-long learning skill development.

Therefore, according to Blake's vignette, Figure 7.4 describes his intention to form a transactive memory relationship with the ICT affordances whilst shifting his attentional focus away from the AL group process and task switching between his multiple resources. He attempted to focus on all resources. However, his misinterpretation or lack of understanding of the AL affordances, opportunities, that face-to-face group co-construction of knowledge affords led him to find a specific answer he was looking for but not consider alternatives. Therefore, Blake's directed his effectivities to use ICT affordances as his transactive memory (convergence), and his notes' extensive ICT organisation he created a misalignment with the AL affordances.

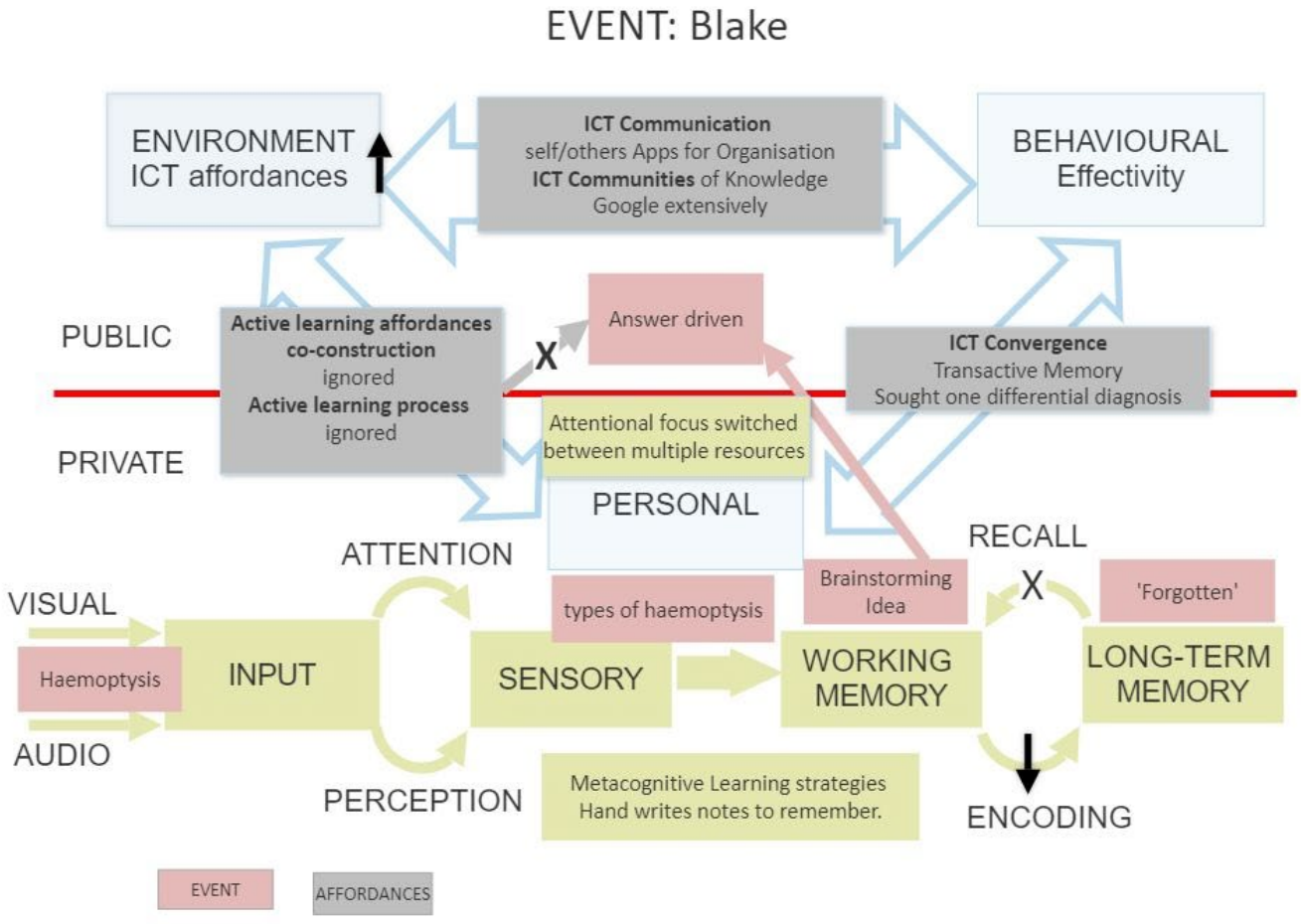

Figure 7-5 Conceptual framework interpretation: Convergence of memory event. The AL trigger of causes of Haemoptysis led Blake's effectivities directed towards seeking one answer.

Interpretation of this event according to the conceptual framework, Figure 7.5 describes Blake's effectivities to use the ICT affordances convergence in the form of a transactive memory relationship as a prompt for forgotten information. Therefore, the ICT affordance of communities, and briefly, collaboratives of knowledge were accessed. Upon finding a specific answer, Blake informed the group, briefly engaging with the AL affordance. But then he returned to his pursuit of using the answer to engage further with another resource (book). Blake continually repeated this behavioural pattern throughout the AL tutorial. The split attentional focus led to increased extraneous cognitive load, which overloaded and negatively impacted recall and overloaded his working memory, resulting in reduced diversity (contextualisation) by listening to the group discussion. In turn, he lowered his encoding of new and or developing his prior knowledge into his long-term memory.

In summary, Blake's focus on his ICT resources and book was detrimental to the AL affordances provided by the PBL group. As such, he did not engage with the co-construction of knowledge and contravened the AL process of elaborating possible mechanisms when considering a range of hypotheses. He focused on one hypothesis and was answer-driven, which undermines the AL process. Finally, Blake had spent considerable cognitive energy to organise his ICT notes by using other convergent ICT affordances to write directly onto his ICT device. The aim was to have neatly organised notes; however, he could not recall the information nor search his notes quickly. Consequently, Blake googled for answers during the PBL tutorial. He mistook the ICT note organisation for learning.

7.3 Kyle (G4S7) Vignette: Contextualisation, Split attentional focus

EVENT
During the problem analysis phase, the medical term for a nosebleed, epistaxis, was sought by

the group, and a discussion ensued.

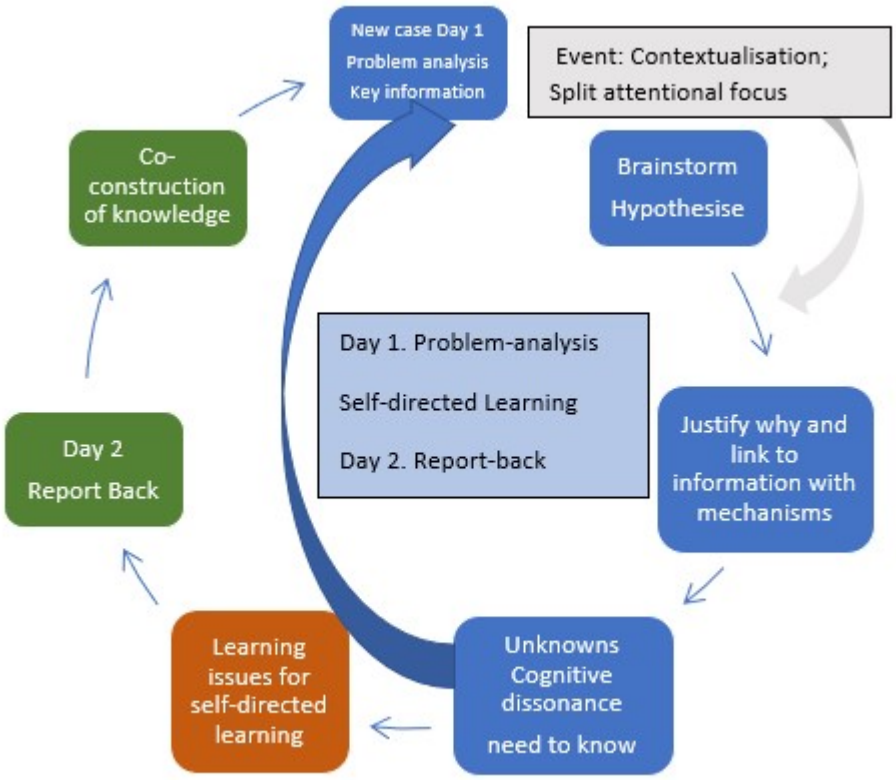

Figure 7-6 Active learning cycle: Contextualisation event occurred during discussion of differential diagnoses proposed and the meaning of the term 'epistaxis.'

Active learning cycle: Convergence of memory event occurred during brainstorming and hypothesising differential diagnoses for 'haemoptysis.'

Kyle wanted to understand the origins of the word 'epistaxis,' so he searched his ICT device. The ICT history log revealed he logged onto the university library website and then searched the clinical decision support website, UpToDate. Kyle then went on to Google and finally briefly opened the Wikipedia page for a nosebleed. He visited five sites during a 12-second interval. The group continued discussing the rationale for considering nosebleed and other differential diagnoses for haemoptysis whilst Kyle was conducting these searches. He was trying to listen to the group discussion and conduct ICT searches at the same time. Kyle was unsuccessful in finding answers online and gave up. Eventually, when he re-joined, the group discussion had already progressed.

Kyle's epistemic curiosity and recognition of how they learnt drove him to seek the ICT affordance of communities of knowledge. He commented that,

> *"I'd heard it [eptistaxis] one time before but clearly it hadn't stuck in my mind because it didn't come back to me when the question was asked "what's the*

other name for that?" I was like [gesture]. Very frustrating that I couldn't remember it so I try to in remembering terms, understand the root of the phrase, particularly if it's one that's clearly Latin or Greek, and I couldn't - that was the main thing I was looking for, was the root of the word so that next time it came up I'd remember it based on how it was related to nose and bleeding and something, but I couldn't actually find it so I possibly will forget it again, knowing the way that I learn".
Interviewer:"So you didn't find anything about epistaxis?"
Kyle: "I found lots of things about epistaxis but not the term because - it was very frustrating. I just - I don't know; maybe I will - now that I've actually mulled it over so many times I won't forget it again. That's the other thing, if I stress about something for long enough then I never forget it". (Kyle)

7.3.1 Background

Overall, Kyle was an active member of the PBL group. He attempted to keep abreast of the group discussion, regularly contributed relevant information and interpretations, and promoted group functionality. During the PBL, he utilised two ICT devices, his laptop, and smartphone. Kyle conducted another three informal searches, accessing formal online resources, used his smartphone, and accessed pdf textbooks during the remaining tutorial. These online searches were each brief with a total of nineteen internet entries over the two-hour tutorial.

7.3.2 Interpretation

Kyle's effectivities of accessing specific information from the ICT affordance of communities of knowledge were hampered by attempting to do several things simultaneously, resulting in task switching that required the splitting of his attentional focus. He was driven by his personal metacognitive learning strategies of seeking meaningful context to retain better the word 'epistaxis,' which aligns with one of the central tenets of AL, namely contextualisation. The group briefly discussed the term but did not pursue it further, unlike Kyle, who searched online for an answer. Consequently, Kyle was attempting to answer his personal learning needs while trying to listen to the ongoing group discussion. By unwittingly dividing his attentional focus between tasks, online searches, and group discussion, he reduced his ability to consciously focus attention on any one task. He thus created an increase in both intrinsic and extraneous cognitive load. The intrinsic cognitive load included thinking about the appropriate keywords and making judgements about the results whilst attempting to listen and follow the PBL group discussion. When he did enter a Wikipedia site, which is fundamentally an ICT Collaborative of Knowledge, he could not quickly find an answer, so he abandoned his search. He increased his extraneous cognitive load by negotiating his ICT device, online library, search engine, and face-to-face group interactions in moving between these sites. At the same time, he added to his intrinsic cognitive load by reading and selecting the appropriate information from these sites to answer his question. Kyle could not pay attention to the multiple communities and collaboration of knowledge simultaneously and consequently failed to find a definition.

As a result, Kyle made simple errors in the online search. Firstly, his ICT effectivities (abilities) at navigating ICT affordances were compromised. He chose unsophisticated broad keywords and made an

inappropriate choice of search engine result. In this case, he selected an unsuitable highly specific clinical database to find etymological information before switching to a general search engine. Consequently, he lost time to resolve the question and lost time to engage in the AL collaborative space afforded by the PBL group process. This contributed to an increase in the extraneous cognitive load. Secondly, he continued to male search errors. In his rush, Kyle selected superficial and non-targeted keywords in the search engine google. Instead of using the term 'epistaxis,' he used the term 'nosebleed' and did not use defining words, such as 'define the word' or 'term meaning' to refine the search question. Kyle's question was the derivation of the word 'epistaxis' thus remained unresolved.

In this vignette, with the time constraints of the fast-moving group discussion, Kyle did not have the effectivity to use the ICT affordances to resolve his question. Compounding this, Kyle became frustrated as he sought this type of information to learn new words routinely. Kyle could not understand why he was having trouble during the PBL. He had expressed frustration at not finding the answer several times during the VSRTA interview and eventually concluded, *'I couldn't actually find it' (Kyle)* and abandoned the online search.

His affective state of frustration may have represented an increase in extraneous cognitive load, further disrupting his ability to conduct a quick search.

Finally, at other times throughout the PBL, Kyle successfully conducted informal searches and accessed formal online resources and pdf textbooks. In these instances, he was able to follow the group discussion flow, and at times the group paused to allow other members time to search online. The group was co-constructing knowledge through punctuated access to the ICT collaborative and communities of knowledge without loss of cognitive resources due to task switching.

A number of things compromised Kyle's level of effectivity to negotiate the ICT affordance in the epistaxis event. He had trouble recalling or locating what terminology to look for whilst manipulating the search engines to get information quickly. This illustrated how not knowing due to lack of specific prior knowledge can reduce students' ICT search effectivity. Additionally, this situation is exacerbated when stressed, under the pressure of time constraints, and causing rushed judgements, culminating in disruption in his ICT search effectivity. Kyle struggled to negotiate the two threads of asynchronous stimuli, group discussion, and online search, resulting in decreased cognitive processing capacity leading to failure to achieve his intended learning goal. However, he was successful in conducting other online searches later in the tutorial. The difference being these later searches were common learning issues for the whole PBL group and, therefore, more meaningfully contextualised. So, it is more likely that Kyle had a more extensive long-term prior knowledge to draw on to inform his searches when under pressure. Consequently, by seeking ICT to find an unknown, Kyle's effectivities lead to fruitless time-wasting ICT interactions under these pressure conditions.

This event also highlighted a student sharing a metacognitive strategy with their group on how to remember new medical words. However, the group was not interested. Kyle's need to contextualise his

learning could have suggested alternative metacognitive strategies to others in the group as AL affords students to collaborate on shared group goals of gaining semantic memories and gaining episodic memories. Kyle did share his learning technique of understanding the etymology of medical terms instead of pure memorisation, which could have potentially resonated with others in the group as a learning strategy. However, the group moved on and did not share Kyle's interest. Kyle could have chosen to make a written or mental note to himself to look it up after the group meeting in this event. In this case, Kyle sought information for his personal requirements, which were misaligned with the AL affordances of PBL.

7.3.3 Summary

Figure 7.7 summarises Kyle's effectivities in addressing his specific metacognitive learning intentions during the PBL tutorial. As these were personal learning needs, he shifted his attentional focus between his ICT affordances and the AL group. Kyle's effectivity to access the ICT affordance of communities of knowledge was hampered due to this task switching, which divided his ability to focus his attention on either task. Consequently, he made errors in his online search resulting in him abandoning his search and returning his focus to the AL affordances of the PBL group.

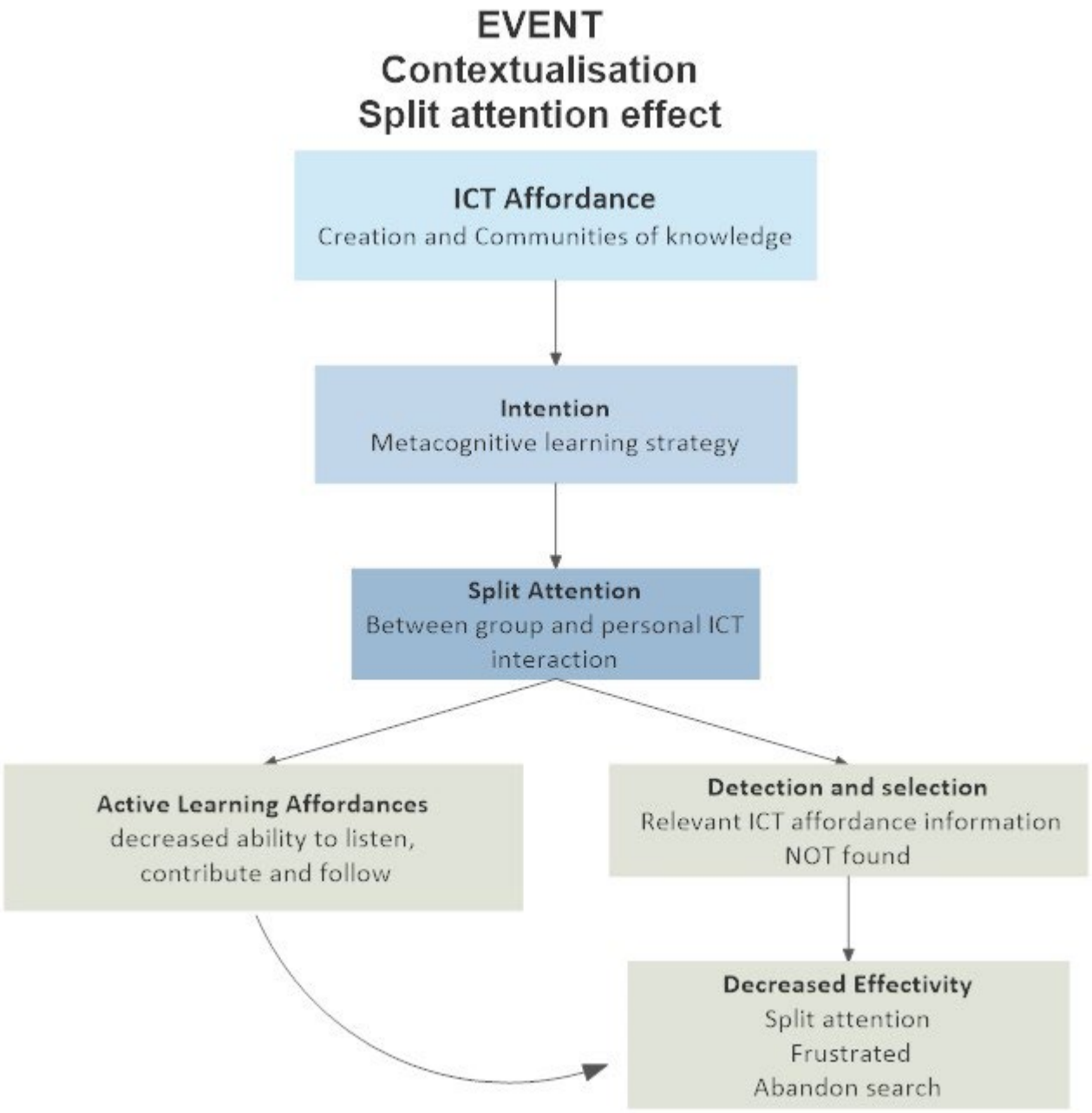

Figure 7-7 Contextualisation: Kyle's effectivities to negotiate ICT affordances resulted in split attention effect.

Figure 7.8 describes the flow of Kyles' cognitive and metacognitive processing. He initially sought the opinion of the group (AL affordance), which was unsuccessful. This led him to seek the ICT affordance Collaborative and communities of knowledge. Again, he was unsuccessful and did not enter any ICT knowledge collaboratives due to ill-defined keywords. His attempt to follow the group discussion and pursue his own learning needs resulting in an increased cognitive load that overwhelmed his working memory capacity. He essentially was not able to focus on one task and failed at both. He realised this was happening and made a conscious decision to re-focus on the PBL group and leave his personal learning need for later. Therefore, Kyle abandoned his search for the meaning of the term 'epistaxis' to re-focus on the AL affordances of the PBL group.

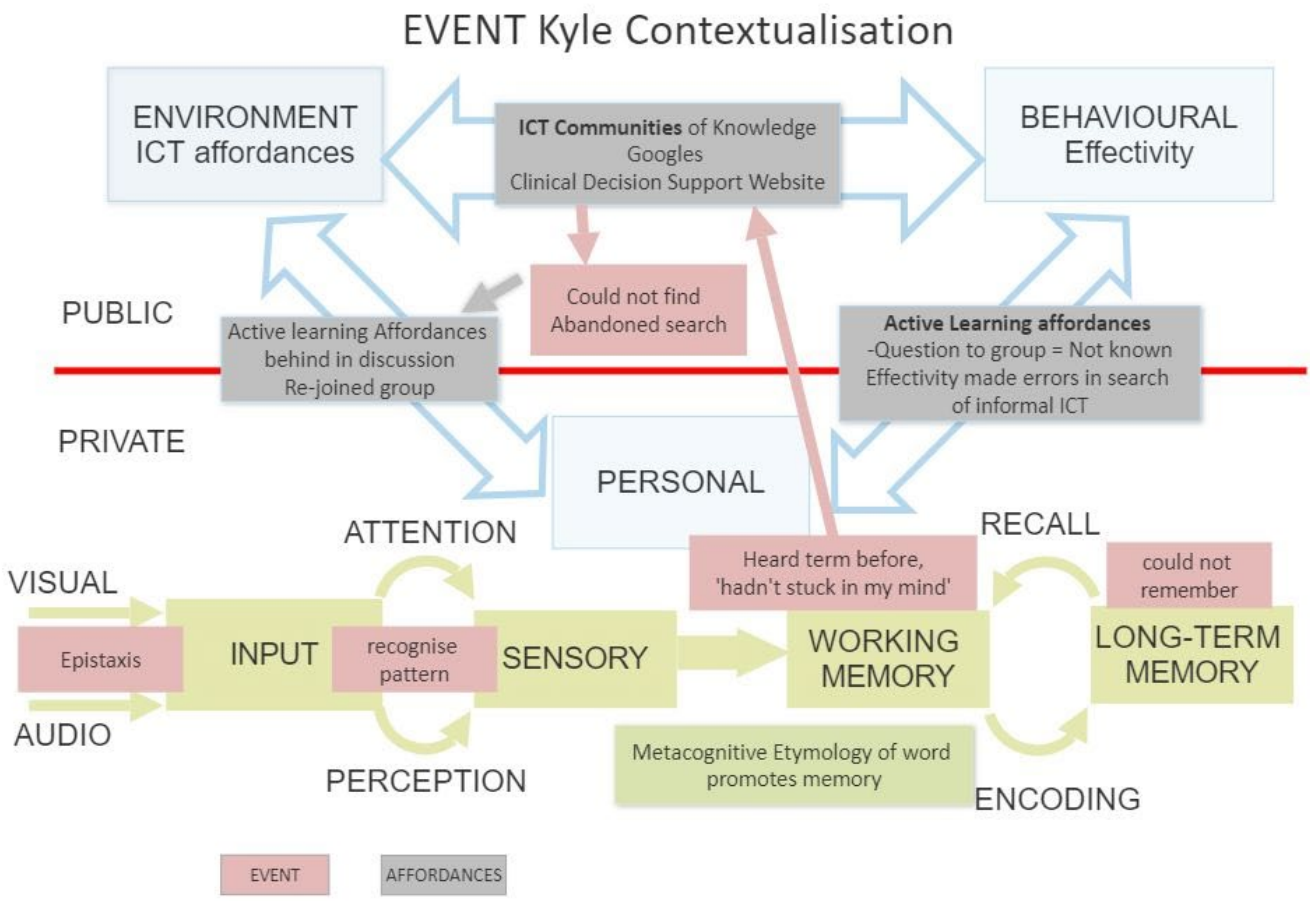

Figure 7-8 Contextualisation: Conceptual framework interpretation of the event (pink) with ICT and AL affordances (grey).

Salient points from Kyle's contextualisation vignette are when a simple ICT search task to resolve an unknown (lack of prior knowledge) under time pressure and split attentional focus conditions fails to achieve either successfully. The intention of contextualise learning aligns with AL affordances. However, the unforeseen difficulties of accessing ICT affordances to seek new knowledge resulted in the misalignment of ICT and AL affordances to create/construct new knowledge.

7.4 Parker (G6S6) Vignette: Co-Construction of Knowledge

EVENT

During the Problem analysis phase, the event described occurred when students were linking the laboratory results to the hypothesised differential diagnoses as per the AL cycle Figure 7.9. The group was discussing why the patient's Haemoglobin would be low in the chronic kidney failure case.

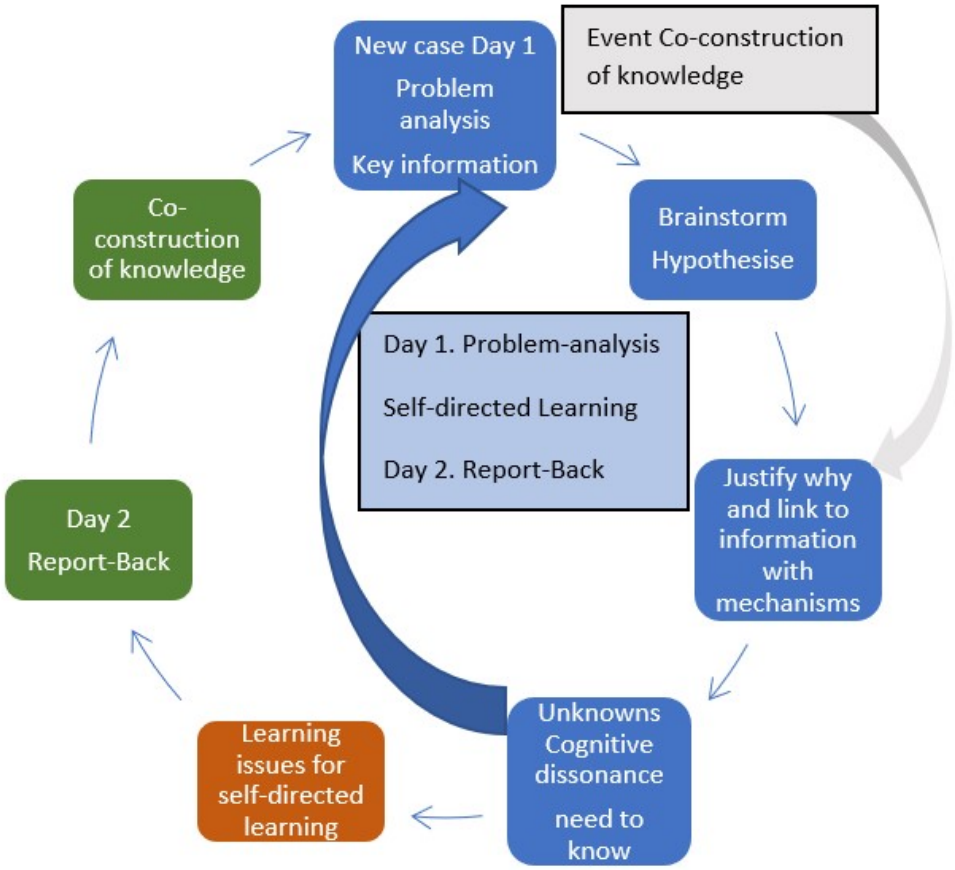

Figure 7-9 Active learning cycle: Co-construction of Knowledge event occurred during group discussing underlying mechanisms to understand the case.

A question directed the group discussion from the tutor *'why does the patient have low haemoglobin? (Tutor from PBL)'.* Parker quickly offered the brainstormed idea of *'thalassaemia' (G6S6 from PBL).* The tutor and group responded that they considered this unlikely. Parker then searched through her paper notes and reflected during VSRTA interview, *'I have read about it but have forgotten' (Parker)* then added *'then I go online' (Parker).* Throughout the tutorial, this behaviour was repeated; offer an idea, search paper notes, and read online open tabs (clinical decision support website; UpToDate) on iPad, followed by an online search on smartphone (no ICT log provided).

> *"So quite often I'll use the internet …because it's so quick and fast, just a quick Google search to get a definition to remind myself, because there's so many terms that come up. So that helps jog my memory, 'Okay yep, that's what it was, forgot' or, 'I thought that's what it was, confirmed'; I find that really helpful". (Parker)*

Parker then shared information with the group. She wanted to clarify her own knowledge but also proffered information to the group for discussion. For example, in this event, she further refined her idea from Thalassaemia to *'It's because of the bone marrow'(Parker)* after going online. Her suggestion started a cascade of ideas from the group and discussion about bone,

bone marrow, and the kidney's role.

> *"I think … I'll think of something and I'm not sure if it's right and so I'll suggest it, but usually when I think of something I've only got part of an idea so most of the time I'm not quite sure what the mechanism is or if it's relevant in that scenario or not, especially in the first tutes because it's usually really new stuff that you don't know. So, then I'll try and just go back and check it to see if I was right or to see if there's any additional information". (Parker)*

The tutor questioned throughout, and students remained focused. Only one other student (G6S2) had ICT devices. The rest used paper notes only.

Parker was observed switching between paper notes, iPad, and smartphone during the tutorials.

> *"And I use my notes (paper) a lot, especially if it's something I know I've done but I can't quite remember a term or I can't remember how it works, or I can remember something but I can't remember what receptors it blocked or something like that and then I'll go back to my notes because I know where I've written them in my notes and go and have a look, if I know that I can find that faster than on there (Smart phone)".(Parker)*

The group progressively co-constructed possible mechanisms and identified areas they did not know or were interested in learning more about. In conjunction with the group, Parker wrote these as learning issues on the whiteboard for self-directed learning and the report back tutorial.

Summary

This event describes the flow of the group co-constructing their understanding of the scenario by each student participating and offering them, not fully formed, ideas by accessing ICT affordances that were contributed by Parker and G6S2, who checked online as the discussion evolved.

7.4.1 Background

Parker used paper notes, iPad, and smartphone throughout the tutorials. The internet access was unreliable on iPad (ICT history log provided); therefore, students often resorted to conducting searches on their smartphones. Parker had a previous degree of Bachelor of Education.

7.4.2 Interpretation

The AL affordances of construction and collaboration were facilitated by *just-in-time* information that increased and helped direct group discussion, group functioning as a whole, and sharing of understandings and knowledge. Parker's effectivities to negotiate her ICT affordances within the AL affordances environment led to positive group interdependence interactions. She successfully obtained and contributed timely intermittent pieces of information from the ICT affordance of communities and by entering the communities of knowledge.

Parker's willingness and confidence in sharing ideas recalled from her memory are integral to the original

constructivist instructional method whereby students activate their prior knowledge from long-term memory and not rely on ICT for help. She was not seeking a definitive answer. Instead, she sought to understand the link in her thinking between the previous case on Thalassaemia and the current case with anaemia. Ready access to ICT affordances enables many students to check their ideas before they share with the group, which truncates discussion. In this event, however, Parker demonstrated an important aspect of her effectivities to incorporate and control ICT affordances in the context of the AL affordances. Therefore, the just-in-time information contributed to refining her original unvetted idea that, when shared with the group, led to further questioning and elaborating possible underlying mechanisms. The group developed their learning issues based upon these deliberations.

7.4.3 Summary

Figure 7.10 shows the ICT affordances of collaboratives and communities of knowledge to refine Parkers' prior knowledge and helped contextualise the new PBL case to previous cases the students had studied. Through this process, the student successfully navigated her effectivities with these ICT affordances with the AL affordances of collaboration and construction of own and group knowledge. In this instance, the affordances of ICT and AL were in alignment.

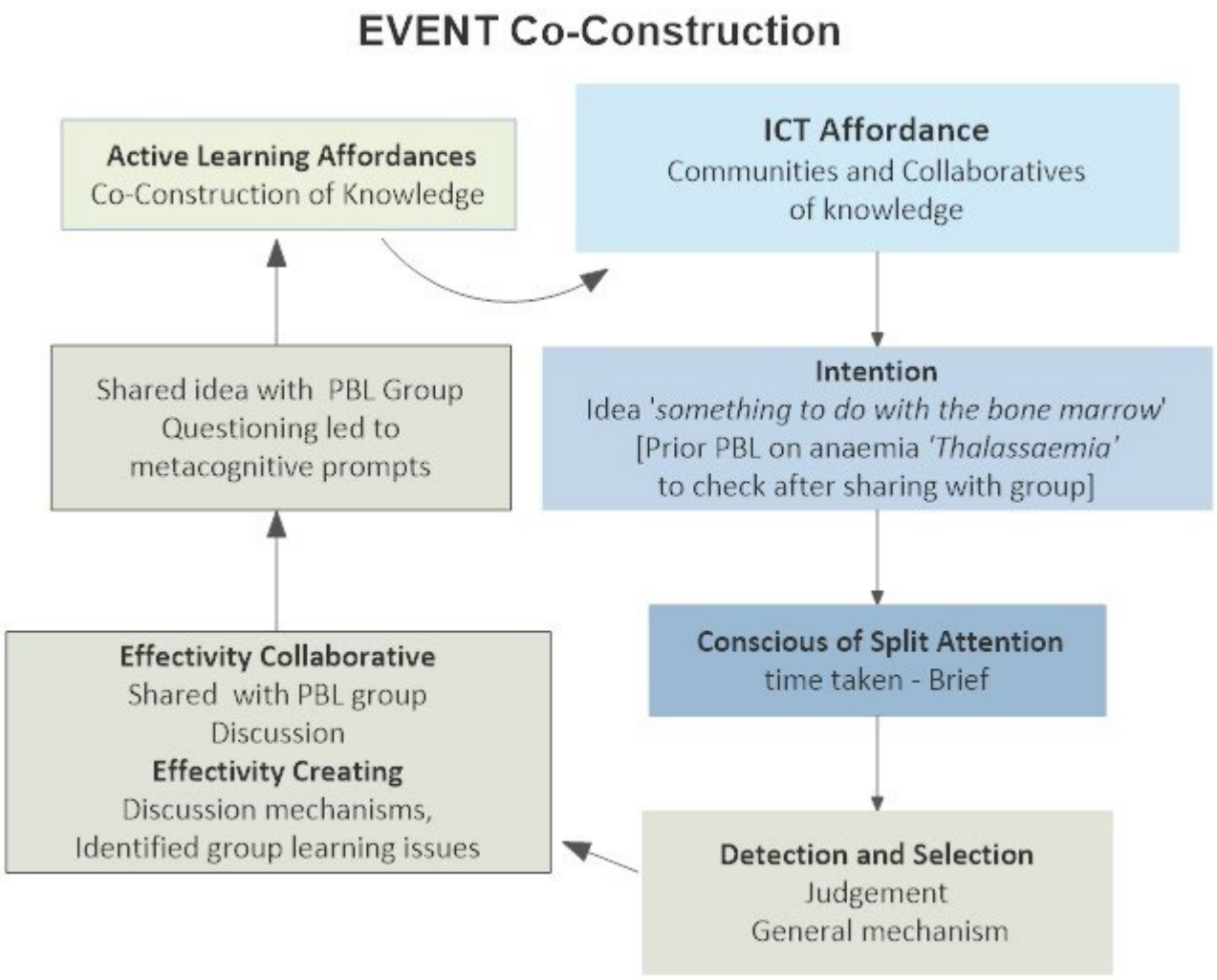

Figure 7-10 Co-construction of knowledge: Parker's effectivities translated into the creation of collaborative discussion and construction of knowledge.

Figure 7.11 describes the individual student's cognitive processing according to the conceptual framework. From a cognitive perspective, Parker activated her long-term memory, recalled a contextualised idea from a previous PBL case, and opened the idea to the group. Parker used her attentional and perceptual processes to recognise patterns from previous knowledge. She activated her prior knowledge and applied it to the new case. This transfer of knowledge through recognising contextual patterns typifies AL processes.

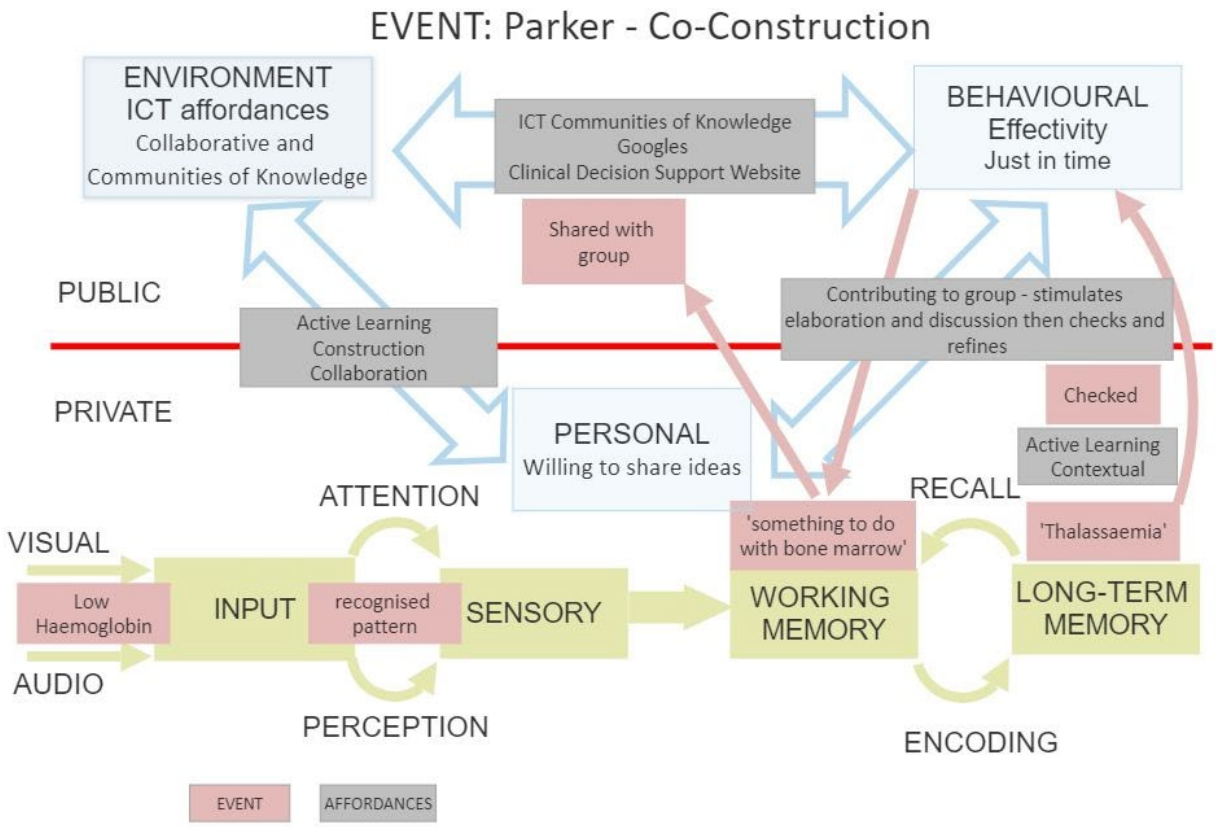

Figure 7-11 Conceptual framework interpretation: Co-construction of knowledge event (pink) with ICT and AL affordances (grey).

Interestingly, the group and tutor thought Parker's idea was not relevant. However, Parker used her ideas (prior knowledge) to communicate with the ICT affordances and sought just-in-time information from the ICT collaboratives and communities of knowledge to verify. She had enough prior knowledge to interact with the ICT affordances successfully. Once she refined her idea to 'something to do with bone marrow,' she shared it with the group. Which then stimulated the group to elaborate upon the concept and identify what they already knew and did not know. The group went on to develop learning issues for SDL between tutorials.

The AL affordances for co-construction of knowledge were promoted by the underpinning learning processes of stimulating interest and elaborating group ideas. An important aspect was when timely ICT information is shared, as it can contribute to the group to the context and flow of the discussion. Therefore, enabling elaboration by the individual and the group led to continuous collaboration with minimal noticeable interruptions. In conclusion, this vignette demonstrates that when ICT effectivities are skilfully aligned with the ICT and AL affordances, learning ensues that benefit individual learning and the PBL group.

7.5 Ryan Vignettes: Transactive Memory and Control of Intrinsic Cognitive Load.

EVENTS

Two events describe how Ryan employed his prior ICT effectivities with ICT and AL affordances during PBL as seen in Figure 7.12.

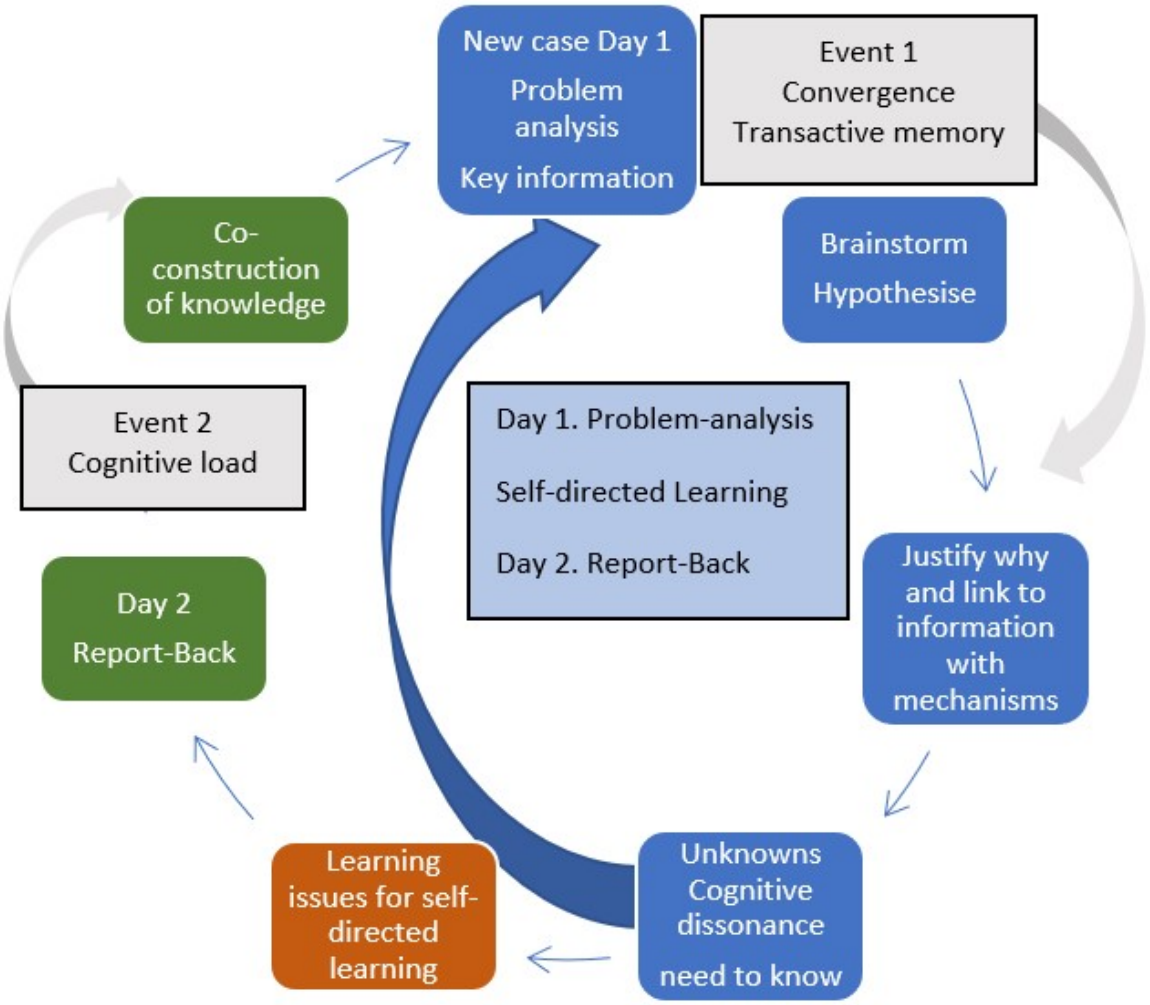

Figure 7-12 **Active learning cycle: Convergence, Transactive Memory, and Control of cognitive load events during problem-analysis and report-back.**

The first event occurred during the problem analysis phase. The group had brainstormed ideas about the potential causes of high blood pressure and were discussing what they understood. They were justifying through activating their prior knowledge as to which differential diagnosis was more likely. Ryan used keywords for five consecutive searches at this stage, which were directly related to the tutors' questions. He searched hypertensive crisis and malignant hypertension.

> *"I had to refresh myself on so I'd Googled a couple of terms for hypertension to make sure that I knew what was happening, kind of like looking up a word in the dictionary, just so you can follow along by knowing what it means without getting caught up on it".(Ryan)*

He read out the first search engine result (SER) snippet prefacing it was from WebMD to group. He did not open the site, nor did he contribute further to this discussion despite the group continuing to discuss. He then opened an 'everyday health site' pitched to non-health viewers.

Ryan then re-joined the group by listening. He googled the term 'ANP.' This was not mentioned by the tutor nor the group, so it was from his prior knowledge or research he undertook to prepare the tutorial. Ryan conducted eight searches that were related to the differential diagnoses generated by the group. He became more engaged, listened, and contributed to the discussion. At this stage, he provided general mechanisms but became overwhelmed and started using terms such as, *"stuff like that" or "what not" (Ryan)* as part of his rationale. Another student helped by providing more in-depth mechanisms, to which Ryan listened and nodded along to.

The second event occurred half an hour into the report-back tutorial. The group was reporting back the learning objectives, and Ryan was participating. However, when the group became engrossed in discussing the difference between the two conditions, he started reading his laptop until his turn to present towards the tutorial. Initially, I thought his behaviour indicated a student having trouble following the conversation and using his ICT affordances to search for information. However, he commented in the VSRTA that,

> *"… they were arguing over classifications and I feel like I'd already done - because I'd already done that LO and I'd already had a relatively good handle on the classification and I knew that the pedantics of the classification weren't really that relevant so at that point I tuned out and I was reading some news. That was actually a news page that I was on, scrolling through reading some news stories while they fought it out with the classification". (Ryan)*

He distracted himself with newsfeeds for the next hour, looking up occasionally, he further commented during the VSRTA interview,

> *"but more to the point I either lost concentration or I didn't want to get too confused based on what I already knew. Sometimes if you over think it, it can get almost confusing". (Ryan)*

When the tutorial was nearly finished, he re-joined the group and presented information regarding the Learning Objective he had prepared. Then he took photos of the tutorial board work to post on the group Facebook page.

7.5.1 Background

Ryan's undergraduate degree was in computing science, and he commented that *'he had not had to*

study much before' (Ryan). He had minimal health science prior knowledge.

> *"I had no background in anatomy, biology, science of any form.*
> *It has been quite steep (learning curve)*
> *… Well, I guess I've managed it well enough but it's been just consistent hard work and making sure if there's things I don't understand, that I go back and try and build the foundation of it". (Ryan)*

To compensate, Ryan extensively prepared for the PBL tutorials, especially the Problem-Analysis tutorial. He accessed formal ICT information, attempted to complete all learning objectives, and was familiar with the flow of the case as preparation for the problem analysis tutorial.

> *"I don't like surprises… to have understanding of what is expected of that week and what to expect in the case … and sometimes the scope of the lectures a well is a good judge of depth". (Ryan)*

Additionally, he used informal ICT resources circulated by the medical students from previous years to gauge the depth of learning.

> *"…going by previous notes from previous years for those learning objectives; they can sometimes give a good depth". (Ryan)*

Behaviourally he meticulously organised his notes and resources. Resources include over 100 PDF textbooks, he used a free-form-information-gathering program, OneNote, to organise weekly topics. Described how he referenced his weeks:

> *Interviewer: "what textbooks have you got"?*
> *"Everything. I have a very large repository of PDFs that I manage and organise but usually the first port of call for clinical stuff would be the Oxford handbooks … the Oxford handbook of Clinical Medicine is something that I've seen a lot of registrars carrying around".(Ryan)*

He was influenced by seeing registrars (trainee specialists) carrying the Oxford handbook and as such collected the entire Oxford handbook series in PDF copies.

However, the searchability of these extensive notes was limited.

> *"Searching through my notes I'd have to know which week it was from, I'd have to know which LO I would've covered it under. It's probably just a lot quicker to Google I would say". (Ryan)*

Yet despite these limitations of his online notes, he stated;

> *"I think … the greatest skills that I've acquisitioned in first year for medicine is knowing where to find resources, knowing how to distinguish the quality of the resources from the depth that they go into and knowing which is important for what situation. I think that's been one of the undocumented skills that everyone has kind of acquired". (Ryan)*

He invested considerable time and effort in collating and creating these highly extensive and organised electronic notes. This was at odds with his previous degree in IT as he used old library-style cataloguing,

which he could not search, rather than, for instance, a searchable database format. He had not aligned his effectivities from prior knowledge of ICT with the ICT affordances and AL affordance.

However, his drive for this organisation was linked to his ICT study strategy. He used 'spaced repetition applications' that were compatible with his OneNote program to generate flashcards. The space repletion program, when he set it up, would routinely test his recall of information at intervals based upon an algorithm of when memory needs refreshing.

> *"My revision plan is to create flash cards for all of the blocks based from my notes and some things from lectures - and they're all digital flash cards - and then work through them throughout the genetics block and then swot vac". (Ryan)*

When asked about his learning strategies, he commented,

> *"I sort of read through it (case) a little bit beforehand just to have an idea as to what is going on and if there's any terminology, I don't understand I'll just Google away [and I'll] write down. I do something similar during the actual tutorial as well where if there's anything that I don't - like terminology that I don't understand I'll either write it down and either immediately Google it or I will look at it later".(Ryan)*

The VSRTA interview was conducted three days after completing the videoed PBL, and Ryan had commenced the next PBL case preparation. He commented that,

> *"I can't remember what he (case from videoed PBL) had but the case this week is a UTI so if I wanted to understand more about UTIs …". (Ryan)*

With the prompts from replaying the videoed segment, he recalled,

> *"… I think essential in secondary or essential - I've already forgotten but, yeah, one of them basically means they have no idea and the other one means 'we have some idea". (Ryan)*

Overall, Ryan's perspective of the medical course was one that required him to be self-sufficient.

> *"I'd heard that this course (Medicine) was very self-directed learning type stuff. I don't want to be too reliant on official material and what not". (Ryan)*

This background of Ryan's perspective on how he says he learns has provided a critical understanding for interpreting the events described below.

7.5.2 Interpretation

The interpretation of these events collectively demonstrated a student who had technical effectivities to utilise the ICT affordances but had minimal effectivities on aligning these affordances with AL affordances for learning. It was almost as though he expected that the ICT information store represented his learning.

Ryan's interactions with the PBL group and ICT were initially difficult to decipher. On the first view, his behaviour appeared to reflect he was intellectually confident. He would participate, and his peers would listen and question. However, upon more in-depth analysis, salient points emerged from repeated observations of the PBL video and reading of the VSRTA that reflected a student struggling to keep up.

Keywords such as, *"'steep learning,' 'what not,' 'stuff like that' and 'avoid confusion'" (Ryan)* recurred and highlighted important signposts to this student's learning level and needs.

In light of the above assessment, Ryan attempted to be fully prepared for PBL by gathering answers to the PBL problem as he stated, *"I do not like surprises". (Ryan).* He focused his effectivities of using ICT communities of knowledge, both formal and informal in origin, to find these answers. For example, informal sources he sought were pre-written learning objectives from previous year medical students. These had been uploaded online and stored on his ICT device. Consequently, preparing for the tutorial in this way provided him with enough intellectual confidence to participate. But he was focused on amassing a vast amount of information but did not appear to focus on learning for understanding.

During the tutorial, he offered SER snippets of information but did not discuss his points in any depth that may have contributed to co-constructing individual and group knowledge. His knowledge was too tenuous. Despite his extensive ICT note preparation and reading of the entire case before PBL, he conducted online searches during tutorials before contributing information to the group. His ICT notes were unsearchable, and he did not trust his memory. Hence he resorted to online search engines. The ICT history logs reveal his searches were superficial, and he used search-engine-results (SER) snippets of information from the ICT communities of knowledge without entering the ICT collaboratives of knowledge sites. To do this would have required him to make judgements regarding the information. The snippets provided abbreviated information from the full text. Ryan trusted the SER snippets more than his judgement. He tailored his ICT searches according to his knowledge level, used cues from his tutor, and selected SERs accordingly. Although the information he found was superficial, he did share it with the group.

Ryan relied on the ICT affordance of convergence. He formed a convergent transactive memory relationship with his ICT, albeit an unsearchable one, to inform and *'jog his memory.'* He entered a cognitive relationship with his ICT throughout the PBL tutorials. He actually thought he was highly successful in accessing the ICT affordances for learning and developing his vast convergent ICT library. Yet, he had no insight into the fact he was not forming meaningful intrinsic long-term memory schemas. He had already forgotten the previous case. He was only superficially engaging with the information and missed the opportunities the PBL group afforded of rehearsal and performance of new information to develop contextually deep learning schemas.

Essentially, he used ICT to control and escape exposure to the increasing demands of the intrinsic cognitive load. In fact, he controlled the intrinsic cognitive load for PBL to fit within his own perceived level of knowledge and did not push himself outside his comfort zone. As a result, he did limit his learning. The AL affordances provided by being part of the PBL group could extend his learning beyond his comfort level, but he was uncomfortable with the level of the groups' knowledge. Hence he used ICT affordances to set his own perceived Zone of Proximal Development (ZPD) (Vygotsky, 1980). In doing so rejected the groups intellectual challenges and the increasing challenges of the PBL cases. He misinterpreted his learning effectivities of finding answers with the face-to-face benefits of the AL affordances. As such, he

created a mismatch between the ICT affordances available for learning and the AL affordances resulting in him being unable to remember the information and the case from the previous week. In this instance, the student's learning from earlier cases had been shallow, superficial, and ICT catalogued to learn at a later stage through his spaced-repetition application. Therefore, this delay meant he was not incrementally building upon his prior knowledge to engage meaningfully with each new cases' increase in complexity. ICT affordances were extensively used as a repository of information to be memorised at a later stage, which does not bode well for deep understanding and construction of knowledge. Consequently, his learning strategies were to limit the depth of information he had to process (to manage intrinsic cognitive load), and ICT enabled him to distract himself during the tutorials to avoid confusion. All of which led to him increasingly trail behind the rest of the group and made it harder for him to catch up.

Ryan directed his prior ICT effectivities in a way he perceived would benefit his learning. He had extensive ICT experience as an IT programmer, used social media, and, therefore, very familiar with ICT. However, he was not accustomed to using ICT affordances for learning and studying medicine led him to working out how to learn in this environment.

> *"I haven't really had to study very much in my previous degree because it was more of a just pure problem-solving. There wasn't really much - it just wasn't in the same tone as [medicine]". (Ryan)*

Ryan used his prior effectivities to maximise the ICT affordances available to help him. In this way, he could filter and control the complexity of information he gathered to learn. He was personalising his ZPD to construct a level of knowledge he was comfortable with through utilising the ICT affordance of creating knowledge at a level commensurate with his learning needs.

For Ryan, having access to ICT device(s) provided him metacognitive control for the impact of cognitive load generated before, during, and after the PBL tutorials. Ryan reduced the effect of, 'surprises' and 'uncertainties',(Ryan) that are necessary for PBL (or learning in general) by controlling the learning intrinsic cognitive load demands through access to ICT. Simultaneously, having pre-prepared ICT resources, notes and knowledge bolstered his germane cognitive load, increasing his intellectual confidence to engage with the PBL group. Increasing germane cognitive load through careful instructional design elements to aid students' information processing has been the educators' domain to scaffold students learning (Sweller, 1988; Van Merriënboer et al., 2003). So, in AL that promotes SDL, the organisation of notes should increase germane cognitive load. Yet, Ryan could not search his extensive ICT notes, which led him to search online for quick answers, increasing unwanted extraneous cognitive load. Therefore, despite attempting to increase germane cognitive load, he inadvertently decreased it and increased extraneous cognitive load instead. Plus, in combination with intentionally keeping intrinsic cognitive load low resulted in creating an ineffective learning environment that was not conducive to learning and forming personal long-term memories, hence he forgot.

The report-back event highlighted the fragility of this student's confidence in his prior knowledge. By withdrawing from the group discussion and remaining focused on his ICT device should have signalled to

the tutor and the group potential difficulties with the PBL content. On first analysis, I too did not perceive this outwardly confident student was struggling and thought his ICT searching to be commensurate with the flow of the group discussion. Initially, he commented that he had already done that learning objective and did not want to get involved in the *'pedantics'* of the discussion. Essentially, implying he did not need or want to learn collaboratively. His comment also confirmed this.

> *"I'd heard that this course was very self-directed learning type stuff. I don't want to be too reliant on official material and what not!" (Ryan)*

As such, Ryan demonstrated he did not consider he needed to engage with the AL affordances of collaboration, construction, and contextualisation. He decided to withdrawal from the group and kept an ear open to interesting bits of information. He further commented that he did not want to become confused and lost concentration. Therefore, Ryan used his ICT device to distract himself from the group's discussion. He escaped the groups' discussion to preserve his tenuous grasp and perspective on the topic. In this process, Ryan preserved his own constructed level of intrinsic cognitive load and minimised his discomfort associated. In other words, he consciously kept his ZPD to what he knew, which negated the educational role of ZPD to extend his exposure to information and take him out of his comfort zone. The PBL case and determined group level of ZPD were ignored by Ryan 'losing concentration' and retreating into news feeds on his ICT device. He denied himself the learning benefits of rehearsal and performance of his tenuous grasp on his new knowledge through participating with the AL group process.

This became evident when, three days later, at the time of the VSRTA interview, Ryan could not recall the videoed PBL case. He was preparing for the next PBL case. Whilst he demonstrated efficacies to utilise ICT from a technical perspective, he mistook these endeavours for learning. Hence, he did not remember. He had compartmentalised and misconstrued learning to be a task of collecting and organising information. As a consequence, he created extensive ICT repositories of information, notes, answers to learning objectives, and had amassed vast online and PDF resources. He commented that he thought this was the most significant skill he had developed during his study of medicine. Yet, he could not remember the information, nor was it searchable. He demonstrated effectivities at collating and organising information, but the purpose of learning for understanding was profitless. The information remained as information and was not contextualised and constructed into long-term knowledge structures. Despite him controlling his level of intrinsic cognitive load during PBL, his digital notes had inadvertently created the unrealistic and unnecessary excessive intrinsic and extraneous cognitive load. Yet, he considered his digital notes vital to his learning.

He commented that digital notes were vital as he would create digital flashcards in spaced repetition applications, and these would serve as his method of remembering. ICT flashcards would be created at a later date when he was studying for exams.

> *"My revision plan is to create flashcards for all of the blocks based from my notes and some things from lectures …work like mad trying to do 500 flashcards in a week". (Ryan)*

By delaying his learning, he created an unsurmountable and unrealistic intrinsic and extraneous

cognitive load. He mistakenly confused collecting information with learning. The task of collecting had displaced the goal of learning. Because of this, he focused on the wrong purpose and missed out on the powerful AL tenets of construction of knowledge working collaboratively with peers through contextualisation and relevance of the PBL to medicine. Despite being proficient with his generic ICT skills, his efforts were unsearchable stores of information. He had not utilised the ICT affordances for learning, nor had he engaged with the AL affordances available to him through face-to-face PBL tutorials.

7.5.3 Summary

Figure 7.13 describes the ICT effectivities Ryan attempted to employ to access the ICT affordances and his ability to use the AL affordances. He intended to create a usable convergent ICT library with vast amounts of information. However, as it was unsearchable, he resorted to relying on ICT search engines. The metacognitive strategy of collating and organising his vast unsearchable digital notes appeared to be for his spaced-repetition application development. His intention to didactically remember uncontextualized information contravened the underpinning tenets of AL. He had misinterpreted the purpose of AL and self-directed learning by relying on the internet to remember for him. Resulting in practically none of the ICT affordances and AL affordances being appropriately used for long-term memory and life-long learning.

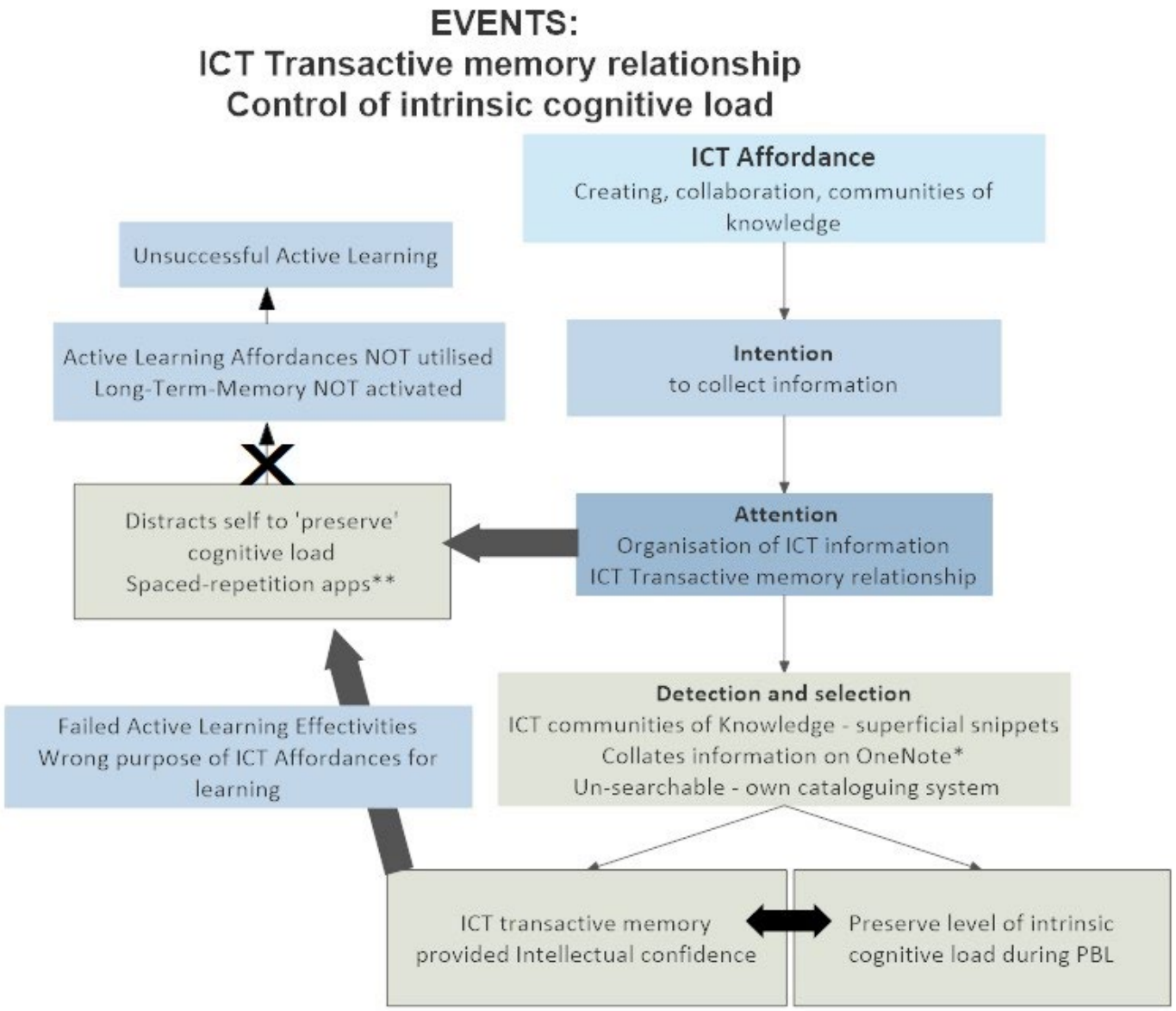

Figure 7-13 Convergence: transactive memory relationships and control of the intrinsic cognitive load.

*** Free-form Information gathering program. ** ICT flashcard application.**

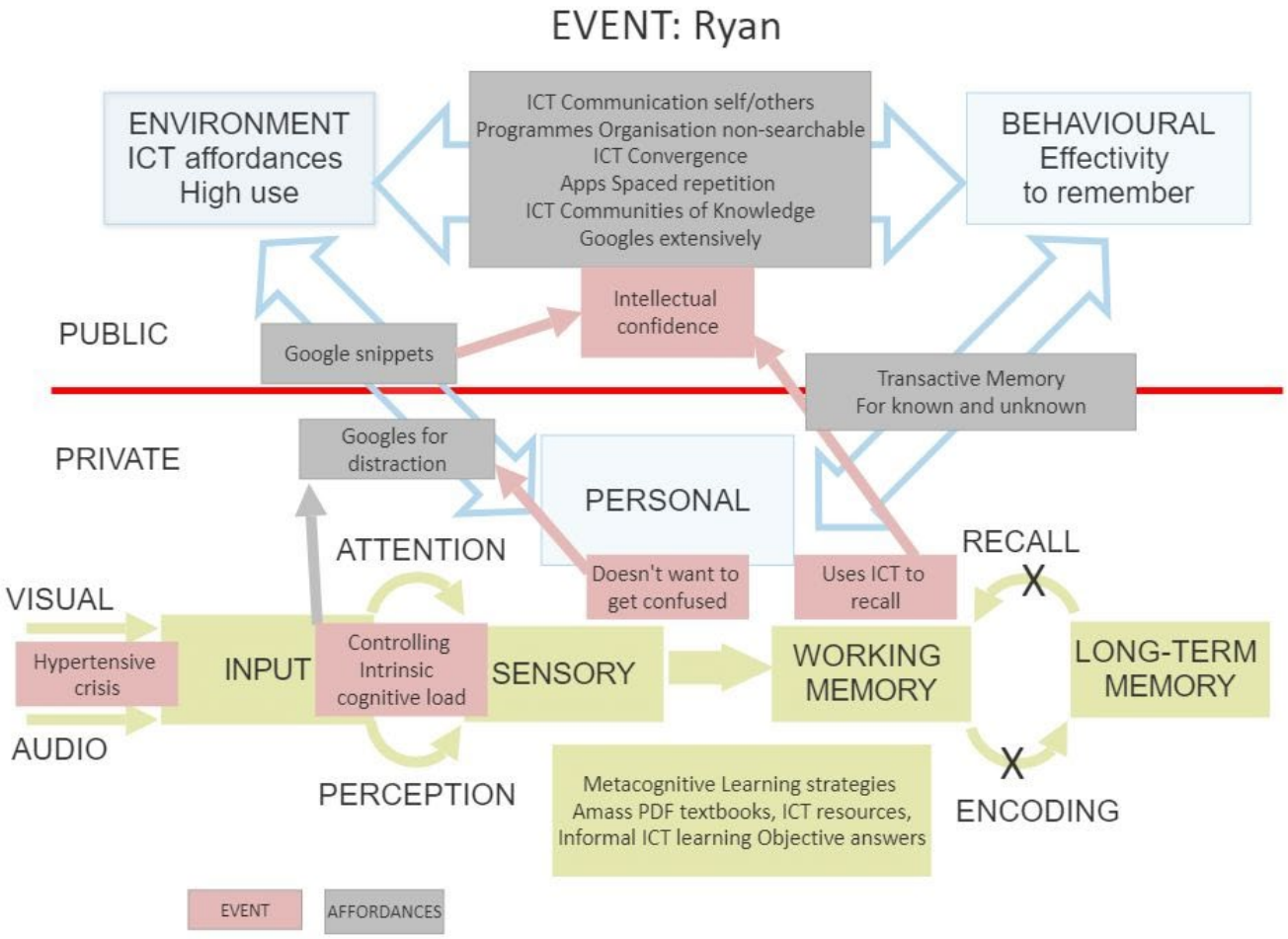

Figure 7-14 Theoretical framework interpretation: Convergence, transactive memory, and Intrinsic cognitive load control.

Figure 7.14 describes Ryan's abilities in the context of the conceptual framework for learning. Ryan directed enormous amounts of extraneous cognitive load energy, mistakenly, into collecting and organizing vast amounts of information as learning. He behaviourally relied on the environmental determinants to recall information he has stored on his ICT device. However, Ryan could not search his digital notes, so he conducted simple search engine snippets from the ICT Communities of Knowledge. He did not create his own keywords and depended on the terms used by the tutor and others. These sites were not entered or engaged with further. The quick search provided him with the intellectual confidence to share information found with the PBL group. Ryan, behaviourally, is heavily reliant on his environment of ICT affordances for all aspects of his learning. He not only ignored the AL affordances but also did not understand his own cognitive and metacognitive needs. Ryan fell into relying on ICT to learn for him and had no strategy to assess his learning level.

7.6 Avery (G9S2), Brooklyn (G9S3), Logan (G9S4) vignettes: Collaboration, Communities, and Communication

The following events addressed the research objective to understand how face-to-face group collaboration during the PBL tutorial was impacted when students supplemented their learning using their ICT affordances. Three students' effectivities to utilise ICT affordances for learning and AL affordances have been interpreted for group knowledge's collaborative construction. Initially, I present the background of the three students who volunteered to participate in VSRTSA interviews and who provided their ICT history logs, followed by describing the events from each of the student's perspectives.

7.6.1 Student one: Avery

Avery had completed the two-year Bachelor of Clinical Science prior to commencing the graduate medical doctorate programme. He used his laptop continuously throughout both tutorials and also had his smartphone available. He had the formal PBL case bookmarked and, on his screen.

> *"I had the PBLs like on my screen. I just do that because sometimes it's hard to read so pull up the [lab] results it's hard to see so I just have it on there". (Avery)*

As well as bookmarks for Facebook and Google in preparation for the tutorial. He also bookmarked sites for later study.

Avery was a quiet student who mainly listened to the group whilst conducting ICT searches. He contributed once in the problem analysis tutorials and twice in the report back tutorial. Avery also presented a learning objective for the group. However, he felt

> *"that others in the group put forward what he was thinking so my contribution is not required". (Avery).*

Additionally, he was not confident in his own knowledge as he perceived others to be more knowledgeable.

> *"This group [Name] is a nurse and [Name] is a paramedic so they both - they're quite knowledgeable of all the medical terms. And then [Name], I mean he studies more than me. He has more knowledge on the different topics and all". (Avery)*

He added,

> *"I don't want to just stop the group just because 'you guys, I've found something you already know' kind of thing". (Avery)*

Consequently, Avery did not ask questions about what he perceived the group already knew, so he interacted with his ICT device continuously throughout the tutorials. He explained that he

> *"kind of get kind of quite lost sometimes with how fast they go so need to like look stuff up and save the links [with] explanation so after PBL can just look it up and read it … like process it at a slower pace".(Avery)*

Avery conducted fifty-one searches in the two-hour problem analysis tutorial and fourteen in the report

back tutorial [Appendix E]. He indicated he split his attention between the group and his ICT.

> *"[Whenever there's] talking I just start to look up stuff, but if I hear that something interesting is happening I'll stop searching and get back into the discussion". (Avery)*

During the tutorials he searched the formal ICT information of the PBL case and associated lectures. Throughout, he googled extensively and entered the distant knowledge collaborative of Wikipedia. He also accessed the PBL Facebook page and other Facebook pages.

In summary, Avery was not confident of his knowledge and perceived others in his PBL group to be more knowledgeable and reluctant to participate with the group. As such, Avery preferred the ICT communities and collaboratives of knowledge to the exclusion of the face-to-face AL affordances of the PBL group. His learning strategy was to endure the formal tutorial and bookmark formal and informal ICT sites to study outside the tutorial at his own slower, controlled pace. In this way, he used the ICT affordance of communication to communicate with himself by keeping these bookmarks open. However, he stated he did not necessarily return to these bookmarked sites.

Avery's extensive reliance on ICT affordances during the tutorials provided him with the option to opt-out of the face-to-face AL affordances. In general, his effectivities in utilising ICT affordances during AL meant he could delay learning to a time and place he felt more comfortable. Yet, this did not necessarily happen. Consequently, highlighting a learning mismatch between the readily available AL affordances for learning and his use of ICT affordances in the belief he was learning.

7.6.2 Students 2: Brooklyn

Brooklyn's background was a Bachelor of Sociology. She felt her physical science knowledge was rudimentary and limited compared to the rest of the group and had to study hard to keep up.

> *"[Science] I think the equivalent of half of high school here but it's not even the full syllabus of science. I never did biology, it's just chemistry and physics, so after my university I just had to sit down and study. That's pretty much how I got through semester one, just studied through everything. Just had to study a lot more than other people". (Brooklyn)*

During the report-back tutorial, her only participation was in presenting a learning objective, but she did not spontaneously participate.

Brooklyn used her laptop continuously throughout the problem-analysis tutorial, during which she conducted fifty-eight searches. She did not provide an ICT history log for the report-back tutorial, during which she also engaged with her laptop. During the problem analysis tutorial, Brooklyn accessed the formal PBL case material and informal ICT information from Google and UpToDate. She liked to have the PBL case on her own screen as she stated,

> "*the screen's a bit far away from the table so sometimes I can't see so I just open it on my own laptop". (*Brooklyn*)*

The key words she used for searches were questions to cater to her level of knowledge. For example, she conducted five searches related to 'why an athlete would suddenly die.'(ICT history log) Other searches were for definitions of words and mechanisms she knew but was refreshing her memory. She transitioned between the formal PBL case and informal ICT affordances of communities of knowledge, google, and supplemented by entering the knowledge collaboratives of UpToDate and Wikipedia. She did not share her searches as,

> *"the discussion goes very fast so by the time - even if I'm looking up something that they're all wondering about, like the moment goes over and then it's a completely new topic really, so I'm just reading it in a way to catch up and keep on par as everybody else". (Brooklyn)*

She also used bookmarks to study after the PBL tutorial.

> *"The things I end up bookmarking are the Up to Date articles because I find those are most relevant. Mainly I will go back and look at them, you know, after I finish my LOs and after I've gotten all the information from all the textbooks, just like because Up to Date goes a lot, lot more in detail regarding the entire physiology so it's kind of just like an add-on".(Brooklyn)*

In summary, Brooklyn did not use the face-to-face AL affordances and instead solely interacted with her ICT device. By amassing bookmarks, she, like Avery, deferred her learning to a time she could control the pace to suit her learning needs. Brooklyn used the ICT affordances of communication with herself, communities of knowledge, and entered knowledge collaboratives of Wikipedia and Clinical Decision Support Web sites (UpToDate). In selecting the UpToDate website, she joined a resource with highly contextualised professional information that she perceived she could align with the PBL case. This site is designed to assist the medical professional in clinical practice, therefore not for the novice learning of the medical students. She did not capitalise on the AL affordance of contextualisation that, through situational interest, strengthens the association of relevant information for long-term memory schema formation.

Brooklyn's learning strategies during PBL tutorials were to delay her learning until she could study in a style that suited her level of knowledge and comfort. Despite this delay, her selection of ICT keywords reflected her questions, which she bookmarked for later. In doing this, she judged the amount of time she would spend on searching during the tutorial and would abandon a search to try and keep up with the tutorial discussion.

7.6.3 Student 3: Logan

Logan's background was Bachelor of Paramedical Science and an avid online gamer. He purposefully separated his online game-time and study-time by having separate computers. Logan strategically selected a laptop for study with no gaming potential to ensure he was not tempted to play. Usually, he would use both a laptop and a smartphone during the PBL tutorials. But in the recorded PBL tutorials, his laptop was not charging correctly and was being repaired; therefore, he relied on his smartphone.

During the problem-analysis tutorial and the report-back tutorial, Logan conducted many online searches.

He punctuated participation in between seeking ICT information, which he would then contribute to the group. Out of the twenty searches performed during the problem-analysis tutorial, sixteen searches were directly related to the PBL case flow and ongoing group discussions. During the report-back, he conducted twenty-one searches which were also aligned with the group.

Logan used search engines to access ICT communities of knowledge before entering the knowledge collaboratives of Wikipedia. His online searches followed this pattern throughout both tutorials. When Logan used his smartphone during the report back tutorial, he made it known to the group that he was using his phone as a laptop and wanted to ensure the group knew he was focused on the PBL.

> *"… I was trying to be clear about my phone use. At the start of the group I was like 'I'm using my phone as my computers not working". (Logan)*

He was also conscious of how long he spent searching online.

> *"After a while I just gave up because there's no point wasting PBL time not engaging with the conversation if I'm just going to sit there and search". (Logan)*

Logan shared how he judged ICT communities and knowledge collaboratives outside of PBL, where he would follow the line of references to check credibility. But during PBL, he would use and share Wikipedia information and check it afterward.

> *"I definitely have a love/hate relationship with Wiki. In instances like this I like it because it's just like I want surface information, broad scope understanding". (Logan)*

In summary, Logan supplemented the AL affordances with just-in-time information he searched for on ICT affordances of communities of knowledge, then selecting the knowledge collaborative of Wikipedia. He contributed information he found to the group to assist in the co-construction of group knowledge. The ICT affordance of communication was used to communicate with himself to check bookmarks in his self-directed time. Additionally, he could switch ICT devices and still have access to his electronic notes that were stored on the 'Cloud' storage. Logan effectively used the ICT affordance of convergence to ensure he had access to his notes and the search engines from the Internet throughout his tutorials. He ensured the gaming aspect of ICT convergence was not possible on his study computers to manage his online gaming habit.

Logan's effectivity in integrating ICT affordances into his learning during AL was something he had devoted time and energy to develop. He had metacognitive strategies in place to ensure he kept focused on his learning, and he was skilled at manipulating his ICT effectivities to align the ICT and AL affordances. Logan presents an example of how, as an avid gamer, he physically divides his ICT usage between his gaming and his study. He commented that he needs to do this to avoid being lured into playing online games.

7.6.4 Group Vignette 1: Prior knowledge and ICT affordance.

EVENTS

The setting was the problem-analysis phase of the first renal PBL case, semester two, with seven first-year GEMD students including Avery, Brooklyn, and Logan. The group had identified, brainstormed, listed differential diagnoses, and listed further information required. Figure 7.15 depicts the G9 PBL group at the stage of the tutorial the event occurred in. They were collectively writing on the whiteboard information and needed to discern between the differentials in light of the newly presented biochemical results.

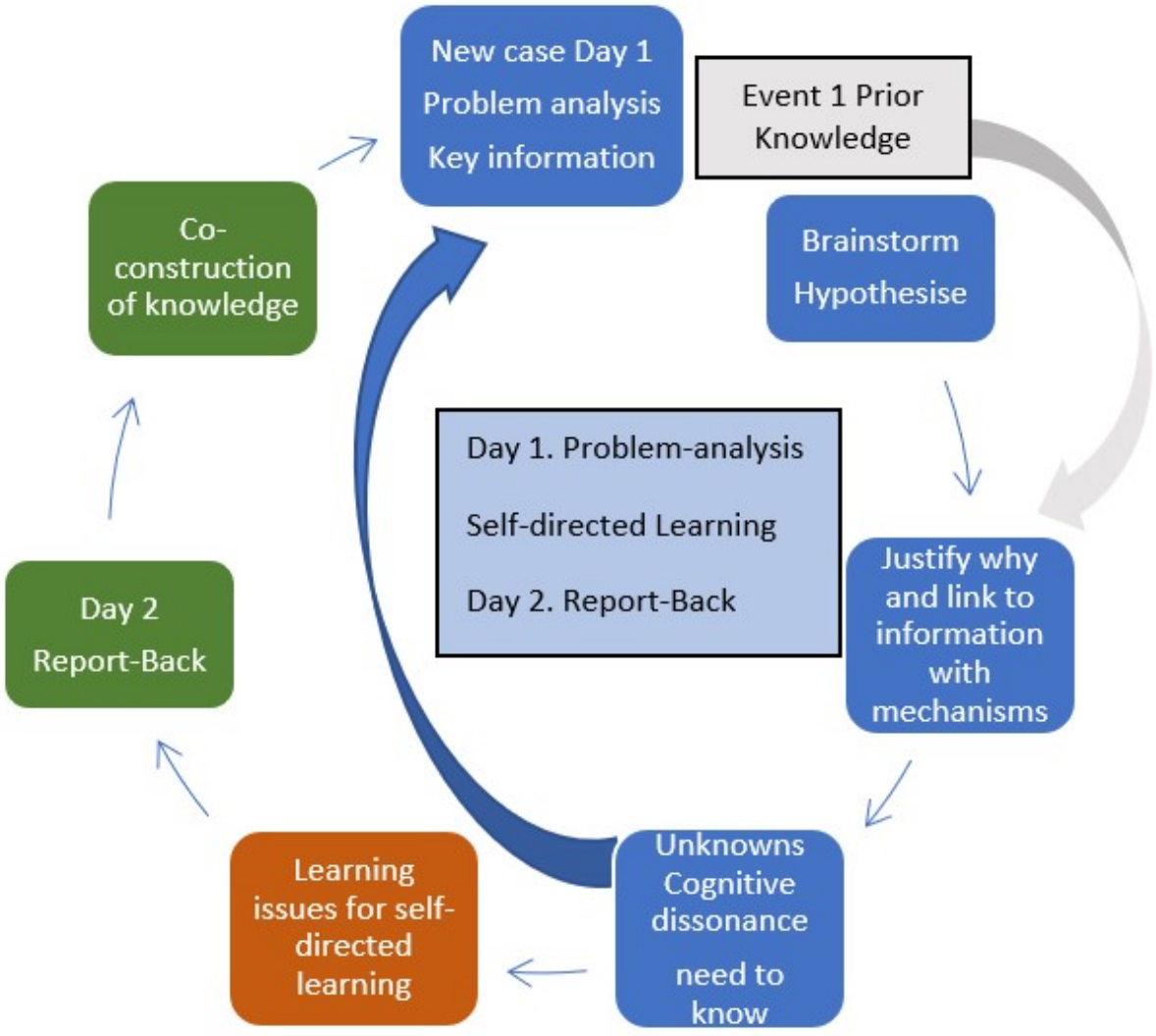

Figure 7-15 Active learning cycle: Prior knowledge event 1 eGFR (estimated Glomerular Filtration Rate). eGFR was abbreviated in the written case without the full term explained. (G9S2), Brooklyn (G9S3), Logan (G9S4) synchronously engaged with their ICT device.

Avery searched for 3 minutes with a total of 9 searches resulting in no useable information. He did not ask the group nor participate in the discussions that were synchronously occurring. His searching led to several incorrect and irrelevant sites (acronym 'egfr' also epidermal Growth Factor Receptor), including foreign language sites, members-only sites, and links to articles he did not recognise. Avery realised he could not find the correct terms and the correct measurement units. It was during this time that it became apparent that Logan searched to a level of his prior knowledge to formulate the keywords.

> *"…really difficult, like finding the correct search terms to find out what it meant…. I think the first thing I searched was square and then it started giving me journal articles … like that's not what I want". (Avery)*

He did not find helpful information and his searches became circuitous, so he abandoned the search. Avery did not contribute to the discussion, and despite bookmarking sites, he had not yet gone back to review these sites at the time of the interview a few days later.

Brooklyn searched at the same time to sites not looking up eGFR specifically.

> *"I was just trying to recall the physiology behind it and because we've done this before, it's just that we did it last semester so I can't really remember the exact mechanisms".*
>
> ***Interviewer: "So what did you find when you looked it up?"***
>
> *"I couldn't find the exact mechanism, so I gave up and moved on". (Brooklyn)*

She did not participate in group discussions and felt her level of knowledge was basic; therefore, she did not want to bother the group with questions.

> *"…I search for are things that people already know about". (Brooklyn)*

Logan searched at the same time, undertaking four searches. In his first search, the acronym led to the incorrect term, which he detected and corrected. He then refined and found the information and shared it with the group

---

> *'…just me Googling up a storm, just trying to like find a semi-legitimate source that has something that sounds reasonable that fits in with the knowledge that we have and then we can later go, and fact check it, but if it sounds reasonable".(Logan)*

Figure 7.16 provides an overview of Avery, Brooklyn, and Logan's effectivities to access the ICT affordances of communities of knowledge to resolve their learning needs and the end result of their searching.

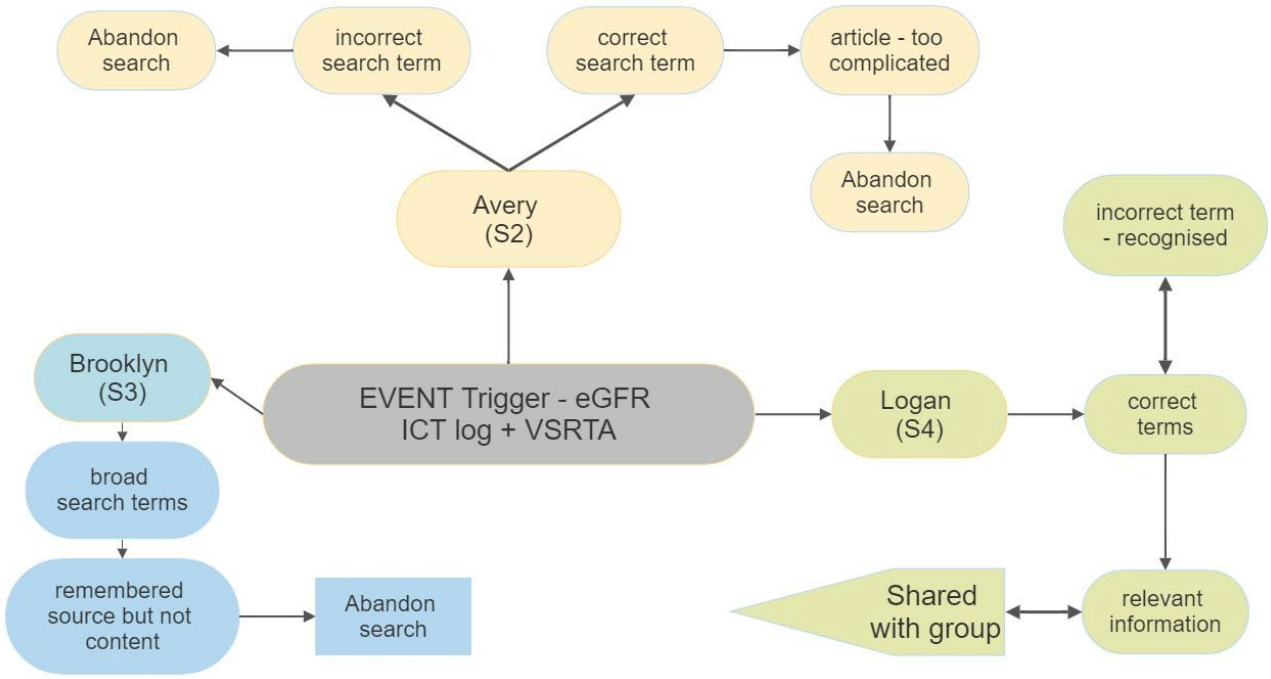

Figure 7-16 Prior knowledge Event Group 9 of the unknown term 'eGFR.' Collation of all three students' simultaneous internet searches. Logan had prior knowledge to guide his ICT searches.

7.6.4.1 Interpretation

These students accessed ICT affordances of communities of knowledge intending to find answers to their individual questions regarding eGFR. They did not utilise the immediate face-to-face AL affordance of collaboration to ask the group to help resolve their cognitive dissonance. Avery and Brooklyn perceived their learning and learning needs to be more basic. Hence, they believed their lack of prior knowledge meant they had nothing to offer the group as their peers would already know, plus they did not want to disrupt the group with basic questions. Consequently, these two students did not ask the group the simple question to help clarify the eGFR, and they did not attempt to communicate these learning needs (Figure 7.16). They were unaware of the AL affordance of collaboration whereby basic questions serve as powerful tools to explore everyone in the groups' understanding of underlying biological mechanisms. Also, the face-to-face group could have quickly resolved the terminology.

Avery and Logan's effectivities to access the ICT affordance communities and collaboratives of knowledge proved problematic. By simply searching for the keyword of 'egfr' led to Search Engine Results (SER) of unrelated challenging to interpret information. They did not have sufficient prior knowledge to understand the acronym had multiple uses in different contexts. For example, instead of eGFR (estimated Glomerular Filtration Rate), they used the keyword egfr (epidermal growth factor

receptor) The students had not considered the format of the acronym, nor had they considered entering accompanying words to help navigate the ICT affordance. Both Avery and Logan had SER of the wrong subject. Avery continued to select incorrect terms until his realised from tenuous prior knowledge the difference and then sought how to calculate eGFR. However, again he became bogged down in SER, which were problematic and circuitous, eventually leading him to give up.

In contrast, Logan, despite finding using ‘egfr’ that led to incorrect sites initially he quickly returned to relevant sites and successfully navigated the ICT affordance, which he communicated with the group. His prior knowledge facilitated him to detect and judge relevant results to collaborate with the group in a timely manner. As such, he was able to follow and participate in the collaborative construction of group knowledge.

At the same time, Brooklyn also accessed her ICT affordance of communities of knowledge. She had limited prior knowledge in this area of study and, as such, selected more fundamental keywords that reflected her learning need to seek renal physiological mechanisms commensurate with her level of understanding. However, she realised this was beyond the time and pace of the PBL discussion, so she also gave up. For both Avery and Brooklyn, their intentions and learning goals were not met; hence their ICT effectivity at obtaining the required information in the short amount of time from the ICT affordance was unsuccessful.

This event highlighted the importance of what student effectivities were essential to navigate the ICT affordance. Without the appropriate level of prior knowledge to engage with the ICT affordance and rudimentary judgement to discern the relevance of SER’s, compounded by time constraints of PBL, these students failed to find helpful information. Students who have low prior knowledge will tailor their searches accordingly as Brooklyn did or be caught up in futile searches as Avery did. These students did not ask the PBL group for clarification. They could have accessed the AL affordance of collaborative group knowledge, but they chose to believe this would be disruptive for other students. Thus, they were not able to access the AL affordance of collaboration and construction of knowledge.

7.6.4.2 Summary

Figure 7.17 highlights an important aspect of students’ effectivities to access ICT affordances for learning. The intention to find an answer to an unknown requires personal determinants of adequate prior knowledge to formulate keywords but also to understand and make judgements of the SER. The higher the prior knowledge, the more effective a student will be at writing keywords and selecting appropriate contextual information that aligns with the problem at hand. Whereas, low prior knowledge results in multiple incorrect online search terms and SER resulting in frustration and abandonment of the search,

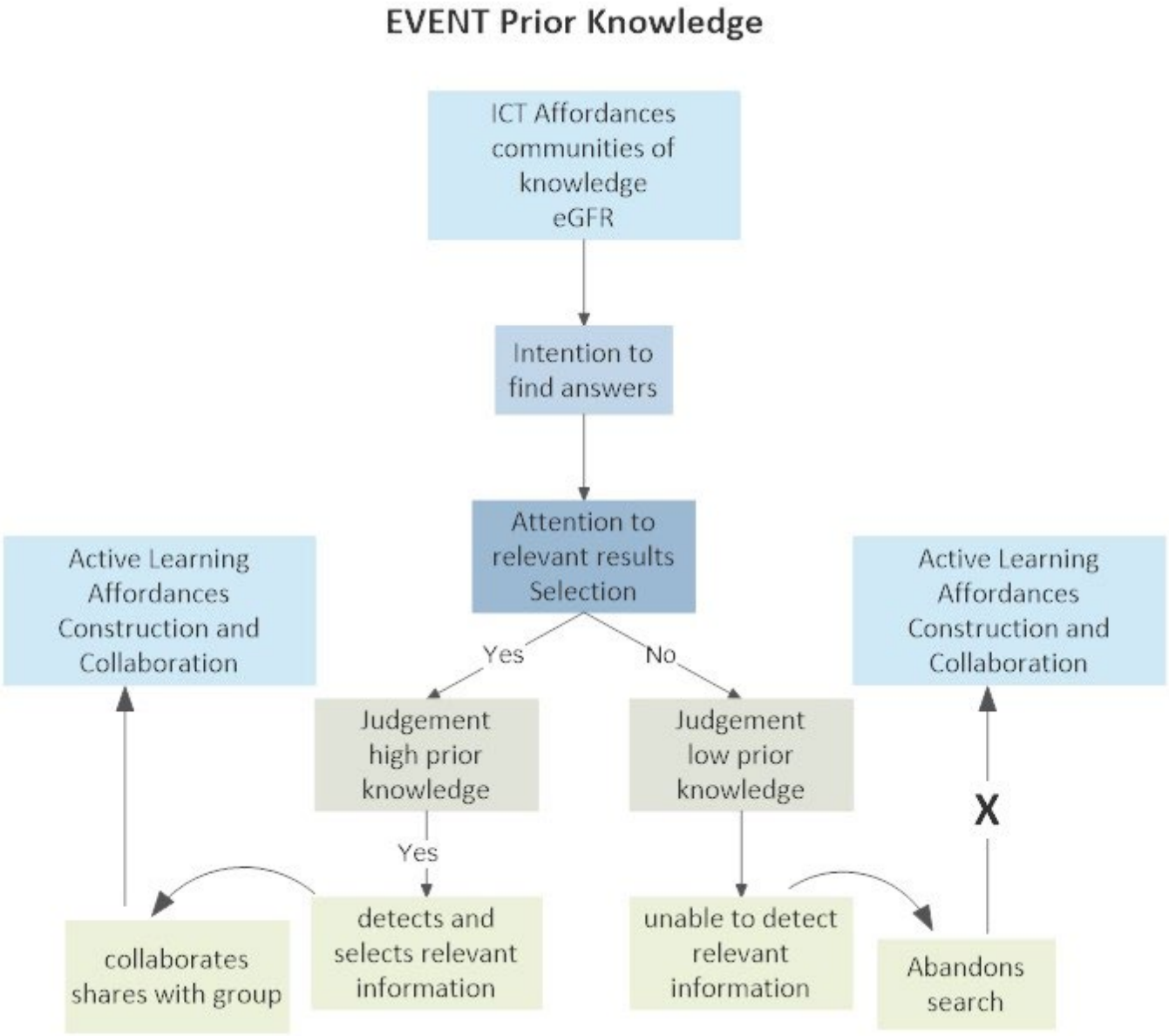

Figure 7-17 Prior knowledge: Effectivities of students using ICT affordances require them to detect and understand the search engine results generated.

In conclusion, when under stress and time pressure, students with low prior knowledge or who are insufficiently prepared make mistakes and cannot find the relevant information online quickly. This has significant implications for online examinations and will be discussed in chapter 8.

7.6.5 Group Vignette 2: Missed co-construction opportunities

EVENT

The missed co-construction opportunity event occurred after key clinical medication information was revealed during the problem-analysis phase of the renal PBL case (Figure 7.18). The group was discussing the dosage(s) of Non-Steroidal-AntiInflammatory Drugs (NSAID's) the patient had ingested.

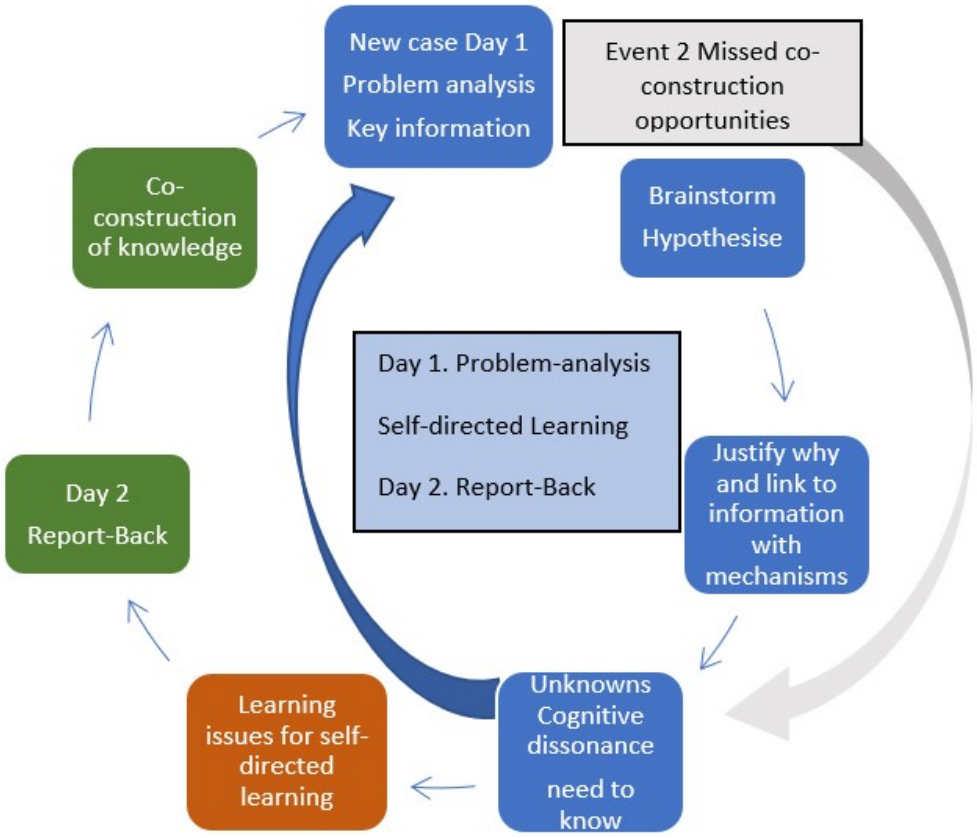

Figure 7-18 Active learning cycle: Missed Co-construction opportunities of the understanding mechanism of action of NSAID medication.

The excerpt below is from the PBL case as presented to the students. They were reading through this information and trying to work out the mode of action of the drug(s) and determine the total amount the patient in the scenario had consumed.

> *"…prescribed naproxen 500mg a non steroidal anti inflammatory drug twice a day. … felt neck injury would impede his performance in the race and didn't want to take more of prescribed medication… so he took 2 (wife's) nurofen tablets … then another 2 prior to the race". (From PBL case excerpt)*

Three students synchronously searched for online information regarding 'Naproxen' and which class the medication belonged to in the Non-Steroidal-Anti-Inflammatory-Drugs (NSAID's) group.

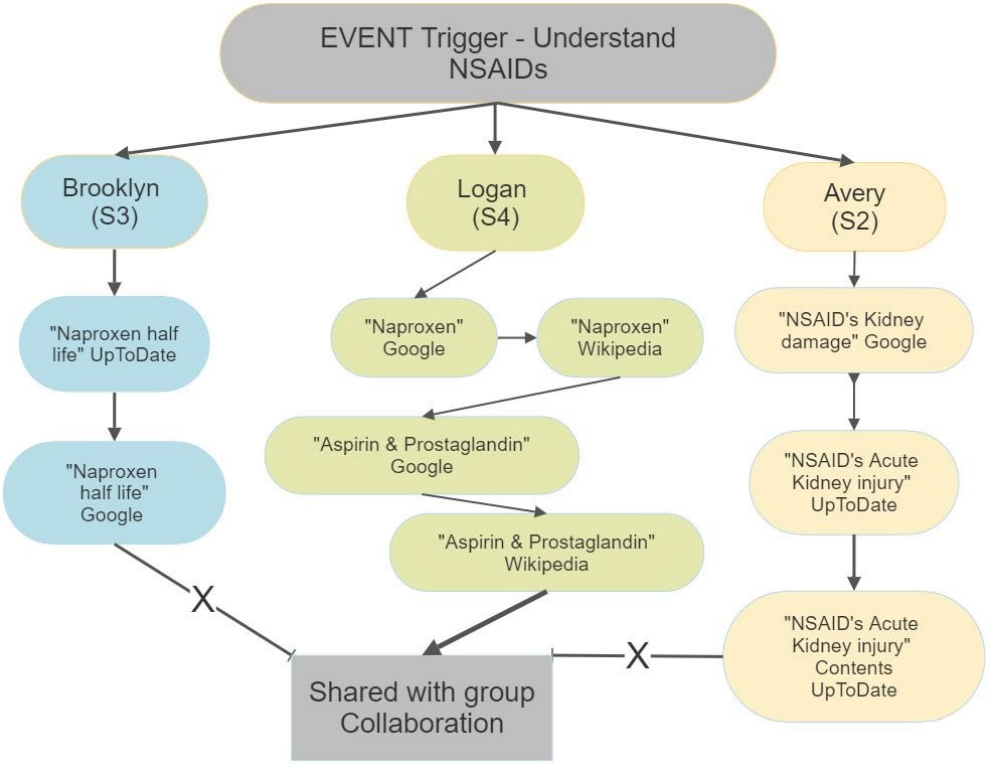

Figure 7-19 Missed Co-construction opportunities collation of three students simultaneous internet searches.

Figure 7.19 tracks the flow of simultaneous searches undertaken by three students. Avery searched an online search engine and a Clinical Decision Support Website, UpToDate, looking for information to find a link between NSAIDs and acute kidney failure.

Brooklyn searched for the half-life of Naproxen as she had activated prior knowledge from a previous PBL case in semester one.

> *"We've done this before, it's just that we did its last semester so I can't really remember the exact mechanisms….". (Brooklyn)*

Brooklyn was trying to focus on her ICT search that was stimulated by the current PBL case and the ongoing group discussion

> *"I wasn't aware about like the relationship between NSAIDs and dehydration whereas my group mates were quite familiar with it. Because I'm from a non-science background and they're all from science backgrounds, some of them even from like pharmacy or even like medical scientists and researchers, so they are quite familiar with pharmacology and even some of the drugs but this is completely new to me. I don't really want to interrupt like the flow of the conversation sometimes, so I just look it up on my own". (Brooklyn)*

Again, Brooklyn's lack of confidence and assumptions about the group's knowledge led her not to ask the group the questions she had. Additionally, she did not contribute information she had found online. So, she remained quiet and did not engage with the co-construction of group knowledge with

the face-to-face community afforded to her by an AL environment. Nor was she able to fully interact with the ICT communities of knowledge sites she found. She initially selected a clinical resource, UpToDate, that could not be quickly read or understood. She then used informal search engines but was again confronted with too many sites to work through in the limited PBL tutorial timeframe. Despite finding some relevant sites, she gave up.

> *"I couldn't find the exact mechanism, so I gave up and moved on". (Brooklyn)*

For Logan, he searched for what class of medication Naproxen, which led to refining his keywords to search for the mode of action mechanisms. He did not initially link his prior knowledge from his previous degree or a previous PBL case in semester one to the current PBL case, but he could activate enough prior knowledge to navigate and refine his search terms.

> *"…being [a] paramedic aspirin is given in the acute setting for MI, specifically for that one reason and it's not an NSAID, it's specifically aspirin, so I learnt about it as aspirin and I forget that aspirin's an NSAID. It probably would have helped in this conversation. No, wait, it did go on because I remember reading it on the page and being like 'oh yeah, aspirin's an NSAID". (Logan)*

ICT knowledge collaboratives, Wikipedia, led him to discover the names of the medications mentioned, in the case, and other familiar NSAID names (e.g. Aspirin). Logan realised the patient in the case has taken an excessive dose of different NSAID's and shared his finding with the group.

> *"…very, very similar families, they're quite closely related, it means that he's actually taking – overdosing". (Logan).*

Upon sharing this information with the group, the group discussed the presenting signs and symptoms of the case and linked it with underlying physiological and pharmacological mechanisms.

Synchronously, Avery and Brooklyn used different keywords to search for different aspects of NSAID's that were mentioned in the PBL case. Despite the ICT history logs revealing a rich array of information was assessed, they did not share this information with the group. Thus they and the group as a whole missed an opportunity for co-construction of group knowledge.

7.6.5.1 Interpretation

The ICT affordances of communities of knowledge and entering collaboratives of knowledge were used in varying degrees. In group 9, vignette 2 Avery utilised the ICT affordances of communities of knowledge to assist in personally contextualising the medication information into the PBL case. He sought clinical-decision-support websites to investigate the potential link between NSAID and Kidney damage. Again, this is an advanced website that assumes basic knowledge.

Whereas Brooklyn searched how long the medication would remain active in the body. She explained they had looked at this class of medication in the first semester and conducted her search to prompt her memory. Hence, despite being unsure of her knowledge, she was the only one to acknowledge they had

all previously studied this medication class. Therefore, she activated her prior knowledge and used that knowledge to direct her search terms concerning the current PBL case.

On the other hand, Logan sought answers to the unknown medication name and then followed up to understand mechanisms of action. He was unable to link this scenario with his prior knowledge from a previous course. Logan initially had reduced recall of this knowledge as it was a different drug name and context. Once he identified the class of medication Naproxen belonged to, he then linked his prior knowledge and elaborated upon them by searching the groups of NSAIDs' molecular actions related to the kidney (the case). He shared this information with the group. Both Avery and Logan did not mention the previous PBL case(s) that had covered NSAID's.

7.6.5.2 Summary

Figure 7.20 describes the flow of each student's effectivities, which were governed by their individual learning needs and prior knowledge. A such, they each searched for *just-in-time* information based upon their prior knowledge, which resulted in each finding different information about NSAIDs and the impact on kidney function. If shared with the group, this would have elaborated the group's construction of knowledge through collaboration. Two of the three students accessing ICT affordances failed to share, hence participate. These missed opportunities to explain, elaborate, and rehearse their understanding and listen to other perspectives resulted in a less rich learning environment. Albeit, Logan contributed and benefited from the AL affordances of collaborative group construction of new knowledge, but the other two students did not.

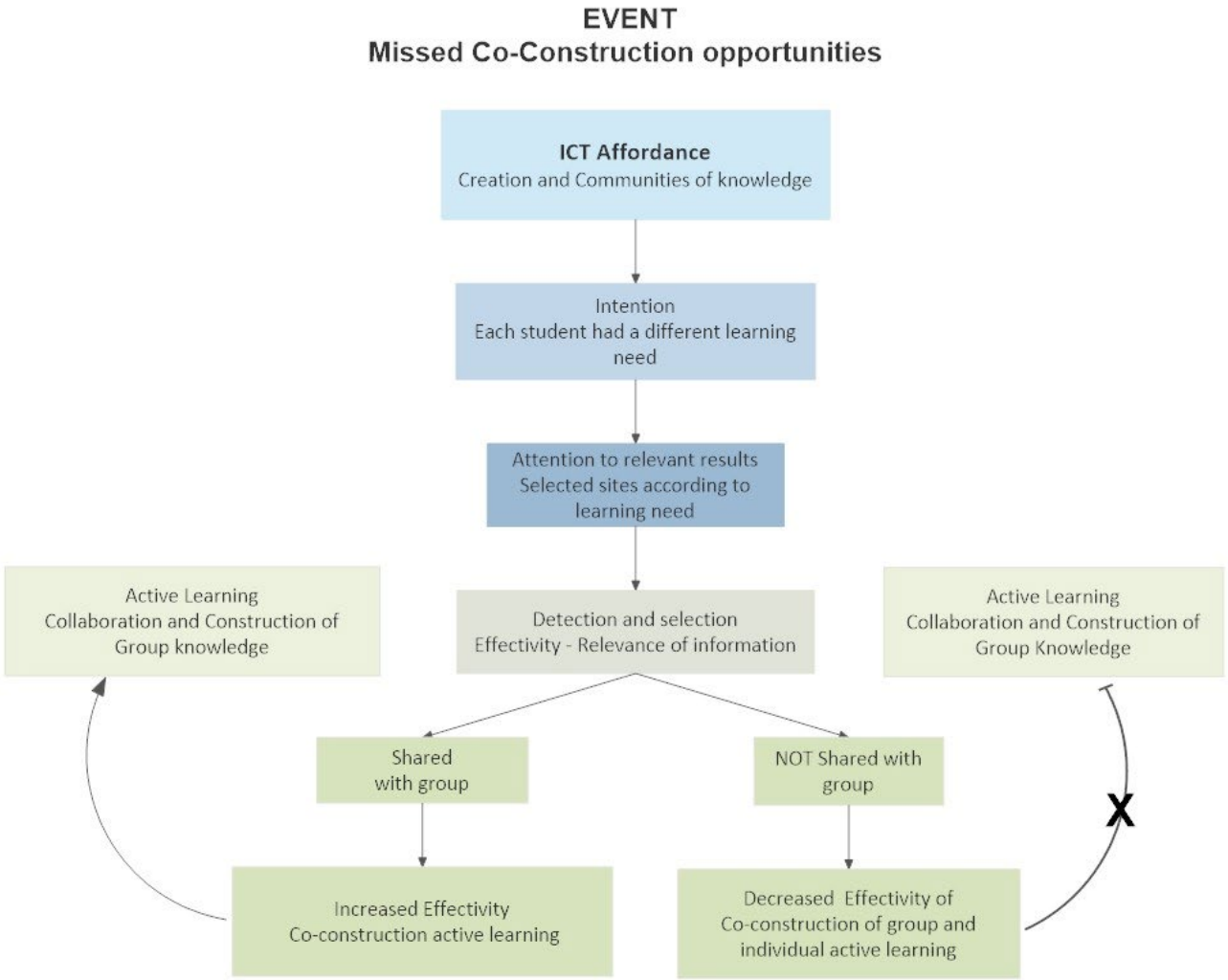

Figure 7-20 Missed co-construction opportunities: Students' effectivities to use ICT affordances successfully led to relevant information. However, only one student shared with the group, and the other two did not share.

Having ICT affordances readily available and controlled by the students during AL tutorials meant they reinforced their assessment of their flawed evaluation of the role of their prior knowledge idea. They did not even attempt to find out by sharing with the group. So, they relied on and engaged with multiple ICT knowledge communities of knowledge, which they read briefly, in preference to the PBL group. However, these assumptions decreased their and the group's learning opportunities. As they did not question or contribute, they denied themselves the chance to rehearse their knowledge and expose their knowledge to constructive discussion.

Avery and Brooklyn's ICT history logs revealed they rapidly moved between ICT communities of knowledge and entered only the knowledge collaborative of UpToDate. Realistically they would not have had enough time to move between these sites and synthesise the information for learning to occur. The additional extraneous cognitive load of task and attention focus switching between several knowledge communities (including listening to the PBL discussion) would lower the ability to synthesize information.

From a metacognitive perspective, Avery and Brooklyn missed the importance of working in a dynamic group. By not participating, they did not develop collaborative group skills that are inherent skills of how to

participate and contribute with and developed group-derived metacognitive learning strategies. They did not consider themselves individually accountable to the PBL group process of co-construction of knowledge. They rationalised their non-participation stance by suggesting that others knew much more than them. So, they engaged with the less confronting ICT community instead. In fact, the ICT affordances provided an escape from the rigours of AL face-to-face process. But by allowing themselves to avoid face-to-face participation, they missed AL affordances to rehearse and elaborate information and learn how to engage collaboratively with others. By hiding behind their ICT devices, they avoided eye contact with their peers and avoided the potential embarrassment of not knowing enough. As they felt they had nothing to offer the group and found solace by fleeing into the ICT affordances for safety. They did not understand the importance of the AL affordances and preferentially sought the protection of the less threatening ICT affordances for their learning.

Synchronously, Logan actively participated in the group learning by reporting his ICT findings to the group, which promoted discussion and contributed to the group's understanding of the case's underlying mechanisms. In doing so, he was task and attention switching between his ICT device, thinking of keywords, typing them, searching, judging the SER, and listening to the flow of the group discussion. Inherent in this behaviour, there would be a reduction in his cognitive resources, leading to decreased overall learning during the tutorial.

In summary of these vignettes, students who use ICT affordances in conjunction with the AL affordances thrive, students who use ICT affordances to replace AL affordances struggle.

Avery and Brooklyn struggled to keep up as they were replacing the AL affordances with their ICT affordances, for which they had limited prior knowledge to navigate. Their limited prior knowledge meant they did not have the vocabulary to design succinct keywords, nor did they have the ability to judge incorrect SERs, which resulted in proliferous continuous ICT searching.

Students to be successful at integrating ICT affordances during the time of need, in this case, AL tutorials, require sufficient prior knowledge to prevent non-targeted time-wasting multiple online searches that require understanding and judgements to be made immediately.

However, when students activate their prior knowledge, limited or developed, and used ICT to find unshared relevant information, they still missed significant co-constructive individual and group learning opportunities. These opportunities would have significantly enhanced the AL environment. Students who believe the group session's purpose is to receive information and find answers rather than build upon and further understand existing knowledge schemas through contextualised knowledge collaboratively, stifle and truncate the AL process.

The student effectivities of navigating their ICT affordances with AL affordance of co-construction is aligned learning ensues. Therefore, when students can co-coordinate the ICT affordances of communities, communication, and collaboration during the AL brainstorming and analysis phase, it can

work to their advantage when they interject and share findings to deepen the discussion for better understanding. The challenge of sharing each other's prior knowledge in the context of new information makes them think, brainstorm and analyse all information at a deeper level. Thus identifying areas, they know and do not know that form the basis for their SDL.

7.7 Charlie vignette – Transactive memory and ICT Convergence

EVENT

Charlie's first ICT interaction occurred 25 minutes after the commencement of PBL. Students had identified key information and were brainstorming reasons for high blood pressure and headaches Figure 7.21). There were several key words she searched for over this timeframe.

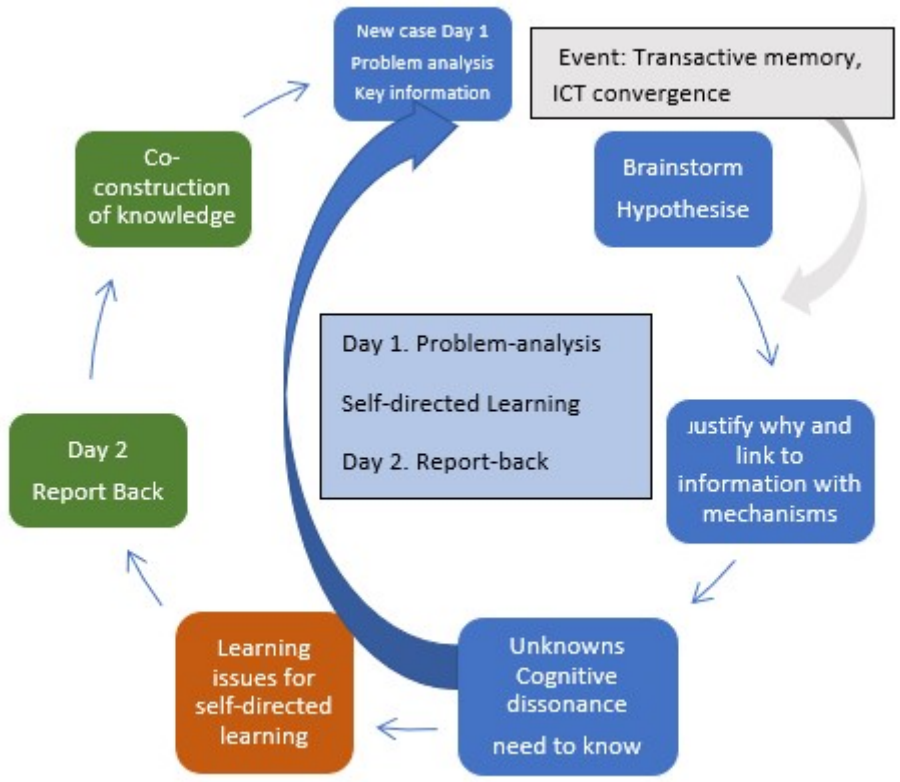

Figure 7-21 Active learning cycle: ICT convergence and transactive memory.

Charlie was continuously engaging with her ICT device, and her search patterns aligned with the sequence of group discussions, questions posed, and formal PBL information on the shared screen. When the tutor asked the group to provide further rationale for the proposed differential diagnoses, she started googling. Initially, Charlie focused her search on potential interactions of taking protein powder and the patients' presentation with high BP. She had seven attempts

resulting in no useful information to share with the group. She surfed the shopping sites for protein powder. She returned to focus on the group after prompting by the tutor.

Charlie rejoined the group discussion for the next 9 minutes and participated in brainstorming the medical mnemonic for differential diagnoses; the group routinely used (Figure 7.22) to help identify possible causes. She continued to google throughout this time.

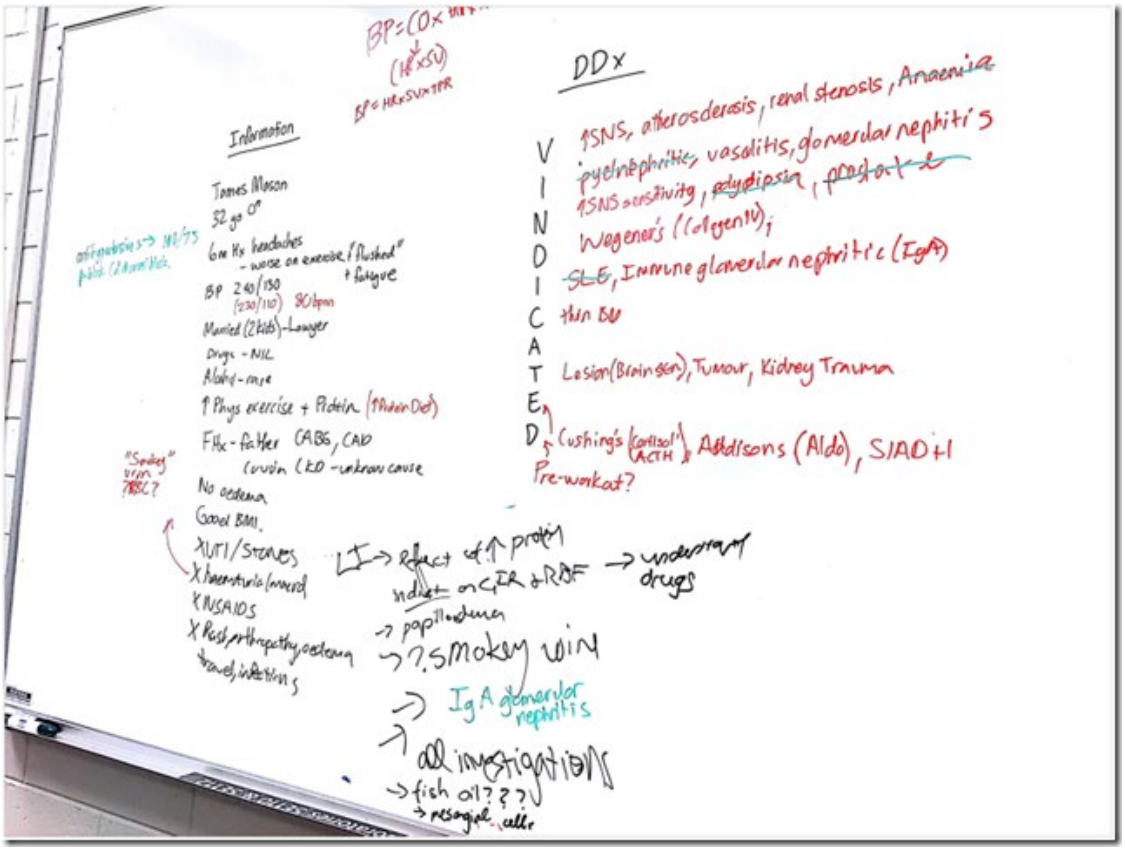

Figure 7-22 Collaborative group board work. Charlie's unusual differential diagnosis was not included.

After much discussion and many students have exhausted their ideas, Charlie proffered an unusual differential of 'male sympathetic pregnancy.' She described her rationale as,

> *"Well, [I] mentioned that if he was female and he could be pregnant and [they were] 'oh that's not a thing because he's male' but I have a tendency to just retain odd facts so I just draw off the top of my head that there's like the syndrome where males actually get physical symptoms in sympathy to female pregnancy for their partners so it's a worthwhile thing to keep in mind, that you can't really just kind of rule out the weird things really". (Charlie)*

The group questioned her but were not convinced as Charlie could not provide more details, so the group returned to their discussion-based upon board work. At this stage, Charlie conducted three google searches to find the medical term with the intention to inform the group.

> *"I mentioned it and I was like 'oh I can't remember the name of it' so I quickly Googled the name of it to then be able to give it to them in another gap. Any time I do that I always wait for a gap because it's like an irrelevant side point". (Charlie)*

Charlie did share her findings with the group, but the group had moved on and did not include her unusual differential diagnosis on the board work (Figure 7.22).

7.7.1 Background

Charlie relied heavily on ICT affordances due to difficulties in typing and handwriting for extended periods. She had used ICT for her learning in secondary schooling and through her undergraduate Medical Science Degree. For written communication with others and self-study, she used voice recognition software. However, this was not amenable for use during face-to-face AL sessions, nor was the software compatible with free-form-information gathering programs (e.g. OneNote). Therefore, she selected, adapted, and manipulated software, applications, and programs to suit her unique situation.

Charlie developed her own online system to store all her notes.

> *"I keep all of my documents on Google drive, one drive, or DropBox". (Charlie)*

These sites were fully searchable. Charlie also used the online word processor Google Docs to be compatible with her other programs and applications.

> *"Most of the time we have a group Google doc that has that week's Los". (Charlie)*

She set up Google Docs links for the group, which was additional to the groups' Facebook page to cater for her ICT needs and to share her work with the group because,

> *"…it's more user friendly and collaborative". (Charlie).*

Charlie actively contributed to this shared site; however, I was not able to ascertain if the other members of the group used it to the same level

> *"Almost all of our notes are on Google docs. There's a couple of things that are less relevant that we've put on - I think this will go into it… so I can access them from my tablet or phone at all times". (Charlie)*

During the formal PBL tutorial, she used her Smartphone to communicate with her work and with others in her group. Her regular ICT Tablet, at the time of this research, was being repaired. She did not take any written or typed notes during PBL and was an active participant in the problem-analysis phase but not in the report back phase. She also was not able to write on the board. She provided an ICT history log for the Problem-Analysis tutorial, Day 1 only.

The problem-analysis ICT history log was extensive. Charlie conducted 33 searches over the 110 minutes session with seven distinct search themes. Twenty-one of these were on google sites that led to opening some of the first or second search engine results (SER), but many she did not open. She was superficial in her online surfing throughout the tutorial. All searches were conducted on her smartphone.

However, Charlie participated with her group in the problem-analysis tutorial and followed the tutorial screen case presentation on the shared tutorial screen.

However, during the report-back tutorial, she did not engage with her group but did engage with her smartphone. Charlie explained that she focused on exam preparation during her self-directed learning by organising her online notes and shared with her group.

> *"I was focusing on a project for myself and the group for study notes, for revision for the exams, so I was a little bit under-prepared as well. I hadn't done as much as I normally do because I compiled all the past exam questions that we had access to.....back to 2007". (Charlie)*

She preferentially devoted her time to her ICT organisation for exam preparation rather than to her AL affordances of face-to-face learning during the report-back.

7.7.2 Interpretation

The ICT affordances and devices used to compensate for her writing intolerance led Charlie to develop unique student effectivities for her learning. She activated her prior knowledge and shared what she knew, followed by checking with online search engines. She relied on a transactive memory relationship she had developed to use her ICT to check her thinking. She had formed an ICT Convergent memory relationship. Charlie's ICT effectivity capitalised on the ICT affordance of creation, which enabled her to create her own knowledge store. However, she could not quickly find relevant information promptly and resorted to online search engines to check her memory rather than her online notes or memory. This raises the question of how much she synthesised her knowledge biologically and how much she relied on this transactive memory relationship for information. Charlie devoted a lot of time and effort to collate her voluminous ICT notes, online organisation, exam preparation, and website, possibly at the expense of the quality of information selected.

Although the group had an existing Facebook page, Charlie set up an ICT-compatible online group collaborative to share work and interesting uploads. The PBL Google doc site suited her learning needs and was ICT compatible with her programs and applications. Therefore, the rationale was purely for her benefit but had the additional functionality of allowing for real-time collaboration rather than the asynchronous method used with Facebook. Charlie used the ICT affordances of creation and collaboration to address her own learning needs, but the group might not necessarily use it. However, I could not ascertain other students' reactions to Charlie's ICT organisation in this study.

Charlie continuously task switched and shifted her attentional focus between participating in the problem-analysis tutorial, listening to the group, conducting online searches, selecting results, and reading online searches throughout the tutorial. She located information on her ICT device regarding definitions and provided brief explanations to the group. However, when the topic was unfamiliar, she conducted multiple unsuccessful searches. Three times, this occurred when searching for connections between atherosclerosis and protein powder, IgA, and kidney disease and attempting to understand what Anti-

DNase was. Here the ICT affordance of linking to ICT communities of information resulted in finding sites that were either about the wrong subject, shopping sites or required specific prior knowledge to understand them. Despite her efforts Charlie's ICT effectivity were mismatched in these instances, with her ICT effectivities to use ICT affordance for learning were hampered.

7.7.3 Summary

Figure 7.23 describes Charlie as a student capable of accessing and setting up ICT affordances for her specific learning needs. She intended to create a practical ICT resource to conduct her learning. The ICT devices and applications she employed were all compatible and could be accessed from any of her ICT devices. However, due to her comprehensive searchable format, accessing her information repository was potentially easier under time-constrained conditions. Yet, she preferred to conduct online searches to find specific information rather than search on her extensive digital notes organisation.

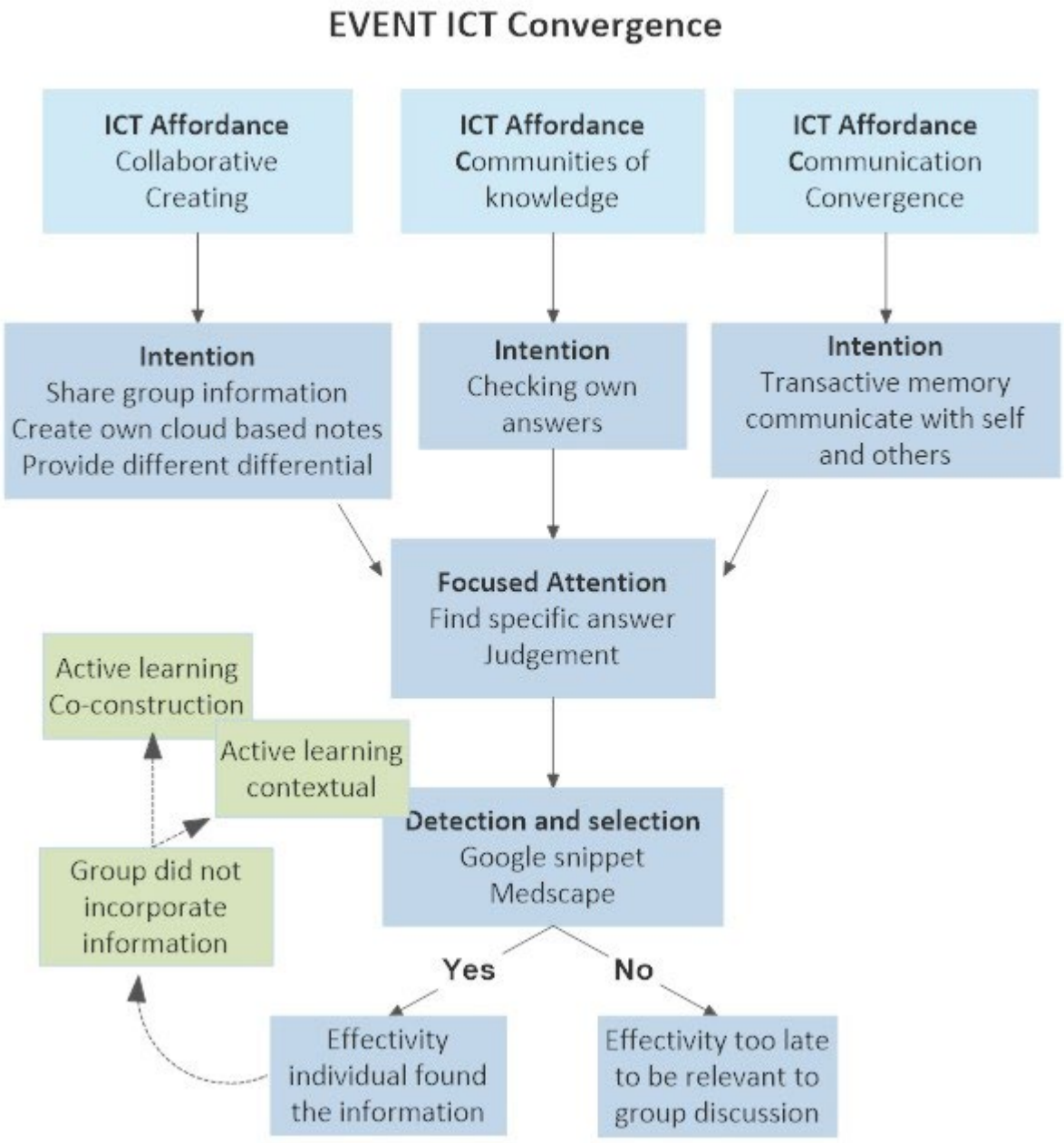

Figure 7-23 ICT Convergence and transactive memory relationship. Charlie's effectivities in negotiating ICT affordances enabled her to seek unusual differential diagnoses that the group did not include.

Charlie relied heavily on her environmental and behavioural determinants for her learning. Figure 7.24 situates Charlie's ICT effectivities to utilise all of the ICT affordances to manage her unique learning needs. Her high efficacy in understanding and manipulating the ICT affordance of communication to liaise with others and, importantly, to communicate with herself were achieved by creating cloud-based sites for storing her notes and ideas online. She opened some of these to her PBL group for online synchronous collaborative interactions. Charlie selected the ICT software based upon being free and having compatibility with her voice recognition program, organisation, and searchability online word processor program, drawing application, and accessible on any ICT device she used. The student's effectivity to access her online notes from any ICT device meant she always had her notes available. Yet, with such a focus on organisation and ensuring her notes were searchable, she still preferred to use ICT search engines to check her thinking and find answers quickly. Thus, raising the question of the true value and searchability of her online notes.

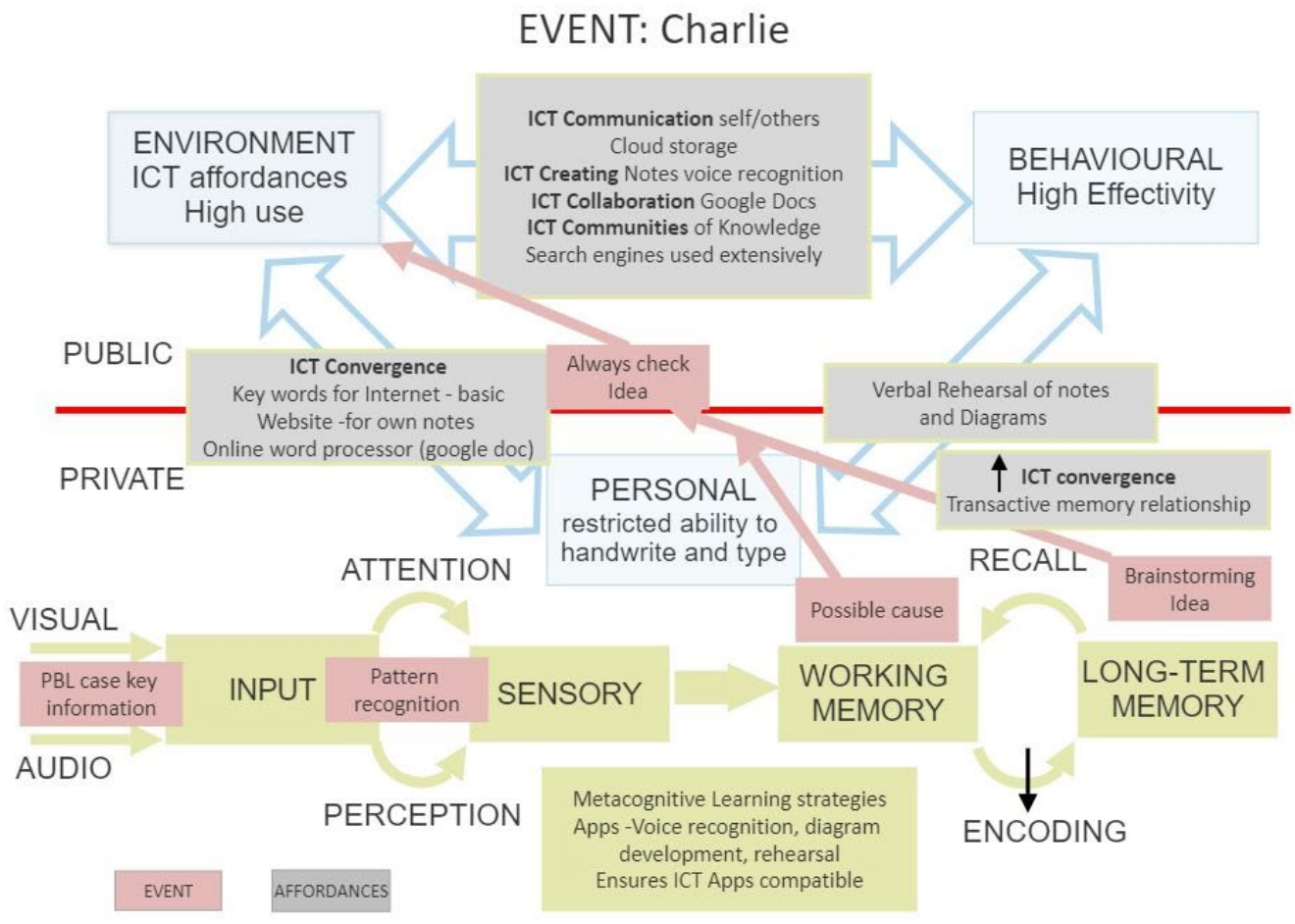

Figure 7-24 ICT convergence and transactive memory: theoretical framework interpretation of event (pink) with ICT and AL affordances (grey)

7.8 Chapter summary

Chapter 7, the students' ICT history logs, provided invaluable additional information from chapters 5 and 6 to interpret student effectivities to navigate their ICT affordances for AL environments. Previous studies have relied on the student perspective of their learning and/or aligned the results with their grades. In this study, the focus was more on understanding what and why the students used ICT affordances and assessing how successful they were to resolve their learning needs. By seeking the students' ICT history logs from their own ICT device allowed a unique, in-depth glimpse of what the students were doing. These logs provided me, the researcher, a conduit to undertake the same online searches to align and analyse with the AL tutorial events with the student interpretations from the VSRTA interviews. The findings highlighted that students' assessment of their learning with ICT affordances was perceived as favourable. Yet, there were many learning assumptions and conflicts identified. Figure 7.25 provides an overview of the finding from Chapter 7.

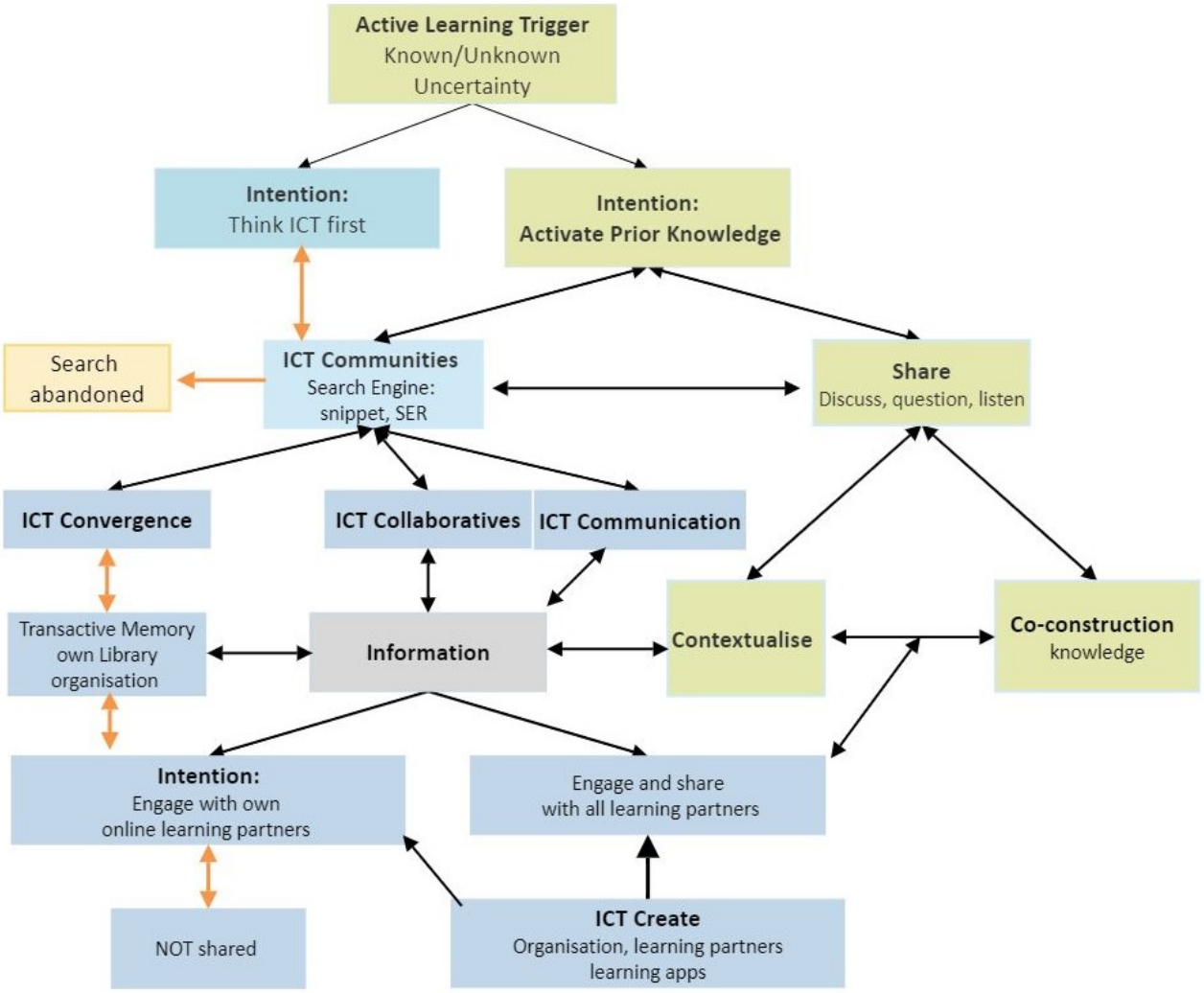

Figure 7-25 overview of ICT and AL affordances employed by students during formal tutorials

Firstly, ICT convergence was observed in most students as they created various levels of dependent

behaviours by forming transactive memory relationships with their ICT devices. Some students were wholly reliant on ICT affordances for their learning, to the extent that they took the ICT information as their own by reading out pre-digested search engine created snippets verbatim to the group and took this as their own interpretation. ICT communities of knowledge were employed to reduce individual cognitive effort and guided students to determine and control intrinsic cognitive load levels of the content to be learnt and escape the challenges of discussions and questioning within the small group tutorial.

Secondly, all students employed the metacognitive strategies to develop digital libraries; ICT convergence. Yet, even when students create searchable notes, they default to conducting ICT search engines to resolve unknowns and find answers. Many students would not offer information to the group unless they checked their thoughts and prior knowledge with the Internet. They depended on the ICT communities of knowledge to remember and check for them.

Thirdly, the ICT history logs alluded to students who did not participate with the PBL groups were continuously interacting with their ICT device and were searching along with the tutorial. The diversity of searches conducted alluded to missed co-constructive group interactions. In group 9, each student searched for different components of the same issues. Only one student shared their findings with the other two keeping quiet. All these searches would have stimulated positive co-construction of group knowledge and significantly contributed to the individuals' knowledge development. These students did not recognise the benefits of the face-to-face AL affordances and poorly used the ICT affordances. However, one student recalled relevant information from their long-term memory and used ICT to find supporting evidence. They shared the information that led to in-depth group co-construction of knowledge. There was a loss for the students as she focused her cognitive effort on the ICT search and ignored the group discussion.

Fourthly, students made simple keyword search errors as they split their attentional focus between their ICT device, the group, and the PBL case. They were attempting to focus on several tasks simultaneously led to simple errors in their search terms and AL interactions. They become frustrated and eventually abandoned the online search.

Fifthly, the erroneous use of ICT affordances is exacerbated by students limited prior knowledge. Online searching under the tutorial's time pressures resulted in multiple errors in understanding keywords, finding suitable keywords, and selecting and judging SER to read. The associated increase in the extraneous cognitive load of attempting to undertake strategic online searches led to errors and abandonment of their searching. However, students with prior knowledge quickly recalled from long-term memory improve their ability to choose appropriate keywords and select SER under the time pressure of the face-to-face tutorial conditions.

7.9 Summary results chapters 5, 6 & 7

In summary, chapter 5 provided insights into students' self-reporting of how they incorporated ICT

affordances and juggled ICT devices and other resources. The number of devices and resources featured predominantly.

Chapter 6 textual analyses of events identified during the formal AL tutorial and explored in the VSRTA interviews. Five themes were revealed. Students expect always to have reliable, fast, and free internet access. ICT affordances enable them not to suffer uncertainty or unknowns as they can be readily resolved, which is in misalignment with the AL trigger whereby an unknown is designed to stimulate and motivate students learning and increase the time learning to form memorable long-term memory schemas. Students create social knowledge economies by establishing multiple tiers of social network applications and controlling the membership. ICT affords them to communicate with themselves and others anywhere in the world. Finally, they expend considerable time and effort into the organisation of unsearchable digital notes that they cannot learn from, so they return to handwriting for consolidation of learning.

Chapter 7 honed in further to uncover the disparity between the students' perception of their learning with ICT affordances and the interpretation with ICT history logs through the lens of the theoretical framework of learning and the ICT affordances and AL affordances. It was apparent that students attempted, and in some instances preferred, to use the ICT affordances and ignored the face-to-face affordances of AL. The insights gained by the ICT history logs exposed students are forming transactive memory relationships with their ICT devices at the expense of their AL group. Students kept their ICT searches to themselves and missed vital co-constructive knowledge opportunities in the AL process. However, when ICT and prior knowledge is strategically combined and shared, co-constructive opportunities are enhanced. The level of prior knowledge has been identified as an important factor, especially under time and pressure conditions. Without prior knowledge to guide keywords use and development and SER judgement, ICT affordances will result in errors, long online searches, and eventual abandonment. Critical time away from their learning group as the student ignored the AL tutorial's learning benefits.

8 DISCUSSION CHAPTER

8.1 Introduction of the original dilemma

This study set out to explore the effectivities of the students who use information communication technology (ICT) during their active learning (AL) in the context of problem-based learning (PBL). Two contradictory observations sparked my interest in undertaking this study. On the one hand, contemporary students are assumed to be so-called 'digital natives' who grew up with ICT and can use ICT seamlessly and with great facility. On the other hand, PBL tutors' observations suggested that students seem to use their ICT affordances in ways that run contrary to the original ideas of AL during PBL. If left as is, educators and curriculum designers would have to depend upon students to adequately choose and use an array of ICT affordances without direction, and assume that students will discover the best approach on their own and be able to self-evaluate the effectiveness of each ICT method. But educators were concerned that students' use of ICT during group learning is problematic to the session and the students' learning. Therefore, this study sought to better understand this dilemma by exploring how students use their ICT expertise for genuinely effective and AL.

Why is the use of ICT possibly a problem?

The AL instructional design of small group learning, PBL, was developed at a time when personal ICT devices had yet to be conceived, and so incorporation of ICT was not part of the original design. With the introduction of ICT as another learning resource into the tutorial setting, it would be reasonable to anticipate that it would impact the AL tutorial processes. Given the assumption that students have grown up with ICT and are adept at controlling informal ICT affordances, it is often assumed that they can also do so to supplement their learning. The question posed here is whether the informal ICT affordances align with the formal AL affordances or violate the original AL tenets?

Aims of this research

The overarching aim of this research was to explore and interpret students' informal ICT-seeking behaviours during formal AL tutorials to understand how these augment or hamper learning in this AL/ICT environment. For this, I used the theoretical lenses of Social Cognitive Theory of Learning (SCT) (Bandura, 1986), combined with Information Processing Theories (Atkinson & Shiffrin, 1968). These two theories combined form the underlying theoretical platform upon which I have overlayed three other cognitive theories: these concern i) the capacity and limitations of the working memory (Baddeley, 2011; Baddeley & Hitch, 1974), ii) the cognitive load theory (P. Chandler & Sweller, 1991; Sweller, 1988; Sweller et al., 1998; Van Merriënboer & Sweller, 2010) and iii) the cognitive theory of multimedia learning (Mayer & Moreno, 2003; Mayer et al., 1999). Additionally, I explored the cognitive component of the framework further through an examination of cognitive taxonomy (Anderson et al., 2001; Krathwohl, 2002), metacognition (Pintrich & De Groot, 1990), and attentional focus (Cowan, 2011; Cowan et al., 2005). Finally, I incorporated the theory of ICT affordances (Friedman & Friedman, 2008) and

researched student effectivities (Turvey, 1992) to compare and contrast AL tenets during identified learning events to address the research questions.

I identified the students' abilities, effectivities, to access informal ICT affordances for AL and used these in further analysis in the context of the AL PBL tutorial. The research objectives are re-stated here as they relate to the overall impact on student learning and the central AL tenets. All objectives are viewed from the conceptual framework perspective as presented in chapter 1.

1. To understand the informal ICT affordance-seeking behaviour and subsequent student effectivities for learning during formal AL tutorials.
2. To explore the level of alignment between the formal AL tenets with the students' abilities to manipulate their ICT affordances to benefit learning.
3. To gauge the interaction of and student dependency on ICT affordances during the AL process and the subsequent impact of these on students' cognitive engagement.
4. To evaluate the impact of informal ICT affordances on cognitive load regarding the individual student and the group's information processing system.
5. To explore the overall influence ICT affordances have on the students' learning strategies and ICT's impact on the development of metacognitive strategies for self-directed learning and lifelong learning essential to AL methods.

8.1.1 Structure of Discussion

The findings of this study are complex, and as a consequence, all interact and are intertwined with each other. Therefore, I have chosen a structured approach for this discussion chapter for optimal clarity.

First, the significant findings and insights are discussed. These findings are then analysed through the lenses of the conceptual frameworks, ICT affordances of learning, and students' effectivities. This includes the description of results and their research implications, which are intertwined with medical education and practical implications, highlighting this work's practical educational relevance.

8.2 Findings and Insights

8.3 Students' informal ICT effectivities should not be assumed

The profoundly inescapable finding throughout this research is that students' effectivities to negotiate informal ICT affordances in their daily lives, such as using social media platforms, are not directly transferrable to the formal PBL tutorial setting and AL in general. Therefore, it is important to highlight that one's ability to use an instrument, such as ICT devices, with search engines and social media platforms does not automatically mean that one can use it for the intended or right purpose (Durning & Artino, 2011) in any other given situation. In this instance, the intended purpose is to support AL enabling the student to construct their own knowledge through collaborative interactions with learning partners whilst actively working on contextually relevant and memorable scenarios (Barrows & Tamblyn, 1980;

Neufeld & Barrows, 1974; Schmidt, 1983; Schmidt et al., 2011). Additionally, it promotes the student to develop lifelong learning strategies by being self-directed learners (Loyens, Magda, et al., 2008).

If students do not understand what constitutes effective AL, they are likely to use ICT ineffectively in the context of a formal educational programme. The assumption that students arrive at university and are immediately able to navigate the pedagogical complexities using their informal ICT know-how is incorrect. It is the educators' role, not the students, to understand what constitutes effective AL. But both seem to be unaware of what constitutes effective use of informal ICT in AL. Educators often assume students can graft their informal ICT know-how onto the PBL setting. Conversely, students believe their ICT skills are proficient and unaware of the learning pitfalls of relying on ICT.

Educators and universities must recognise that students' ICT effectivities gleaned from social media are not suitable for academic learning. Students are confident ICT users, and when they readily apply their personal and social ICT know-how to their learning, they portray digital confidence. That confidence, however, is not one hundred per cent as students almost unconsciously recognised that they need and want face-to-face learning as well. Another reason for their confidence is that they can use many different applications. But these applications are selected on their availability rather than on their compatibility and functionality for effective learning. Therefore, students displayed digital confidence using ICT devices that did not translate into competence in using ICT affordances for AL. Theoretically speaking, students had the ICT affordance available and were trying to be self-directed learners, but in practice, they were not. They did not know how to align their effectivity with the available AL affordances.

8.3.1 Students confuse digital confidence and competence

So, although digital confidence using ICT devices does not automatically translate into digital competence for AL, it is a feature of students who have grown up with ICT. They are digital natives (Prensky, 2001a, 2001b) who should possess the inherent knowledge and ability to navigate ICT and who have a wide range of ICT tools for their effective learning. Yet students' ICT efficacies for learning should not be attributed to them simply because of the era in which they were born. It became evident that contemporary students are digitally confident to use ICT in most spheres of their life (Bennett & Maton, 2010; Judd, 2018; Passey et al., 2018; Šorgo, Bartol, Dolničar, & Boh Podgornik, 2017). For example, students are proficient ICT users for social, entertainment and personal use, but in the context of education, students require digital competence to navigate and utilise the ICT affordances to supplement their AL (Benson, 2019; Passey et al., 2018). Therefore, digital competencies require students also to have digital literacy strategies of information and data analyses to create digital content and communities to communicate and collaborate within the academic learning environment (López-Meneses, Sirignano, Vázquez-Cano, & Ramírez-Hurtado, 2020). These digital competencies should align with the identified ICT affordances (Friedman & Friedman, 2008, 2013) for AL. Hence, students need digital skills beyond their everyday social media skills to deepen and contextualise their academic learning.

Previous literature has been predominantly from online surveys seeking the students' self-reported perspective of their digital skills to support their learning with ICT (Barry et al., 2015; Rashid & Asghar, 2016). However, as already noted, students reported that they want more face-to-face learning opportunities. In fact, they want it all (Hood, 2013). This subtle extra rider of wanting all forms of learning opportunities indicates there are deficiencies in relying on one learning approach, which has seen an increase in blended learning opportunities (Broadbent, 2017; Donnelly, 2010; Van Doorn & Van Doorn, 2014; Woltering, Herrier, Spitzer, & Spreckelsen, 2009).

In this research, students explained their digital confidence by detailing the array of informal ICT applications they used to support their learning. Students sought ICT programs that were readily available from their own ICT device set up and the university's programs. The majority of students used ICT programs that were readily available and free (fiscally frugal) without reflecting on each applications' compatibility. They perceived ICT applications that provided access to quick, just-in-time information (search engine, e.g., Google™; free online encyclopedia, e.g., Wikipedia; clinical decision website, e.g., UpToDate™ or eTG) as critical to their learning. Also, ICT helped organise their notes (free-form-information gathering program, e.g. OneNote™) and organise themselves (free habit and productivity app, e.g., Habitica™).

Furthermore, they linked their digital notes to help them remember information by using online repetition-based learning (spaced repetition app, e.g., AnkiApp™). Other ICT uses included facilitating information entry into their devices (voice recognition program, e.g., Dragon™) and creating artefacts of learning (e.g., free drawing apps, Lucidchart App™ form mindmaps etc.). Students digital competencies centred around accessing the internet and organising their notes digitally using ICT convergent functionalities based on their social media know-how. For example, they are adept at gaining internet access and their digital notes anywhere. A telling illustration of this was how students relied on their smartphone when their laptop/tablet, their primary ICT device, was unavailable. Consequently, students did display a digital competence level with fiscal frugality with online resourcefulness to develop and organise their study notes, including access to their cloud-stored information from any device, anywhere and anytime. However, juggling several ICT devices' during the AL tutorial led to frequently shifting between engaging with their ICT devices to ensure connectivity for online searching and the AL affordances of face-to-face, resulting in split attention.

In theory, ICT afforded students can be self-directed learners, which should align with AL promoting lifelong learning (Dolmans et al., 2005; Loyens, Magda, et al., 2008). However, the onus is on the students' digital competencies, such as their judgement of the informally sourced applications and ICT information quality and relevance to AL. Despite students displaying confidence in manipulating their ICT devices, their effectivity to navigate ICT affordances did not always translate into digital competence for learning in aligning the ICT for AL affordances.

8.3.2 Students confuse organising information with having actual access to the information.

Students demonstrated skills in creating and organising personal ICT libraries and resources. However, they mistook the time and effort to create and collate these resources and find online information to be their learning. This misconception became specifically apparent when they quickly searched or used these digital notes during PBL but failed. They had not organised them for meaningful searchability. Students commonly used free-form-information gathering programs (OneNote) to collate and organise their study. They used index systems similar to a hard copy book or programs that were incompatible with each other, rendering their notes unsearchable. In order to retrieve relevant information, they had to mainly recall where it was stored rather than recall the information itself. Sparrow and colleagues found that under experimental conditions, students could remember where to find information online but could not remember the details of the information itself (Sparrow & Chatman, 2013; Sparrow et al., 2011). This differed from my research findings in which the students could not quickly recall where they had stored the information in their digital notes nor the information itself. The naturalistic learning environment of the PBL tutorial exposed significant differences between learning complex information and the simpler information associated with the controlled experimental conditions that Sparrow and colleagues studied. In my study, I found that students had created unsearchable digital 'libraries' stored in the cloud, which were rendered virtually useless under the tutorial conditions and, therefore, likely in later practice as well. In other words, students focused their attention more on the specifics of gathering and collating the information rather than the intricacies of understanding the information itself.

8.3.3 Students confuse the' having' of information with being able to access that information readily.

Students did not reflect upon this as a problem as they had ready access to ICT search engines as a backup. Consequently, the internet availability abrogated the students' need to remember the information (Ståhl, 2017). They relied on the just-in-time information from search engines which served as an external memory store (transactive memory), and in some cases, they cognitively offloaded the responsibility to select and judge the rigour of the information for their learning to the search engine results. Their biological memory, as already mentioned, was used to recall the temporal components of when they researched a topic and where they had stored the information rather than recall the information itself. Which, especially when they attempted to remember complex information, failed.

Interestingly, before commencing medicine, students were reflective of their learning strategies and how these strategies and ICT could assist their learning. However, they did not appear to reflect on whether the changes they had made by incorporating ICT were fruitful for their learning. They just assumed they were. They relished what ICT afforded to their learning environment but were oblivious to the potential impact ICT was having on their long-term memory and learning.

Therefore, students wanted and needed internet access for their just-in-time informational needs. They had confused the ICT organisation with actual learning, and they confused having procured information

digitally as being in control of that information.

8.3.4 Creating organised ICT notes and resources.

Students mistakenly believed collecting information and resources into digitally organised notes were synonymous with understanding, learning, and biological long-term memory formation. They intended to create readily available digital resources for their study and tutorials. Students went to great lengths to develop their digital resources as they collected, collated, and organised information and resources for their learning. They amassed enormous individually collated ICT libraries with hundreds of PDF textbooks, formal lecture notes, other 'cut and paste' resources and websites. They also had their notes from previous and current work units and near-peer notes from earlier years all open and ready to use during PBL. These notes, intermingled with their own digested notes, formed the collation of their digital notes.

To prepare and organise their work for their face-to-face tutorials, students pinned links on the computer toolbar ICT sites, such as search engines and clinical decision websites, and tabs to pre-digested information and their own work for easy access during PBL. In other words, ICT afforded them to carry all of their work and associated resources with them for their just-in-time needs 'virtually.' I found that more students returned to the report-back tutorial with ICT devices and paper-based resources than in the problem-analysis tutorial. Ostensibly with the products from their self-directed learning.

To be organised is beneficial to learning as it increases germane cognitive load (Anmarkrud, Andresen, & Bråten, 2019; Sweller, 2010; Van Merriënboer & Sweller, 2010). Germane cognitive load does not impose a cognitive cost but facilitates cognition. Therefore, in practice, ICT organisation and preparation for AL tutorials should promote knowledge co-construction in the AL and the ICT affordance arena. Hence, students using ICT affordances to create convergent libraries and communicate their digital notes through ICT organisations facilitate their learning environment.

One student (Charlie, Chapter 7.7) had created digital notes and resources in an online word processor format, Google Docs™, to create her own web page to store all her work within a search algorithm. This was serendipitous, as the ICT applications the student wanted to use were not compatible with the other popular word programs used by the rest of the students in the study. However, despite creating searchable digital notes, Charlie still preferred to use the internet search engines to find information and not her searchable digital notes during PBL.

Therefore, the critical point is that students' ICT effectivity to develop their convergent library, resources and notes are tailored to their individualised learning needs and the learning needs identified by the AL group. But for academic learning, these notes must be readily available, or students must be willing to use them. If given ample time, students could find their stored information. But with limited time, they could not retrieve specific information quickly during the AL tutorial. Moreover, many students had not formed biological long-term memory schemas for the information, so they had to try to remember where they had stored their work.

This has significant ramifications when considering biological long-term memory activation during AL, clinical practice, or online examinations. Students' effectivities in searching digital notes were ineffective under these conditions. They might think that they prepare for these encounters by collating and storing information to share but fail to realise they did not have the ICT know-how to store their work in a retrievable prompt manner for AL tutorials requirements. This reveals a lack of understanding that retrieval from long-term memory is only possible after biological memories have been formed and ICT will not remember for you. Hence, students were attempting to recall complex data about finding the ICT stored information instead of the relevant information itself. Interestingly students did not perceive this as a learning problem as they could access search engines, 'google', to compensate. Again, students had not reflected on the time taken to develop their digital notes and, subsequently, the actual usefulness of incorporating informal ICT affordances to their AL tutorial and ultimately the impact on the construction of long-term memory knowledge.

In summary, even if students do have searchable notes, they prefer to access informal ICT knowledge communities and collaboratives via search engines, as it is quicker than searching their own digital notes and or relying on their biological memory. Thus, students follow socially entrenched ICT seeking behaviours that are endemic in our ICT afforded learning environment. In other words, they are enculturated into thinking 'Google™' first (Duran-Nelson, Gladding, Beattie, & Nixon, 2013; Judd & Kennedy, 2011; L. Russo & Russo, 2020; Sparrow et al., 2011; Ward, 2013a; Wegner & Ward, 2013). Consequently, individual students' digital notes and PBL preparation are practically inaccessible under the PBL conditions distracting and conflicting with the AL affordances of developing deep understanding and construction of knowledge both individually and within the group. As a result, students rely on the unprocessed information from search engines to share during AL, potentially leading to shallow, less memorable long-term memory schemas. In addition, students tend not to use their digital libraries and resources.

8.3.5 Students' use of ICT Affordance in AL tends to significantly increase the volume and complexity of resources they attempt to learn from.

The following section reports the range of student effectivities to organise their learning and how these effectivities align with the ICT affordances of learning and AL affordances. Figure 8.1 illustrates the complexity of students' digital organisation whereby they assembled and employed many layers of manipulating information for their study.

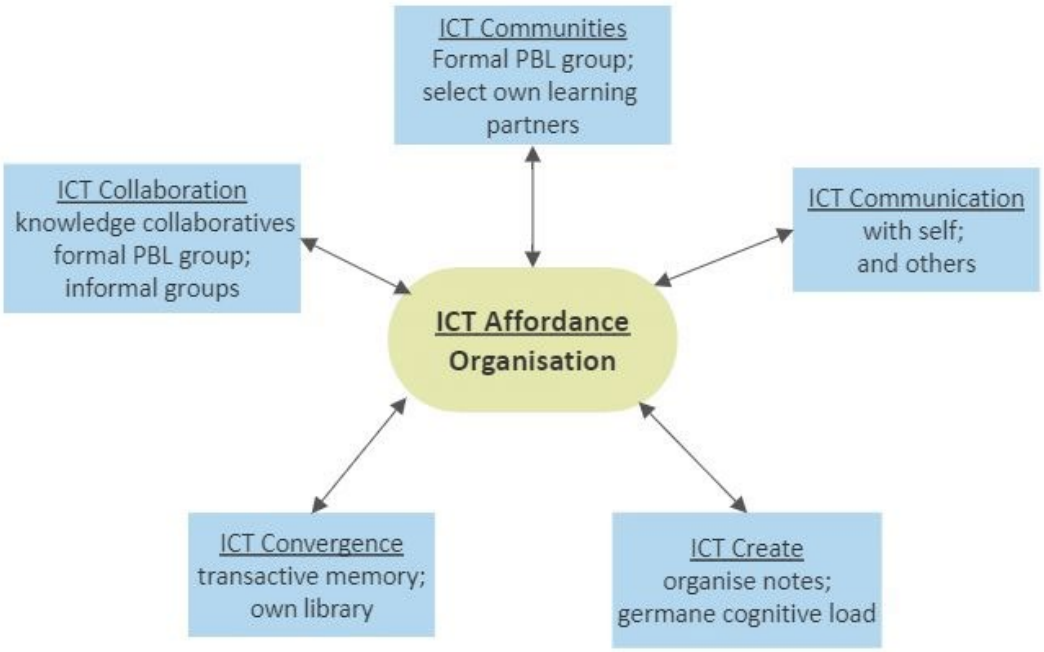

Figure 8-1 The ICT Affordances-Effectivity of the student organisation.

Students employ ICT affordances to organise their learning environment by adapting their social networking *'know-how'* to their learning space. In doing so, they are creating multiple levels of ICT networks. The original impetus for this research was the observation that students struggled to manage voluminous amounts of information and felt overwhelmed *'there is so much information to learn in medicine [Ryan; Chapter 7.5].'* Interestingly, I found that students, individually and in groups, developed complex ICT organisational networks to handle this perceived voluminous ICT information and, in doing so, created many more layers of complexity. One aspect of a formal curriculum is that curriculum designers are aware that the knowledge level (intrinsic cognitive load) needs to be made regarding the subject matter relevant to learning and the subject matter that is not relevant. Even though students like Ryan were concerned about the curricula' depth, high level and deliberate decisions scaffold the curriculum's content.

Additionally, conscious choices have to be made about the formats, types and availability of resources that deliver the formal intrinsic content and the number of academic experts available to support students in the AL environment. Upon entering the informal ICT learning space, those boundaries and scaffolding are no longer there. Students are by themselves. There is no local expert to help as they navigate infinite un-scaffolded intrinsic content with no limitations to draw upon. Compounding this, they need to judge the calibre of an endless number of other expert informants as well as an endless number of ICT communities and collaborations. This poses an additional cognitive load burden on students to individually make decisions about which so-called expert to believe and use. Moreover, whereas in a managed curriculum, care is taken to ensure that all information is to a certain extent scientifically defensible or practically credible and aligns incrementally with students learning progression, this is not

the case with all information on the internet. Consequently, students will constantly have to make a judgement by themselves.

8.4 Students use ICT to widen their collaborative knowledge communities beyond the face-to-face AL tutorial.

Students expect to be always electronically connected to the internet but also with each other. They adapt their personal knowledge of social media to set up informal learning communities to collaborate and communicate during the AL cycles. As such, students developed multiple personally controlled networks of social media groups. At the time of this research, Facebook was the preferred social media site as found previously (Manasijević, Živković, Arsić, & Milošević, 2016; Manca & Ranieri, 2013). But other ICT platforms are constantly emerging in preference to Facebook, for example, WhatsApp (Manca, 2020). The social media platforms will change, but the ICT affordances should remain constant with adaptable subsequent effectivities. Therefore, utilising social media platforms enables the creation of multiple overlapping students controlled informal learning ICT communities.

8.4.1 Formal PBL group to form an informal Facebook group

All PBL groups researched had set up a private PBL group Facebook page. PBL tutors were excluded, as were faculty members. Several other researchers have also found that students keep their social media pages out of sight from their tutors (Ali, 2016; Gray, Annabell, & Kennedy, 2010). The faculty determined the formal face-to-face PBL group membership, which was out of the students' control. On the other hand, students used the PBL group Facebook page predominantly for private group communication, organisation of group learning, day-to-day running of the group, and informal activities. For example, they would post (communicate) group related work, such as photos taken of the PBL tutorial group board work, interesting websites or references, study-related issues, post questions for others to help with, and organise social events. Facebook, however, is a social media site designed for sharing information and images asynchronously and sequentially. In addition to having a Facebook page, students used a group Google Docs™, which, as an online word processor, enabled students to contribute more synchronously, but there was no indication that this led to more effective ICT collaboration. Although, these sites were to share information, there was little evidence of its use for collaborative learning in my videos of the PBL tutorials.

Students pre-organised their face-to-face PBL tutorials through their PBL group Facebook page. With this, the students scaffolded their learning environment - a desirable characteristic of self-directed learning (Loyens, Rikers, et al., 2008; Schmidt, 1983). In the time before ICT affordances existed, an AL group would discuss and negotiate the flow face-to-face or scaffold each tutorial in conjunction with the tutor, which took up valuable tutorial time (Schmidt, 1983; Wood, 2003). All students in the group would arrive at the tutorial prepared to present, question, listen and discuss all learning objectives and issues. The report-back session was when the students co-constructed their knowledge to collectively form deep

learning associated with developing long-term memory schemas (Barrows, 1983, 1996; Barrows & Tamblyn, 1980; Dolmans et al., 2005).

Creating ICT communities outside of the face-to-face environment enabled students to maximise their face-to-face time and focus on the content to be addressed rather than spend time dealing with how to run the tutorial. All groups ran a learning objective/issue poll, either before or after the problem-analysis tutorial. Students would pre-select the learning objectives (and or learning issue after the problem-analysis tutorial). Shy students were able to select what they wanted to present during the report-back tutorial. In doing so, these students avoided the stress of negotiating face-to-face on the day. Therefore, ICT affordances of creating communities for collaborating and communicating enables students to control their AL environment and manage their contribution in a highly individualised way.

From a cognitive load perspective, the prior organisation increases the germane cognitive load by positively enhancing the learning environment. This frees up the student(s) to focus more on the PBL case intrinsic cognitive load. In theory, this also reduces the unwanted extraneous cognitive load associated with having to negotiate the report-back organisation face-to-face, especially for the shy student. Thus, students felt pre-organisation of the tutorial promoted their AL.

Students using ICT to organise their PBL tutorial led to several benefits and several disadvantages. First, the prior organisation of the report-back resulted in that most students presenting a learning objective/issue to the group. Active participation in PBL increases individual students' learning (Carrasco, Behling, & Lopez, 2018) and is a desirable AL tool. Prior organisation suited the shy and less confident student as they could select a learning objective/issues without the stress of face-to-face negotiation. Without this ICT affordance, these students might be reluctant to speak up for themselves in the group, which possibly meant missing out on presenting (Hendry, Ryan, & Harris, 2003). I found that the shy and less confident students did present their allocated learning objective. Therefore, ICT communities and communication acted as enablers for shy and less confident students to participate without face-to-face negotiation.

The second benefit included remote communication of a completed learning objective when one student was unwell and could not be present, highlighting the possibilities for remote online learning. However, the ill student did not present their work themselves in this instance, but it was left up to the group to decipher. That way, the ICT affordance did not benefit the ill student’s learning, and it led to a relatively static and non-interactive report-back. The purpose of the report-back is not necessarily to inform other students but to create interaction and, through this, deeper understanding.

The third occasional use observed was when students used the tutorial room screen to display ‘cut and pasted’ diagrams they had on their group Facebook page for all to view and work through together. Although this seems to be an advantage, it negated the need to hand draw diagrams on the group board. Students potentially perceive they understand the presented diagram, but as Ertmer and Glazerwski noted, some students go through the motions of understanding without actively engaging with the tasks

(Ertmer & Glazewski, 2015). Therefore, collectively creating diagrams on the group board facilitates each student's cognitive processing by following each diagram component as it is logically drawn and improves memory through understanding (Hmelo-Silver & Barrows, 2006). The hand-brain relationship of writing and drawing by individuals (Mangen & Velay, 2010) with group contributions enhances the placement of new information or concepts into prior knowledge of those that contribute (Daley, Durning, & Torre, 2016). This visual representation of progressively developing diagrams contextualises basic sciences and clinical sciences for each student (and the tutor) to follow (Van de Pol, De Bruin, Van Loon, & Van Gog, 2019; Van Loon, de Bruin, Van Gog, Van Merriënboer, & Dunlosky, 2014). Thus it provides students with thinking time to assess their understanding of new concepts and monitor accuracy and relevance according to their prior knowledge as the diagram evolves (Daley et al., 2016). However, when diagrams are not created but are cut and pasted or even pre-drawn on the board, students do not have time to contemplate and work through each step's increasing complexity. This decrease in engagement with the co-construction of information reduces time to consider one's own understanding because it truncates learning. Students have less time to identify what they know and do not know, less time to contribute their unique knowledge, and raise questions to discuss. These are critical cognitive processes that lead to deeper understanding and contextualisation, resulting in robust knowledge construction. On the surface, this level of pre-organisation and presentation of fully developed diagrams save time. However, learning requires time and persistent cognitive effort.

Another ramification of pre-organising the report-back tutorial relates to the prior distribution of learning objectives. The purpose of the report back is for students to engage in discussion. This occurs when all students are prepared to discuss their perspective and understanding of all researched learning objectives/issues. Students can then each apply their unique frame of reference to determine appropriate resources to use, and their interpretation of the information found. This creates a diversity of information, understanding, and resources resulting in a rich information learning 'soup', leading to discussion, questioning, explaining, and listening. Ultimately this culminates in negotiating a shared summary of the groups understanding and knowledge (Bate et al., 2014; Hmelo-Silver, Chernobilsky, & Jordan, 2008; Papinczak, 2009; Schmidt et al., 2011; Visschers-Pleijers, 2006; Yew & Schmidt, 2009). This collaborative meaning-making requires each student to conceptualise and reconceptualise their biological prior knowledge of the subject matter and, in doing so, strengthens and enriches that memory to develop stronger contextual cues for subsequent retrieval. This way, the information is contextualised into meaningful, memorable long-term memory schemas.

However, having a prior organisation level for the report-back tutorial led many students to only prepare their designated learning objective in-depth and only superficially researched the rest. In these instances, the report-back tutorial consisted of a series of mini-lectures predominantly by the confident students. These were the students who had prepared all learning objectives/issues in-depth. Only they would be participating and driving the collaborative construction of understanding and knowledge. The shy and less confident students, on the other hand, could present their learning objective, but these then quickly retreated and did not participate before or after their presentation. They depended upon their peers to

deliver and to provide the required depth of information. The in-depth learning objectives presentation would, upon request, be posted on the group Facebook page. Therefore, by not researching each learning objective in-depth using ICT affordances, communication and collaboration resulted in students being less prepared to question, pose different points of view, discuss, elaborate, and critically listen to each other. They were well prepared for one learning issue only. This phenomenon is not entirely new. Division of labour, pre-allocating learning goals to students, happened before ICT affordance use in the PBL tutorial, but the availability of ICT affordances seems to have magnified the problem significantly. One reason for this is that it all happened in the informal learning space to which the tutor was not privy and, therefore, potentially unaware. As a result, she or he could not address the issue.

Consequently, some students had not considered their perspective and understanding of all the learning issues, leading them to rely on another person's view. In doing so, they bestowed an implicit trust in another student's resources and interpretation. This creates an unwanted situation. The importance of diversity within the PBL group leads to useful cognitive dissonance, whereby differences are discussed and worked through, resulting in a shared understanding of the learning content (Bate et al., 2014). Motivation to resolve cognitive dissonances leads to perseverance and the development of memorable long-term memories. Therefore, pre-preparing for PBL in this limited fashion leads to less preparedness to question, elaborate, and discuss differences regarding the information content, as students are not aware of their own interpretation. These attributes are central to the co-construction of the groups' knowledge and that of the individuals (Fonteijn & Dolmans, 2019; Van Blankenstein, Dolmans, Van der Vleuten, & Schmidt, 2013; Van Blankenstein et al., 2011; Visschers-Pleijers, Dolmans, de Grave, & Wolfhagen, 2006).

Although ICT affordances enabled shy students to participate in the PBL process, albeit briefly, it is unlikely that access to ICT affordances benefitted or encouraged the shy students to engage with the AL affordances to benefit the group's or their own learning. They performed a purely didactic mini-lecture to their group without directly seeking or possibly wanting the group to contribute. This is an important point, as ICT affordances, in this instance, provide the shy student with a false feeling that they can safely participate. Yet, the shy student, their group, and their tutor did not have the effectivity to extend this situation to engage both ICT affordances and AL affordances, and the perceived safety comes at the cost of reducing learning. This is another illustration that educators make incorrect assumptions about how well students can manage their ICT affordances with the AL affordances during tutorials.

8.4.2 Facebook groups were created.

Other groups set up were based upon the student's friendship groups within medicine and outside of medicine. Also, so-called inter-PBL groups study groups were formed. In these cases, students selected their learning partners and applied their individual selection criteria. One crucial factor was trust. For example, G7S2 (Chapter 6.7; G7S2) sought a friend's opinion in another PBL group whilst being face-to-face with their own formal PBL group. This synchronous communication was undertaken as G7S2 did not agree with something their PBL peers said and distrusted the ensuing discussion. After communicating

with their trusted friend (in another group) and concurring they had been correct, and the PBL peers were incorrect, they chose not to share or question the issue further with the face-to-face PBL group. The PBL group's issue was, therefore, left unresolved. This illustrates a student who capably negotiated the informal ICT affordance of communities and communication for their own perceived benefit but failed to engage in the group AL affordance of collaboration and construction of knowledge. The ability to question and discuss with others is a key affordance of AL and the workplace environment. There might be multiple reasons for not sharing the information. The student, for example, stated they did not want to openly doubt their peers, believing they would adversely disrupt the group dynamics. When students do not address such a dilemma with their face-to-face group, they do not practice, rehearse, learn, constructively criticise and challenge other people's opinions through questioning, listening, and discussing. Developing group skills is critically important when working with diverse health workers and patients who are not their friends but characterise their work environment. Learning such group skills is part of the educational basis for PBL in professional courses. The readily available ICT self-selected community allows the student to opt-out of these faculty selected learning communities to the detriment of learning group skills.

Essentially, students formed and were members of many online groups, and it became evident that students were engaging with several ICT communities synchronously during AL. The diversity of these online groups could theoretically benefit learning. Students demonstrated resourcefulness to utilise ICT affordances to create their tailormade learning communities outside of the formal PBL group. Rienties and Tempelaar found students performed better when they formed individual learning relationships outside of the formal learning groups. These boundary-crossing and intergroup learning opportunities (Rienties & Tempelaar, 2018) are potentially applicable in this situation. However, the ease and less challenging access to their selected ICT community can deny students the opportunity to develop skills in working with non-friends which is analogous to the clinical medical practice. They missed learning opportunities to rehearse and develop critical people skills to work with others who have different views and create information 'bubbles' or 'echo chambers' to speak. The impact of these informal networked ICT communities' student's set-up, creating intergroup learning opportunities warrants further investigation.

8.4.3 Students do not want to engage with the formal learning management system

Students prefer social media platforms and their own selected online search engines for their learning environment over the university-provided online systems. Universities attempt to offer similar designs for learning online spaces and invest significant resources and money into their ICT services for all aspects of academia. A commonly used university internet software system is the Learning Management System or LMS (Cabero-Almenara, Arancibia, & Del Prete, 2019). LMS has features for creating and communicating content, such as course material and sessions, collaborative spaces for group work in class and out of class times and provides diverse assessment platforms and cloud storage, to name a few (Anand & Eswaran, 2018). Various universities rely on their LMS to create a dynamic online learning environment that appeals to the digital native student (Tess, 2013). However, students find the university

LMS ‘clunky’ and non-intuitive compared to their social media platforms (Sleeman, Lang, & Dakich, 2020). Social media and online formats are familiar to them and are continuously used in their everyday life. Students know how to manipulate them confidently. They are part of their life. So, no matter how much the university promotes, incorporates, and upgrades its LMS, students return to the ICT format they are most comfortable and familiar with. This observation is the basis why some resource-constrained universities in poorer countries adopt social media platforms for their collaborative learning spaces instead of the expensive LMS’s (Vandeyar, 2020). However, in these settings, the educator controls the social media spaces and invites the students to join. Compared to no LMS, the use of social media, such as Facebook, for collaborative work has been well received. It is unknown if these students set up additional private social media spaces away from their educators, but it is highly likely.

In the context of my research, students used the formal LMS when directed to for formal requirements, such as accessing the PBL case, the writing of the group's learning issues, assignments, and reflections, but otherwise, they used private invite-only social media spaces with not educators invited as previously found by others (Gray, Annabell, et al., 2010; Gray, Chang, & Kennedy, 2010; Kennedy, Gray, & Tse, 2008). Consequently, students communicate privately on their Facebook pages to work through the drafts of the formal assignment before posting the final product on the formal group LMS allocated site. These layers of Facebook pages have been hidden from previous researchers investigating the use of formal ICT collaborative sites, and as such, they have only been obtaining the finished product, not the development of the assessable product.

When required to use the university's formal LMS, students comply by ‘cutting and pasting’ the required information. However, these formally provided sites are in addition to their preferred multiple social media sites. Anecdotally, students mentioned they prefer to conduct all the collaborative work away from the educator's eyes. Therefore, the course's formal requirements to engage with the LMS also add to the number of online sites students participate in and monitor. Consequently, increasing task-switching and shifts in attentional focus between alerts and sites increase extraneous cognitive load.

An unexpected finding was students didn’t like changes to LMS platforms. They want familiar online platforms. An important difference between the management of LMS and online platforms and programs is that the LMS goes through a significant update once a year not to disturb the academic flow. Whereas online platforms and programs routinely conduct minor incremental updates. Significant updates require the user to adapt and often relearn how to use the program effectively, whereas small, continual cumulative updates keep the interaction between the user and the platform or program intuitive. This is another reason why students see the formal LMS as clunky.

8.4.4 Students use ICT affordances of creation and collaboration to self-direct their learning.

During AL, high ICT engaged students were more likely to ignore the face-to-face AL affordance of collaboration. Instead, this cohort of students accessed ICT affordances to collaborate and communicate with online communities of their choosing rather than asking their formal face-to-face peers.

8.4.4.1 Select own collaborative group

Students preferred to select their learning partners, primarily because they did not trust their own knowledge or that of their allocated AL group.

Students set up and or belonged to many online groups for social and learning-related reasons (social media sites, Facebook™ or accessed ICT knowledge collaboratives, such as Wikipedia). Through this, they increased their exposure to a broader range of others' knowledge and experiences, well beyond what is possible with the formal AL group members. Diversity of students' knowledge, backgrounds, and experiences, even just within the formal PBL group, is already associated with enhancing and facilitating AL (Fonteijn & Dolmans, 2019; Holen et al., 2015; Rotgans & Schmidt, 2011) it is therefore likely that the myriad of informal student-selected ICT groups improves this effect. Of course, students have always had the opportunity to engage with informal learning networks in the general students and friend's community, but it is clear that ICT increases the possibility immensely by allowing time-asynchronous and location-independent communication. But it is not all necessarily positive, and problems arose when some students avoided questioning their face-to-face group and chose to only contact their privately selected social media groups during the tutorial, ignoring the tutorial environment's AL affordances. This is a problem because, with social media groups, there is the risk of forming like-minded online learning groups which are less likely to challenge each other's views or extend their knowledge and understanding. So they are playing it safe. This is similar to students conducting online searches to get specific answers by trusting the abbreviated search engine snippets rather than the cognitively challenging method of judging the information for themselves by entering the ICT knowledge community and collaborative. By avoiding the rigorous cognitive effort and allowing the search engine to direct their knowledge, they abrogate their academic responsibility to ICT. When they have had enough listening to the AL group, they can retreat into unrelated ICT activities during AL to control the intrinsic cognitive load.

Consequently, ICT affordances, when employed without an understanding of AL, are not likely to facilitate collaboration and stay at the level of just sharing information. Additionally, student-selected ICT groups are potentially not challenging and diverse enough for a robust academic discourse as should take place in face-to-face AL.

8.4.4.2 Student characteristics

As mentioned before, the shy and under-confident students may be likely to participate scarcely, but ICT has enabled them to participate somehow. But, unfortunately, these students also mistakenly believed they had very little to contribute as they assumed other students already understood the case better than they did. As a result, they used their ICT devices to hide behind during AL and attended to their learning outside of the active-learning environment (Chapter 7.6.1 and 7.6.2) as they were reluctant to participate. Thus, ICT provided a private, non-threatening path to enter other ICT knowledge collaboratives.

Yet, a divide became apparent in students' prior knowledge and metacognitive skills capacity. The highly motivated and high-achieving students researched all learning objectives in detail. However, the less confident or time-poor students explored their selected learning objective in detail but relied on others to

provide in-depth information and requested ‘answers’ to be posted on the online group Facebook page. These students misunderstood the importance of AL affordances of co-construction of group understanding and knowledge on several levels. They were learning superficially and did not consider or undertake the necessary in-depth self-study to question others, tease out different points of view, or analyse opinions and information sources. As a result, the group knowledge and preparation diversity, a key feature of AL, decreased. They used the ICT affordances as a shortcut to their learning, which ultimately was detrimental to their learning and group learning.

It is important to note students have always taken learning shortcuts in PBL. Pre-ICT, the facilitator's role was critical in identifying and helping these students. Much research has been undertaken into the tutor's facilitatory role to promote the utilisation of the AL affordances (Dolmans et al., 2002; Maudsley, 2003; Schmidt, 1994) and cohesion and working of the PBL group (Azer, 2009; Dolmans et al., 2005; Johnson & Johnson, 2002). However, today the facilitator is excluded from the pre-tutorial organisation and not invited to join the groups' Facebook page (Gray, Annabell, et al., 2010; Madge, Meek, Wellens, & Hooley, 2009; Selwyn, 2009). Gray and colleagues concluded, in their studies of students’ use of Facebook in academia, that the educators should provide students with a professionally oriented social networking site (Gray, Annabell, et al., 2010) thereby encouraging them to use a more suitable online site with educator input and maintain their Facebook as their private social site. In theory, this could work. However, students do have formal collaborative sites provided but prefer the privacy and intuitiveness of Facebook. Also, they actively choose not to include the educator/tutor.

8.4.4.3 Collaboration aligned

When aligned with AL collaboration, ICT collaboration can stimulate and facilitate group discussion leading to co-construction of knowledge. This was apparent when Parker (Chapter 7.4) proffered spontaneous brainstormed ideas based on prior knowledge from a previous PBL case. The group initially ignored her. However, Parker searched her ICT affordances to develop her ideas further and re-express her thoughts. She shared her reframed explanations with the group, leading to extended group discussion and co-construction of group knowledge. When used appropriately, meaning that it is used to stimulate group discussion, ICT affordances can facilitate both individual and group learning, but it can be detrimental to learning when ICT is misused.

8.4.5 Students need to physically separate ICT for fun and academia to avoid conflict of ICT use and distraction.

The increase of computer technologies has led to a whole industry of online serious game development industries that capture educational gaming through personal gaming (Bergeron, 2005), such as making learning fun (Awan et al., 2019). There is an assumption that this is what students want. But learning requires dedicated cognitive effort for which there are no easy shortcuts, so learning is not necessarily fun, but it will always have to be engaging. Yet the lucrative ICT medical and health education industry will tell students otherwise as evidenced by a plethora of medically orientated serious game platforms.

These tempt the educators to include them in their teaching and for students to purchase them (Haoran, Bazakidi, & Zary, 2019; Singh, Bharatha, Sa, Adams, & Majumder, 2019; Tsopra et al., 2020). Gorbanev and colleagues conducted a comprehensive systematic review and categorised predominant gaming pedagogical strategies as being focused on behaviourism and cognitivism instructional design. They also concluded that serious games' formal use only had moderate effectiveness on students learning outcomes (Gorbanev et al., 2018).

It is important to realise that the gamification in education for students is driven by the ICT industry's financial imperatives, not by knowledge construction through deep understanding as fostered by educationalists. There is, however, research from educationalists who were able to capitalise on the motivational aspect that ICT games engender (Shi & Shih, 2015). Furthermore, the importance of increasing students motivation to learn is linked to a resultant increase in learning outcomes, and this is well recognised (Kusurkar et al., 2013; Pintrich, 2002; Pintrich & De Groot, 1990; Stegers-Jager, Cohen-Schotanus, & Themmen, 2012). Therefore, merging the AL affordance of contextualisation that increases motivation with educationally designed ICT game motivation could enhance contemporary students learning outcomes (Chang, Chung, & Chang, 2020; Singh et al., 2019; Tsopra et al., 2020). But there is also a growing concern over the addictive nature of promoting online games in education (Dias et al., 2020), and students with lower self-control are more vulnerable to suffering from online game addiction (Safarina & Halimah, 2019).

There seems to be a risk when educationalists assume that contemporary students want their education to be gamified and all online, as this might be setting up students to be dependent on the online game format for their learning. One student in the interviews was an avid online gamer who was very aware of the risks these alternate realities would pose to his university studies. This student went to great lengths to avoid being distracted by them. In this case, Logan (Chapter 7.7.1.3) separated his online gaming world and learning time by purchasing another computer, specifically for his learning. This computer had no gaming capacity. In this way, he kept himself focused on his education and was able to control his online gaming by physically separating these two activities. Otherwise, he said, he would not study effectively. This is an important illustration of the amount of self-directed learning that is needed when combining ICT with learning.

In light of this student’s dilemma, it is essential to be mindful not to let the ICT industry and popular assumptions dictate or seduce today's educationalists into blindly promoting gaming. Learning is generally cognitively effortful. Educators have a responsibility to support student’s cognitive development rather than offload that responsibility to the perceived fun and quick learning options, especially because they have not shown to benefit learning.

8.5 ICT affordances and Cognition

8.5.1 Students do not weigh up the investment in extraneous cognitive load with the return in lowering the intrinsic cognitive load.

Students reflection on how they allocate their time for learning is limited when they invest considerable time and energy to develop, collect, and organise their digital notes, which end up being unsearchable, leaving students still with the need to resort to search engines for just-in-time information. Students believe the search engine results (SER) are correct, pitched appropriately, and relevant to their learning level. However, the interpretation and appropriateness of these SERs require the student to be well informed about their formal learning level and, through this, judge the information's veracity. This conundrum is interpreted from a cognitive load theory perspective (P. Chandler & Sweller, 1991; Sweller, 2010; Sweller et al., 2019; Van Merriënboer & Sweller, 2010; Wong, Leahy, Marcus, & Sweller, 2012).

8.5.1.1 Intrinsic cognitive load

When students organise their ICT notes through collation and categorisation, they potentially facilitate the flow of study patterns, increasing germane cognitive load, which is considered beneficial (Paas & Van Merriënboer, 1994; Van Merrienboer & Ayres, 2005). But when these notes cannot be used efficiently, students use ICT affordances to source simplified information which is ‘pre-digested’ into quick and easy to understand formats. Through search engine (Google™) snippets, YouTube™, and search engine images, ICT allows students to only think in terms of keywords to link them to this pre-prepared information. This simplistic and pre-digested information creates an inflated sense of knowing (Fisher et al., 2015) and may lead students to trust the biases of information that has already been reviewed, regardless of whether that review was an appropriate evaluation of the information (Pattanaphanchai, O'Hara, & Hall, 2013; Singal & Kohli, 2016). Many students did not access the actual website after a google search and trusted and relied on the abbreviated snippets to portray the article's key points. Had the student had opened the site, they would be better positioned to judge the relevance of the information to the unknown or problem at hand. However, this would require them to read through the article to find the relevant points, which also requires valuable AL time and cognitive effort.

Students trust the search engine companies and their judgements of the websites implicitly. There are important considerations apparent here as these online content producers can control the format and content of the search engine results (SER) order on the page and create review snippets for the students. This way, they are making it quicker and easier to gather essential pieces of information, but when it comes to using it for learning, this process is flawed. Formal education research is starting to challenge the SER’s value (L. Russo & Russo, 2020). The ethical considerations of this are beyond the scope of discussion, but the impact this highly pre-digested and pre-selected information has on student learning is relevant. The most vulnerable students are those who struggle to keep up or have lower prior knowledge levels in the area under discussion. The search engine snippets provide them with cognitive shortcuts, and so these students typically direct their ICT effectivities towards selecting these pre-digested online pieces of information they believe to be appropriate for their course. In doing so, they

potentially decrease the rigour of the required intrinsic cognitive load inherent in the formal education course. The risk is they are not extending themselves intellectually sufficiently and may not even realise this to be problematic.

Yet, ICT afforded students are in a position to virtually manipulate and control their Intrinsic cognitive load, which could be too high or too low. It is at the behest of the learner. Traditionally, the intrinsic cognitive load is set by the curriculum. Educators scaffold and control the content to extend learning collaboratively with others. Vygotsky called this region the appropriate level of learning the Zone of Proximal Development (ZPD) (Vygotsky, 1980). The aim of scaffolding is to increase the difficultly in incremental steps to pique interest but not overwhelm (Shabani, Khatib, & Ebadi, 2010). However, when students use ubiquitous ICT information, there are no filters or directives from educators. The responsibility falls to the student to judge which SER to read, apply it to the PBL case, and decide to incorporate it into their learning. Essentially, students may have the freedom to determine their ZPD in conjunction with their ICT affordances but may lack the understanding to do so correctly. The selected level may then or may not lead to the required level of intrinsic cognitive load according to the curriculum and consequently may or may not motivate and sustain the long-term memory development and knowledge construction.

Students who rely heavily on ICT affordances to control their intrinsic load and who organise their learning digitally are more likely to ignore the face-to-face AL affordances. They manipulate their ICT devices, ICT applications, and digital notes, which they believe constitutes learning. For example, Ryan (7.5) diligently collected, stored, and catalogued his digital notes. He adapted a book index system to catalogue his digital notes on an ICT free-form-gathering program. Ryan had not considered how he would search his digital notes in a time-pressured environment. Therefore, he conducted a quick internet search that revealed multiple ‘how-to’ SERs created by ICT communities and collaboratives through cognitive surplus sites (Agrawal, Sahana, & De', 2017; Shirky, 2010). This is surprising given the fact that he worked as an IT programmer before coming into medicine. Ryan had amassed large volumes of information that was pre-digested by others (snippets included). But this information had limited retrievability when required. He resorted to online search engines for information instead of remembering or searching his ICT notes. He openly admitted that he could not remember the previous week’s learning as he focused on organising the current week. He used ICT affordances to compartmentalise his work for learning through speed-repetition apps closer to exams. His primary focus at the time of my research was to gather and store as much information as possible into his digital notes and to develop digital flashcards for the spaced-repetition app. By delaying learning in the belief that the spaced-repetition interface would be sufficient, he ignored the AL affordances available in front of him. Importantly, though, despite Ryan being convinced that his ICT effectivities were well developed, he did not know how to adapt his ICT know-how to the AL environment. It is essential to highlight that ICT-technical know-how can be easily misused. Students can be lured into using it to reduce intrinsic cognitive load in a way that does not lead to better learning. For example, reducing intrinsic load by a stepwise breakdown of complex learning tasks into a series of simple steps within the ZPD, is a sound educational approach, but when it is

confused with learning superficial snippets only, it is highly ineffective.

8.5.1.2 Extraneous Cognitive Load

When the students divert cognitive effort to set up ICT learning structures to support their learning, they should theoretically be freeing up their cognitive capacity to engage with the information to be learnt (intrinsic cognitive load). However, as reported, students are amassing large volumes of unsearchable, pre-digested Internet snippets for digital notes and use them to interface with spaced-repetition apps, which they misconstrue as learning. In doing so, they, in fact, increase their extraneous cognitive load and negatively impact their ability to engage with the actual content to be learnt. Ordinarily, the planning and organisation of notes are associated with freeing up cognitive capacity for knowledge development and long-term memories by increasing germane cognitive load (Sweller, 2010). However, in this instance, working memory capacity limitations are overwhelmed when students unsuccessfully try to source relevant information during the AL tutorials.

That way, students are unwittingly reducing their working memory capacity (Baddeley & Hitch, 1974). Although there has been extensive research into cognitive load over the years by educators developing instructional design (Mayer, 2014; Mayer & Moreno, 2003; Moreno & Mayer, 1999; Van Gog, Kester, Nievelstein, Giesbers, & Paas, 2009; Van Merriënboer & Sweller, 2010; Vandewaetere et al., 2015), few have considered students' contribution to their extraneous cognitive load through their self-directed use of ICT affordances for learning. Debue and colleagues' recent work found that extraneous cognitive load increased when students used small screen tablet devices over the easier to read and navigate larger screen laptop devices, and therefore, they encourage students to work on laptops for learning (Debue, Ou, & Van de Leemput, 2020). In my research, students were navigating and alternating between several devices at the same time, for example, their laptop, tablet, and smartphone and the formal ICT in the tutorial room. Therefore, they contributed markedly to extraneous cognitive load factors by negotiating each device and switching attentional focus between devices. Extrapolating from Debue *et al.,* work, the students in my study were experiencing increased extraneous cognitive load that detracted from the their attentional focus and working memory capacity.

Yet, if students did have sufficient time or a provision was provided to have more time, they could retrieve relevant and useful information from their ICT ‘memory’, resulting in less cognitive effort. However, I found that students did not have enough time during PBL tutorials to check their ideas or search for ideas with the internet or search their digital notes and so they resorted to internet search engines using multiple possible fruitless keywords. Time pressures will always be omnipresent during AL tutorials and in the students’ future medical practice workplace. Consequently, a better understanding of what students are doing and the cognitive impact of using informal ICT affordances helps determine how to accommodate these educational problems to prepare students better for clinical practice. It must also be recognised that one of AL's critical educational concepts is that students learn how to be self-directed life-long learners (Dolmans et al., 2005). Inherent in this concept is that it is unrealistic to expect students to know everything, but they do need to know how to quickly find and evaluate relevant information at the

time it is required. This raises the question of how much students need to know and how they can attend to and process large amounts of information whilst negotiating the self-imposed extraneous cognitive load associated with ICT affordances. Therefore, characterising extraneous cognitive load during AL tutorials is essential.

Three extraneous cognitive load areas were identified whereby students were altering their attentional focus and cognitive capacity.

First, there were microsecond external distractors, such as alerts for messages, news feeds, emails, posts, etc. Attentional focus is then momentarily diverted because a judgement has to be made as to whether to respond or not. These constituted quick regular cumulative diversions from the PBL tutorial. Carrier et al., found that young people were less able to resist and ignore these irrelevant environmental intrusions from external ICT device alerts than older people (Carrier et al., 2015). Even the students who placed their smartphones in their pockets would be distracted when receiving a message. Therefore, cumulatively, these microsecond external distractors impact attentional focus more than initially thought and must be considered a regular incremental increase in extraneous cognitive load. The intrusion of ICT alerts and the subsequent impact on the students' face-to-face AL were identified but not investigated further.

Second, students access and use several ICT devices (laptop, smartphone) and paper resources simultaneously throughout the PBL tutorial (chapter 5 and 6). I found that students routinely use all their ICT devices/paper resources for their learning. They were juggling access to the internet between their laptop/tablet and smartphone. Quick online searches were conducted regularly on their smartphone, not their laptop/tablet. Students had divided the ICT devices utility, preferring one device to perform searching online and the another to access databases and their notes. Therefore, they were also switching between multiple formats on each ICT devices. Unfortunately, only one device’s ICT history log was obtained. Therefore, many more internet searches were conducted that were not considered in the results of this study.

Third, students were seeking ICT information to potentially assist their learning and understanding. Some students would share this newly-found, just-in-time information such as definitions and alternative ideas to support AL tenets. This interface of task switching between their online learning communities and collaboratives and the face-to-face AL collaborative of the PBL tutorial will be discussed in the following research objective.

8.5.2 Students believe they can maintain attentional focus during task-switching.

Analysis of students' perceived multitasking draws on the cognitive and cognitive load aspects of the conceptual framework. A brief re-orientation to the relevant theory is given here before discussing the implications of the results. The perception of being able to multitask is a much-discussed topic in the

literature (Barry et al., 2015; Courage et al., 2015; Taatgen et al., 2015; Wieth & Burns, 2014). Every day we multitask. We do not need to think about how to walk while we are talking. Both these tasks are of everyday life that does not consume cognitive attention. However, when we are required to think and react quickly to external stimuli, such as driving a car while using a mobile phone, our cognitive capacity to interpret and make quick decisions is drastically compromised (Oviedo-Trespalacios, Haque, King, & Washington, 2016). This, for example, is the basis for most countries having imposed laws to prevent mobile phone use while driving. As cognitive capacity is limited (Baddeley, 2011; Baddeley & Hitch, 1974), the individual adjusts their attentional focus (Cowan, 2011; Cowan et al., 2005) to adapt to their working memory capacity. (Pollard & Courage, 2017).

Therefore, the working memory capacity, which can process a limited number of elements simultaneously, can be extended by retrieving long-term memory schemas of prior knowledge to address new AL scenarios (P. A. Kirschner, 2002). Cognitive Load theory describes novices as having fewer long-term memory schemas than experts. In this research, on the surface, I investigated novices, first-year medical students, who are developing their knowledge schemas to become experts. But the variable levels of knowledge in the graduate-entry students was diverse (Chapter 5.2). This student diversity enriches the AL environment, simple questions can prompt different students to contribute but also to reconsider their previous understanding of their knowledge to effectively re-visit their prior knowledge and apply it to the new context and share with their group.

Today, ICT affordances could be considered to be an extra expert in the room. ICT ‘virtually’ occupies an extra seat alongside every student with an ICT device. Thus, it creates an huge diversity of perceived ICT expert knowledge collaboratives and communities joining every tutorial. Previous research has shown that students take the Internet information as their own (Fisher et al., 2015; Sparrow et al., 2011; Ward, 2013a, 2013b). They trust the ICT information and personally selected ICT learning communities (Chapter 6.4.6) over their formal face-to-face faculty chosen group. Consequently, students are routinely task-switching between different communities to seek information and check their own and peers' knowledge.

8.5.2.1 Multiple micro-attentional focus shifts compromise cognitive capacity

In the tutorial situation, task-switching results in students continually dividing their attentional focus between several tasks and, in doing so, incurring a significant increase in extraneous cognitive load. In this context, extraneous cognitive load refers to students' self-directed learning strategies (ICT search engines, ICT applications, ICT programs, paper notes etc.) place upon themselves over and above the formal face-to-face instructional design.

Students routinely conducted internet searches throughout the tutorial. They were oblivious to or unaware of the impact of continuous task-switching and attention-focus switching behaviour on their learning. Some students recognised they would be left behind in the group process if they spent too much time on their ICT device during PBL, so they limited their searching to short bursts. They assumed that short

bursts would not be detrimental, and so, they continued to regularly switch between the face-to-face tutorial and the ICT affordances of communities of knowledge. This led to the accumulation of splitting their attentional focus and decreased cognitive capacity to participate well in the PBL process or the ICT search. However, students do not seem to see this as a problem. They assume that being 'digital natives', they are good multitaskers but seem to fail to realise that being good at technical multitasking is not the same as being able to multi-attention in the learning setting.

As a result, students believed they could listen to and participate in the PBL discussions punctuated by online searching using keywords or questions and select relevant information on their laptops or smartphones. Instead, they often struggled to find the required information with sufficient promptness to return to the group learning dynamics seamlessly. They split their attentional focus between two cognitively demanding activities, listening to the tutorial discussion while thinking about interacting with their ICT affordances. This resulted in some surprising online search engine errors. Students were trying to engage with two different communities simultaneously, but they superficially engaged with both the ICT information and the PBL group due to cognitive capacity constraints. This issue is illustrated in the Kyle vignette (Chapter 7.3), who implemented his routine metacognitive learning strategy of contextualising information to form more robust long-term memory schemas. He planned to quickly look up the etymology of the word 'epistaxis' during the PBL tutorial.

A seemingly simple task. However, it was far more complicated than anticipated as he was also trying to be an active participant in the formal tutorial environment. He was consciously trying to pay attention to synchronous communities of knowledge (tasks, ICT and tutorial) and attempting to select keywords to engage with the online search engine during which he then had to judge, read and assess the SERs plus attempting to listen and contribute to the PBL discussion. These tasks all required attentional focus and cognitive capacity. Hence all were complex cognitive rich environments. In order to be able to pay attention to both the face-to-face group interaction and engage with the ICT affordances of communities of knowledge, such as Wikipedia, he had to pay attention to two communities at the same time and consequently failed. He became frustrated and made simple errors in his keywords, which led to his attentional focus shift being longer than anticipated away from the group. He stated he usually would be able to find the relevant information quickly. He then abandoned the ICT search to fully re-focus on the face-to-face discussion, demonstrating insight into the process of AL. This seemingly innocuous fleeting event highlighted how an increase in extraneous cognitive load from two complex thinking veins results in cognitive overload. His emotional state of becoming frustrated exacerbated this even further. Educationalists may not be aware of these incidents and depend on the student to have and gain insight into their learning from both the tutorials and ICT environments perspective

8.5.3 Time-constrained ICT searches result in simple errors – implications for online examinations.

Simple mistakes were evident in the students' online searching ability during time-constrained tutorials. In this situation, students typically conduct multiple quick internet searches using an array of keywords

throughout the AL tutorials, to then only fleetingly skim-read the first Search-Engine-Results-Page (SERP). The ICT history logs provided insight into how few of these SER's the students really opened. Even if they did open an SER, it was predominantly the first results at the top of the first page but never extending to SER's second page. This I a problem because search engine contributors pay search engine optimisers (SEO's) to obtain the coveted first SER and first page positions (Westerman et al., 2014) and present the links to their web site in a visually appealing fashion (Pattanaphanchai et al., 2013). For example, Google™ increasingly promotes 'google snippets' as the first SERs that are highly abbreviated pre-digested easily read information not based on quality but financial rewards to the company (L. Russo & Russo, 2020).

Despite this manipulation of internet information, students still perceive 'google' as accurate and, as mentioned, take the information as their own knowledge (Fisher et al., 2015; Ward, 2013a, 2013b). This finding was confirmed in my research (Chapter 7.6). Students sought quick answers and trusted SERP ranking. As a result, they judge the first page as accurate (G1S7 Chapter 6) and therefore a reflection of the most relevant search results. The combination of thinking 'google' first and increasing reliance and trust on ICT affordances have increased their dependence on checking everything using online search engines and decreasing confidence in their own biological memory.

Time constraints of the AL tutorial mean students rarely open the actual website to judge the information's relevance and accuracy but constructing information into knowledge requires productive and sustained engagement with the information. Therefore, the ICT interactions were fleeting and lacked academic rigour. Consequently, students may have a huge ICT knowledge creation community at their fingertips, but their ability to benefit from it for their learning is limited by not really engaging with it. The tutorial provides an environment for students in a face-to-face safe forum to rehearse and perform their understanding of the information to each other (Hommes et al., 2014). The scenarios form contextualised conduits through situational interest (Schmidt, 1983; Schmidt et al., 2011) that motivate meaningful long-term schema development. Therefore, rapid multiple online searching interferes with and prevents students from sustaining enough time to engage with the ICT information constructively and led to superficial engagement with the PBL group.

Some students demonstrated a lack of insight into their ICT behaviour and continuously searched online throughout the formal PBL tutorial using an array of poorly conceived keywords. They did not critically read the results (SER) and did not participate. Instead, they stated they were attempting to listen. If they did find relevant information, they did not share it *'as they (the group) had moved on'* [Brooklyn, Chapter 7.7.1.2]. This way, they blindly overloaded their cognitive capacity from the sensory attentional focus level and the working memory level without understanding that they were actually compromising their learning. This is a pity because they were ignoring the AL affordances that were in front of them.

Interestingly, there were two categories of student responses. Some recognised and were aware of ICT distracting them, and others did not. Both ended up abandoning their search(es) to either return to

participate in the tutorial or continue their fruitless ICT search cycle throughout the tutorials.

8.5.4 Activation of prior knowledge is essential to conduct internet searches under limited time-pressured conditions.

Prior knowledge is pivotal for cognitive processing during learning and gaining knowledge (Anderson et al., 2001; Bloom, 1956; Krathwohl, 2002; Miller, 2003). These processes allow us to view and understand and interact with the world around us and develop an ever-evolving frame of reference. It is not static; it is lifelong. We continually learn by processing new information and seek resources from our environment to form new memories and connect with our prior knowledge and experiences. Collectively, these unique individual frames of reference to view the world or a problem leads to rich formal AL processes. In addition, these skills form each students' personal determinants (Bandura, 1986). To interact with environment determinants, students require know-how on how to communicate their learning requirements. The following discussions address this need for prior knowledge and how students form transactive relationships with their ICT devices in the context of students' expectations of themselves and their ICT devices.

8.5.4.1 Prior Knowledge

Language, prior knowledge, and experiences are essential conduits to communicate and engage with one's environment, such as the Internet for relevant just-in-time information. In other words, communicating appropriately with the Internet to access its affordances depends on the students' effectivity to write, detect and select keywords, followed by judging the SER's and knowing how to use the retrieved information. For example, Kyle (chapter 7.3) attempted to engage synchronously with two cognitively demanding tasks, which diluted his ability to apply his attentional focus to both, resulting in neither task being undertaken well. Kyle commented that he would typically resolve this form of search very quickly under different circumstances. However, split attentional focus, along with tutorial time constraint conditions, the pressure to achieve a result and the expectations of himself and others culminated in Kyle abandoning the search and missing valuable time with the group.

Interestingly, this form of word search was an existing strategy. Thus, Kyle had prior knowledge on how to resolve this form of unknown. However, when simple Internet search tasks are conducted under timed or pressured conditions without adequate prior knowledge of what to expect, it leads to simple mistakes, frustration, and abandonment.

Another instance of the importance of prior knowledge became clear in students who were less confident or had less prior knowledge of the issues raised in the scenarios and group discussions. Under time and group pressure conditions, these students were attempting to split their attentional focus by listening to the group, following the scenario online, writing keywords, and selecting and judging SERs applicability. For example, when Avery (Chapter 7.6.2) sought to use the ICT affordances to resolve an unknown, in this instance, an acronym, he found unusual SER's which led to him rapidly typing in an array of

keywords to no avail. His lack of prior knowledge hindered his ability to discern the appropriate keywords, which, under normal circumstances without pressure, he would have possibly been able to resolve. Additionally, he did not seek the AL affordances available to him through the face-to-face group and preferred the ICT affordances.

In contrast, when students have relevant prior knowledge, they can navigate the internet better by identifying pertinent keywords and evaluating the SER applicability. Thus, they are engaging higher cognitive skills of analysing, evaluating, and creating their knowledge. As aptly demonstrated by Avery's peer, Logan (Chapter 7.6.3, 4 and 5). Logan conducted the same search, using the exact keywords, but quickly identified incorrect results and identified the correct SER to read. Logan had enough prior knowledge to successfully navigate the SER's under these PBL time conditions, whereas Avery did not. Prior knowledge, therefore, is an essential attribute when confronted with limited time and pressured conditions to navigate an unknown concept or situation.

Herein lies an educational conundrum, as Avery (and Brooklyn, see 7.6.2) would have significantly benefitted from participating in the group co-construction process. Yet Avery and Brooklyn went on long, convoluted ICT searches, which either resulted in important information that the group could have benefitted from but which wasn't shared, or went on 'wild goose chases' due to poor prior knowledge, and lack of understanding of the keywords used. Both are examples of a failure to use the AL affordances in front of them. By not sharing just-in-time ICT information and not asking simple questions to the group, they ignored the AL affordances of face-to-face learning. ICT, in these instances, stifled the students learning.

8.5.5 ICT Convergence of Transactive Memory relationship

AL processes promote students to search their own and explore each other's biological memory instead of their ICT devices' memory. ICT affordances provide students with an external place for information they call their own (Ward, 2013a) and form so-called transactive memory relationships with their ICT devices (Sparrow & Chatman, 2013), allowing them to access just-in-time information. Transactive memory relationships were initially described by Wegner, who described the group sharing and storing of memories with people who lived or worked closely together (Wegner, 1987; Wegner et al., 1985). The memory dynamics of students in small group learning work closely together to achieve learning goals and form transactive memory relationships as they take on a collective cognition of sharing knowledge to become learning partners in the co-construction of group knowledge and among the many strengths of AL (Roschelle, 1992; Van den Bossche, Gijselaers, Segers, & Kirschner, 2006; Visschers-Pleijers, 2007). Established and well-functioning PBL groups have been shown to distribute the cognitive load and form transactive memory relationships (Hommes et al., 2014), increasing the small group performance (Tuckman & Jensen, 1977). However, for these relationships to work, students must be willing to take risks, trust each other, listen to different views, constructively critique those views, and, importantly, accept being wrong. A purely individual ICT memory relationship stifles this, as students will not rely on the biological memories, will not express different views of perspectives or accept being wrong. But the

memory of ICT affordances can be included and used appropriately for learning. For example, it can create another 'instrument' in the PBL 'orchestra' tutorial and lead to an additional perspective. However, for this to happen, it requires students, and educators, to understand how to use, integrate, and capitalise on what constitutes the strengths of AL affordances this means sharing of search results, comparing different results and critically evaluating the validity of the online information.

This research confirmed previous findings that students did think of online search engine first and automatically sought information from their external 'internet memory' and not their own biological memory (Risko & Dunn, 2015; Risko et al., 2016; Risko & Gilbert, 2016; Sparrow et al., 2011; Ward, 2013a, 2013b; Wegner & Ward, 2013; Zhong, 2013). Storm and colleagues, in 2017, found students who accessed internet information for one situation were increasingly reliant on the internet for finding other information (Storm, Stone, & Benjamin, 2017). I found that students felt that they required confirmation from online search engines before sharing knowledge and ideas with the group. They had to check with 'Google' first as they lacked trust in their own knowledge and wanted only to share 'correct information.' Essentially, students created transactive memory relationships with ICT (Sparrow et al., 2011; Wegner, 1987; Wegner et al., 1985) whereby they cognitively offloaded the responsibility to remember correctly, and in some instances, to remember to the external memory of the internet. This is of course appealing, as it seems to reduce cognitive load, but as learning is a constructive and therefore active process, easy ICT solutions are often not the answer.

8.5.5.1 Remembering and forgetting

Continuous online searching can be a major distractor to individual learning, but it can be beneficial if used strategically to supplement learning. This might sound contrary, but ICT as a learning partner incorporated during AL can promote learning. My research demonstrated that individuals who sought ICT information via internet search engines and shared it with the group were doing so seemingly altruistically. They sacrificed their group interactions by metaphorically leaving the PBL group discussion to search online and then assist the group in knowing and understanding. For example, Parker (7.4) sought ICT affordances to validate and clarify ideas that were discussed in the group.

When prior knowledge is activated, but ICT searches kept private, the AL affordances of co-construction is ignored. For example, Blake (Chapter 7.2) chose to ignore the group and the AL affordances to find the correct words for one differential diagnosis. His goal was not to communicate information to his group but to find words to search his hardcopy medical dictionary index. There are several problems with this level of transactive memory employment. First, this form of searching is answer-driven and rarely AL's goal. As said before, the purpose of AL is not necessarily to solve the case but to further the students learning. Also, secondly, when students shift their attentional focus and cognitive processing away from the cognitive collective of the group, they miss out on expanding their own cognitive diversity. These are examples of how ICT affordances when not strategically employed during face-to-face activities lead to missed learning opportunities inherent in the AL affordances.

Students who solely rely on ICT affordances as an external memory engage minimal cognitive effort

resulting in reduced long-term memory schemas. For example, Ryan (chapter 7.5) could not remember the information itself during AL and relied on searching the internet using keywords mentioned by the group. These simple google searches and snippets shared with the group by low prior knowledge students can increase their intellectual confidence to participate. ICT search results judiciously selected also enable the students to control the level of intrinsic cognitive load they are comfortable with. In these instances, ICT provided a sense of knowing and taking that information as one's own (Risko et al., 2016). However, the risk is that they are fleetingly interacting with the information, and consequently, long-term biological memories are not formed, As evidenced by Ryan, who had forgotten the previous PBL case although it was completed only a few days ago.

ICT affordances of organisation of information for ICT learning applications tend to delay learning. Students mistook the collation and creation of questions for spaced-repetition applications as their learning rather than undertake the effortful learning process for understanding. Several students devoted considerable cognitive effort to organising digital libraries, digital notes, and flashcards. These students relied on their transactive ICT memory relationship to remind them when to learn and remember information. Therefore their reliance on their biological memory role was diminished. In conclusion, learning is ineffective when ICT affordances are relied upon to learn instead of the student. Essentially ICT affordances cannot do the learning for the student.

8.6 Metacognitive strategies with ICT affordances

Critical to this research has been understanding the students' metacognitive strategies: how they think and think about their thinking (Flavell, 1979), with informal ICT affordances during AL. The interface between new information, AL tutorials, and their prior knowledge in conjunction with the ICT transactive memories create a dynamic and continual challenge for the students (Dochy & Alexander, 1995). Students undertaking AL are self-directed learners (Dolmans et al., 2002). They cognitively process information, critically monitor their collective cognitive skills (Flavell, 1979; Zull, 2011), and reflect on their thoughts. They discover gaps in their level of understanding and prior knowledge, determine learning goals, and self-monitor their level of performance (Ellis et al., 2014; Zimmerman, 2000) and mastery of their knowledge (Coutinho, 2007).

The level of student awareness of metacognition is integral in content-heavy, high stakes learning, such as in medical courses and postgraduate specialisation curriculums (Colbert et al., 2014) for lifelong learning (Berkhout, Helmich, Teunissen, Van der Vleuten, & Jaarsma, 2018; Hmelo-Silver, Kapur, & Hamstra, 2018; Murdoch-Eaton & Whittle, 2012). As a contextual learning environment, AL facilitates metacognitive development (Barrows, 1983), supporting lifelong professional learning. The students who enter medical courses have established self-confidence in education and high self-efficacy (Papinczak, Young, Groves, & Haynes, 2008). They have navigated the selection hurdles to secure a position through academic achievement and successful interviews as either an undergraduate or graduate entrant.

Therefore, they have developed high self-efficacy, standing them in good stead to cope with higher education rigours (Bandura, 1993).

Inherent in metacognition is being aware of and having the ability to self-monitor one's learning. With informal ICT affordances added into the learning equation, students should reflect and monitor their learning with ICT affordances they use. But in fact, most students assume ICT is compatible without metacognitive judgements. The lure of the ICT affordances with the quick internet search capabilities overpowers the face-to-face AL affordances.

8.6.1 Impact of ICT affordances between high and low self-efficacy students.

High achieving students believe in their capabilities and abilities to perform a task. They have high self-efficacy (Bandura, 1982, 1995). The presence of ICT affordances can result in an increased confidence level, which can lead to an increased feeling of competence, irrespective of the students' effectivities during the formal PBL tutorials (Risko et al., 2016).

To illustrate this further, I found students habitually connected to internet Wi-Fi before the commencement of tutorials. If they could not easily connect, they manipulated their ICT devices to ensure they had access. A two-hour tutorial was considered a long time not to be 'connected.' Essentially, students wanted and needed access to search engines, online communities of knowledge, online learning groups, and online notes. During PBL, they relied on ICT access to support their learning, find just-in-time information, check their thinking and understanding, and check information proffered by others in the group. ICT search engines, such as Google, were immediately thought of when confronted with an unknown. This finding aligns with other studies (Sparrow et al., 2011; Wegner & Ward, 2013).

Students can cognitively escape to their ICT device to divert their attention away from the AL group. Ryan, for example, chose to escape into social media news feeds and claimed he was disinterested in the task. From a metacognitive perspective, he controlled his learning to avoid negative judgements (Dweck & Leggett, 1988; Elliott & Dweck, 1988) and to keep comfortably within his own level of ZPD. When he was at risk of becoming confused and his knowledge challenged, he withdrew cognitively from the group. Students with low self-efficacy tend to monitor their learning success through external assessments, exams rather than the more self-efficacious deep learners who seek mastery achievement goals (Broadbent, 2016, 2017; Honicke & Broadbent, 2016; Honicke, Broadbent, & Fuller-Tyszkiewicz, 2020).

8.6.2 Students who learn for understanding and retention of information use handwriting

In this study, I found that students who extensively used ICT affordances also returned to handwriting when they felt they really needed to understand and remember for tutorial report-back, clinical encounters and exams. As mentioned earlier, the hand-brain relationship of writing and drawing by individuals (Mangen & Velay, 2010) enhances the placement of new information or concepts into prior knowledge (Daley et al., 2016). Therefore, this is an indication that most students recognise they are not able to

learn solely on the pure ICT format effectively. Therefore, it is important that contemporary student digital competencies need to be re-purposed from their social and personal use and adapted to the academic requirements to maximise AL.

8.6.3 Control over learning partners

Most students devoted extended time and effort to create their own online informal ICT communities consisting of friends they trusted and valued more than their faculty-selected formal tutorial group. When these students wanted to check the information, they preferred to ask their online groups rather than the formal AL group. They ignored the face-to-face formal co-construction process of AL affordances. Intuitive social media applications, such as Facebook, were preferred as students constantly engaged with them as members of multiple Facebook groups.

The potential problem with students engaging with their preferred online groups is that they are not being exposed to the diversity of non-like-minded colleagues, patients, or others. Also, they are not learning how to work collaboratively with others with different views or perspectives. Metacognitively they are not able to develop strategies to cope with diversity and to learn from the variety. In fact, their intolerance to the uncertainty of working with others is likely to be amplified by ICT affordances of communication and communities. As a result, students are at risk of missing key people negotiating skills which are so essential for clinical practice (Colbert et al., 2014). The formation of such skills is one of the key features of small-group AL tutorials. ICT affordances increase students' intolerance of uncertainty

Contemporary students do not need to suffer uncertainty and unknowns anymore. Readily available ICT affordances provide instant relief. However, the unknown plays an integral role in AL instructional design and resolving it too quickly is detrimental to AL processes. Dealing with the unknown without quick resolution requires active access to biological memory, retrieval of existing knowledge and schemas, and critical weighing of different pieces of information. This is not an easy process, and PBL students have always been uncomfortable with not knowing. It is also fair to say that this is not a new phenomenon (Fonteijn & Dolmans, 2019). However, now, with readily available ICT affordances, it has become magnified and more pronounced. Some students want to find definitive answers, while the PBL cases are purposely written to be ill-defined to optimise learning. It is not the central aim to be quickly solved. Even if a definitive solution would exist, the purpose is to exercise collective reasoning through an unknown issue, discovering.

Intolerance of uncertainty was evident throughout my research, and it is not surprising. Medicine is a profession in which the ramifications of a doctor's decision about patients can be huge. Not knowing and uncertainty are, therefore, likely to create angst in medical students. This is further increased by assessment systems that reward knowing the correct answer and rarely credit students for being comfortable with uncertainty and 'not knowing'. So, it is logical that students turned to ICT for simple clarifications or when the case or discussion challenges become too great. Several students conducted over fifty searches in a two-hour tutorial. ICT enabled them to avoid participating in group discussions,

especially if they thought everyone else in their face-to-face group knew the answers. Many of these students remained predominantly on task by engaging with distance ICT knowledge communities to search their questions and those of the group. They could have positively diversified the group discussion if they had shared their findings with their different frames of reference. This was evident in students Avery and Brooklyn (Chapter 7.1.1.1 & 7.1.1.2), who continuously conducted internet searches throughout the tutorials but did not contribute information to the group. Yet during the VSRTA interview and analysis of their ICT history log, they had found relevant information that would have significantly contributed to the co-construction of group understanding and knowledge. Their ICT effectivity of seeking just-in-time information had not been translated into learning effectivities to capitalise on the AL affordances.

Students predominantly ignored the metacognitive tool of reflection to assess their learning interactions with their ICT device and their AL face-to-face group. For example, some students were conscious of taking too long to conduct internet searches during the PBL, whereas others were not concerned. The unconcerned students were unaware of missing significant AL opportunities for themselves and the group. Instead, they relied on and preferred ICT affordances. Essentially, they had formed a private-dependent transactive memory relationship with the ICT knowledge communities and not with their formal group. In doing so, they were shielding themselves from the rest of the perceived knowledgeable group. This way, they used the ICT affordances to keep up with the group whilst not exposing their self-perceived lack of knowledge or uncertainty.

8.6.4 Students' belief in their own knowledge appears to diminish in the presence of ICT affordances.

Many students did not want to share information with the group until they had consulted ICT affordances to check or find answers. They did not like the idea of sharing incorrect information and did not trust their biological memory sufficiently. The notion of sharing only correct information and answers with the group runs contrary to part of the AL principles. AL strengths are founded on sharing diverse and rich students' prior knowledge (Barrows, 1996; Barrows & Tamblyn, 1980). Students collectively learn to discuss and negotiate relevant information and elaborate on ideas to form co-constructed group knowledge (Schmidt et al., 2011; Visschers-Pleijers, 2007). The ready availability and access to ICT knowledge collaborative and communities diminished the students' confidence in their knowledge.

8.6.5 Importance of the PBL tutor with ICT afforded students during AL

The tutor's role in facilitating the face-to-face PBL tutorial has always been of critical importance (Azer, 2005; Barrows & Tamblyn, 1980; Dolmans et al., 2002). But each student accessing ICT affordances during the tutorial requires the tutor to be even more aware of the students' ICT interactions. During face-to-face discussions, the tutor can follow the students' logic. However, when students seek ICT affordances for information, the tutor encounters an unknown deviation from the collective conversation. The examination of the ICT history logs testified to these multiple and regular deviations. In other words, it is even more challenging to facilitate group learning when there is another layer of hidden ICT

affordances sought for information seeking over and above the overt personal factors each student brings to the group.

8.7 Epilogue

From this research, it is clear that ICT affordances provide students with powerful tools that they could potentially use for their learning. But it also shows that students do not have the effectivities to use them effectively and efficiently. Instead, students use ICT in ways that run counter to the principles of AL or the principles of human learning in general. Managing uncertainty, engaging with unknowns, and the willingness to put time and cognitive effort are essential components from the learn's side and support, scaffolding, and coaching are the components from the educator's side. When both cannot be combined effectively, for example, the informal and formal learning environments do not interleave well enough, learning suffers. Learning suffers in those cases because of poor management of cognitive load, decreased tolerance of uncertainty and not knowing, lack of group cohesion, limited opportunities to learn collaborative learning and group processing, and finally, underdevelopment of the metacognitive skills needed to be self-directed and lifelong learners.

9 CONCLUSION CHAPTER

the whole is greater than the sum of its parts [5]

This well-known saying is an apt way to look at how we learn. No one piece of information can result in learning when it exists in isolation. It has to be connected to other pieces of information to lead to knowledge. But when it comes to Information Communication Technology (ICT) and active learning (AL), students have multiple ICT collections of myriads of pieces or parts of information from various resources but often struggle to form the whole knowledge and eventual wisdom.

The motivation for this dissertation originated from my observations as an experienced Problem-Based learning (PBL) tutor of student learning strategies. I noticed students becoming increasingly reliant on their Information Communication Technology (ICT) devices, seemingly at the expense of their biological memories and leading to fewer collaborative interactions with other students or tutors. PBL discussions became truncated as students appeared to place greater value on information from ICT search engines than their peers. Paradoxically, at the same time, they were overwhelmed by the sheer volume of available ICT information. As reported in the literature review (Chapter 2), students mistook storing ICT information for their own learning and thus formed transactive memory relationships with their ICT devices. One way to counteract this educational conundrum would be to ban ICT devices and return to the pre-ICT style of PBL. However, this simplistic 'remedy' does not acknowledge the ICT-afforded environment in which our students live, study, and eventually work. So, in line with the cognitive constructivist environment (Chapter 4) of active learning (AL) and self-directed learning, students actually need to develop ICT strategies and lifelong skills for academia and their future work in this ICT-afforded world.

Therefore, in this research, I sought to explore and interpret these student ICT-seeking behaviours during formal active learning (AL) tutorials to better understand how and when such behaviours augment or hamper learning. Using a qualitative analysis methodological approach, with Social Cognitive Theory and Information Processing theories of learning as my conceptual framework (Chapter 3), I studied the levels of alignment between the ICT affordances (Chapter 2.3) and AL affordances (Chapter 2.2) to fulfil my research objectives (Chapter 1.7). To understand the student's perspective, I conducted three levels of inquiry, commencing with a survey to obtain an overview of the first-year graduate entry medical doctorate students cohort and their self-reported use of ICT and the importance of ICT for their learning (Chapter 5). The second level used video recordings of PBL tutorial sessions to focus on the small group learning environment of the PBL and on events of ICT device use. This formed the basis for video-

[5] as attributed to Aristotle, and in recent times to Gestalt theory

stimulated-retrospective-think-aloud interviews probing the students' reasons and thinking and assessing the degree of alignment between the ICT and AL affordances (Chapter 6). The third level included replicating students' ICT history logs of their searches during salient PBL/ICT events. These logs provided a unique, invaluable insight into the students' behaviour. To investigate this, I replicated the exact ICT searches. This way, I was able to compare the students' thinking (Chapter7) with my observations. This three-level analysis method homed in on the students' actions and thoughts which, in conjunction with my theory-informed interpretations, provided the foundation for my research findings and insights (Chapter 8).

This research set out to understand the strengths (learning successes) and weaknesses (learning failure) of students' ICT use in the context of AL. The underlying premise that ICT can provide unique learning affordances is a plausible one, and it would be logical to assume that these lead to much better learning outcomes. However, this was not at all clear and, therefore, the focus of this study. In this concluding chapter, I proffer my reflections on the overall meaning of my research for today's and future learning environments.

9.1.1 ICT and AL affordances and learning

The findings have led to the following conclusions concerning students' use of ICT affordances and combining them with AL affordances.

1. Contemporary students need and expect internet access and the ability to communicate via ICT during their formal AL, both for personal and individual learning requirements. They use ICT to communicate with others outside of their formal AL group simultaneously and, through this, can engage or disengage with them at their own will. The AL affordance of collaboration, on the other hand, requires and facilitates the learning of collaborative communication skills with a variety of individuals in a safe tutor-controlled environment. ICT communication takes place predominantly with self-selected groups, and as a consequence, difficult face-to-face discussions can be avoided. As a result, sharing complex issues or exchanging conflicting views does not happen. In other words, ICT provides a conduit for students to opt-out of engaging with the AL group and, in preference, choose their like-minded learning bubble. This leads to a decrease in their metacognitive skill development of learning how to communicate collaboratively face-to-face. These skills are vital when working in a group, such as in clinical medicine.

2. Students use ICT to create and organise multiple personalised digital resources, which may appear helpful but turn out to be difficult to use under time-constrained conditions. For example, students create extensive digital libraries of books, images, lectures, notes, and many online groups, but in order to access them, students need to remember unrelated information of where they have stored the information as the exact information in their notes are not directly searchable. To mitigate these effects, students create an extensive ICT organisation that focuses on non-learning related information. However, this process increases extraneous cognitive load

unnecessarily which comes at the expense of learning the actual information itself. In a way, they create a learning environment that has an increased complexity with decrease searchability.

3. The ICT affordances of creation enables students to create self-selected ICT communities. This allows them to access information and views at any time and, irrespective of location. But the learning trap, as mentioned in ICT communication, is that students informally create like-minded groups that decrease the diversity of opinions and prior knowledge exposure. This results in ignoring the AL affordance of collaborative learning, which exposes them to diversity and prefer to set up and trust their own self-selected learning bubbles.

4. Students can access ICT collaboratives of knowledge that provide them with multiple options to find information and potentially quick answers. With internet access, they can visit multiple online knowledge collaboratives. However, students tend to passively select the information and not actively participate in the collaborative process of constructing the knowledge. So, they are visitors to these sites with no reciprocal contribution of information or discussion. In other words, they are not actively collaborating. The students' formal educational face-to-face group provides a safe space for potential collaborative interactions in which mistakes can be made, and uncertainties can be shown. This is a key feature of AL, which can easily be underutilised when students prefer to engage with an ICT collaborative or their own self-selected online group.

5. Students use their ICT devices' overt convergent affordances, such as a camera and online search applications to supplement their learning. They use these capabilities to capture the groups' work and to post on the group online platform. However, with students taking more control of their informational needs, the line between the student and the educator is blurred. In the informal learning space, the student has to be a learner and an educator at the same time. This requires them to be expert navigator and expert 'scaffolder' at the same time. Inherent in this shift is that students are not connecting with the various ICT functions in a meaningfully convergent way to supplement their AL at the academic level. Students are not educators. But through using these affordances, they take on the responsibility of controlling their own and others' learning in complex higher education courses without the requisite knowledge of how to manage this learning. The impact on the development of lifelong learning skills is still insufficiently well known.

9.1.2 Ramifications for learning

The more concrete findings below specifically address the learning ramifications of students' effectivities and assumptions when incorporating ICT affordances.

1. ICT affordances require students to be able to manage both formal and informal resources for their learning. The formal resources are university provided and are typically quality-assured and are bounded by the curriculum. In contrast, the informal resources, which refer to the whole

internet, have no boundaries and are also more often than not quality assured. Some information may be of value and rigorous, but considerable information sources are either irrelevant or incorrect, and this is now a judgement the student must make. As a result, students juggle hardcopy notes and digital resources on up to three different ICT devices with various online sources on an almost continual basis. This requires extraneous cognitive load resources that side-track and potentially overload the cognitive load capacity. The cognitive load that goes into this cannot be spent on germane load. Therefore, the 'return on investment' is doubtful in many instances. Apart from technically managing multiple devices, there is an added effect that students must continually judge the veracity or relevance of the information they have sourced from the ICT collaboratives and communities of knowledge resources. They can do this by either checking other ICT devices, other online groups or their prior knowledge. Unfortunately, when their knowledge is insufficient due to lack of prior knowledge or insufficient face-to-face group processing, the search strategies become ineffective. The judgment of the informal information is not accurate and, consequently, is likely to lead to ineffective or incorrect learning. An example of this is "Avery", who searched for eGFR but wholly misunderstood the search engine results (SER) and ended up with incorrect information he could not decipher, causing led him to abandon the search. This led to a truncation of his learning process and his learning from the case.

2. Students ICT effectivities are honed in the context of using informal ICT affordances in their personal lives, but they are not automatically transferrable to the AL context. Students who enter higher education have basic prerequisite knowledge, abilities and expertise that saw them fit to gain a place at university. This pre-requisite knowledge forms a starting point for educators to centre their learning and tutelage around, with a purpose to develop and grow the students academically. But students expect to learn and develop new knowledge and new abilities in an ICT-afforded environment. Simply, assuming students' can translate their informal ICT know-how to the use of ICT in an AL-afforded environment is not sufficient. It not only ignores the needs to guide the students learning journey to learn but also abrogates the educators' responsibility to support and expand the ICT-afforded students learning.

3. Students overestimate their effectivities (abilities) to use ICT in the AL setting. They are digitally confident and, as such, considered to be 'digital natives'. Inversely, students perceive educators and universities as 'digital immigrants'. The formal online Learning Management Systems are considered 'unintuitive and clunky', and educators as insufficiently ICT proficient. As a result, students overestimate and misappropriate their informal ICT effectivities for learning. Because of this misunderstanding of each other, student-driven ICT communities and collaboratives exclude educators and universities from their informal course focused sites. Therefore, students widen the divide between the informal and formal AL curriculum and remove the opportunity to interdigitate both worlds. This is unfortunate because, generally, students are unaware of what constitutes effective AL in the higher education environment. Students are not educators, and academic

educators do not have insights into the students' ICT effectivities when attempting to use informal ICT affordances for their learning. Both groups make incorrect assumptions about each other.

4. Students informal ICT-seeking behaviour and ICT effectivities of organisation requires considerable time and cognitive effort and ultimately takes them away from learning the actual information. ICT affordances provide students with access to large amounts of information in multiple formats that students then organise and store on their devices. Students want access to all formal learning resources and informal online resources on their ICT device to engage with at anytime and anywhere. They want it all. They amass complex ICT hierarchies of resources and online search methods linked to online networks to support their learning. In the process, students run the risk of mistaking their ICT organisation for actual biological learning.
   An example is when Ryan considered his greatest achievement in studying medicine was to organise and collate his ICT notes, yet he could not even remember the previous case. Despite expending considerable time and cognitive effort into amassing these online resources, Ryan and many other students could not search their digital notes for just-in-time information. They had to use online search engines and websites to remind themselves of the information instead. They had not learnt and had a poor understanding of the material and relied on ICT to remember for them.

5. Implicit with relying on just-in-time information is that ICT affords students access to quick answers and immediate resolution of uncertainty. This fuels their need to be correct and increases their intolerance to uncertainty. This is unfortunate as the field of medicine is fraught with uncertainties and unknowns. The intentional design of formal AL cases challenges students with these uncertainties and unknowns to encourage collective meaning-making. This collective meaning-making environment facilitating concepts and scripts to be processed, leads to the long-term memory becoming stronger and more likely to be retrieved when needed. When students short-circuit their and the groups' thinking time by quickly finding an answer, they negate this educational benefit of sharing and learning to take the risk of being incorrect. When confronted with an unknown, students' initial thought is on using a search engine rather than relying on their biological memories. By this, they reduce individual cognitive effort and collective cognition, which results in shallow concept formation. The safe environment of small group learning whereby students can make mistakes and learn how to negotiate a path towards group consensus and resolution is then reduced and co-construction truncated.

6. Accessing ICT affordances in a meaningful way depends on the students' prior knowledge and ICT effectivities, and on the extent of their applied cognitive effort. Online search strategies are dependent on the students' prior knowledge in selecting relevant keywords, assessing the SER's and making an effort to enter the website to judge the veracity of the information for themselves. However, students readily take the first SER's from the first page and do not even open the

website. The search engine optimisers' algorithm leads to abbreviated precis of the content within the website. Students are using this abbreviated precis as correct without clicking on the website, as this quote from G1S7 student highlights.

> *"… pop up an answer for me in that nice little summarised box on the top and I'm going 'thank you, Google™'". (G1S7)*

Referencing of the search engine snippets for information only became apparent in the study by me replicating the students' ICT history. These snippets are predominantly to promote businesses and influence the SER ranking. Therefore, this feature is not concerned with academic rigour or veracity but with economic and marketing attributes. When students form transactive memory relationships with ICT, they are at risk of trusting and developing shallow knowledge devoid of a depth of understanding that assists long-term memory formation and subsequent recall. Students even employed ICT affordances to help them rote memorise information through didactic ICT applications, which leads to even more shallow learning.

7. Students rely on multiple ICT applications (apps) to organise their time, navigate and schedule learning times and encounters. These apps recommend strategies to prompt study and remind students to answer questions based on memory and lifestyle balance algorithms. A commonly used app was a spaced-repetition application, which cyclically challenged students with repeated questions from multiple question banks sourced from the internet and developed from the students' digital notes. Many students changed to digital notes specifically to create their spaced-repetition flashcards. They wanted the learning to be easier, streamlined and quicker. Students did not reflect on what benefits they achieved by incorporating these informal ICT affordances into their learning. They just believed these ICT affordances would be beneficial. They trusted the science behind the development of the applications.
   However, Learning is not easy. It invariably requires time and cognitive effort to construct biological long-term memory schemas. Relying on student-ICT transactive memory relationship led to students delaying their learning as they prioritised the collation of information into the appropriate ICT format to transfer into the ICT applications. As a result, students could not keep up with the weekly incremental increases of the AL case complexity inherent in the AL scaffolded cases. They missed the contextual and collaborative affordances of the AL knowledge construction both as individual learners and as a group.

8. The students' selection criteria for which ICT app and programs to use for their learning were determined by whether the application was free and could be easily uploaded. Being fiscally free and, in one instance, being compatible with their existing ICT device operating systems formed the basis of selection criterion, not the functional specification concerning effective learning. Therefore, the choice of ICT affordances was not based upon academic rigour and requirements. This highlights that the students themselves do not consider their own learning needs but are

being directed by non-learning related forces. One student, Charlie, however, highlighted the need to have the apps and programs aligned. She had multiple free or purchased applications to support her learning that was all compatibly linked. In addition, she had developed a personal website to view her notes and resources that were also searchable. However, even she reverted to online search engines to check her knowledge as it was quicker despite all the effort. Essentially students did not consider how the ICT apps and programs would contribute and be combined to better their learning.

9. Contemporary students continually engage with various ICT affordances simultaneously during AL. Their attentional focus is constantly shifting between the multiple ICT affordances, the AL face-to-face group affordances and the formal ICT affordances in the tutorial room. They are essentially time-slicing between all these affordances, splitting their cognitive capacity between tasks and reducing their cognitive ability for each task. This became clear when simple errors in typing and selecting keywords into search engines occurred. Students who seek new on-topic information or ideas under time-constrained conditions are prone to make mistakes when engaging with and navigating their ICT affordances and interpreting the SER. Despite popular beliefs that contemporary students are effective multitaskers, they cannot do it all. The cognitive costs are too high, and consequently, students do not succeed. Kyle's simple search engine question to understand the term epistaxis aptly illustrates this point. Kyle attempted to divide his time and attentional focus between two cognitively intense tasks. As a result, he made simple mistakes and became frustrated, which all exacerbated his errors and made him abandon the search. As a result, he did not meet his learning goals in the group or individually. Yet, when students shift their focus away from the group to focus strategically on searching the internet, they are more successful at finding and judging SER. For example, Parker successfully found relevant information to share with the group to promote group collaborative learning. However, this still meant she missed the groups' continuing discussion.

   ICT affordances used for off-topic reasons also occur. So, the mere availability of the ICT affordances even tempted the students to use them to escape both the formal and informal learning environment deliberately. Students felt that two hours for the tutorial was a long time to be disconnected from the outside internet world. As a result, they regularly checked their devices (laptops and phones), resulting in at least microseconds of attentional focus switches, essentially interrupting their concentration. Other students intentionally decided to leave the group discussion and engage with their personal ICT affordances. For example, Ryan's ICT provided him with an escape from the cognitively challenging report-back tutorial. Despite initially stating he knew the content during the video-stimulated-retrospective think-aloud interviews, he could not recall the case or topics a few days later. Other students openly read social media, texts and emails but commented that they always had an ear open on the conversation. This mistaken belief of being able to multi-task when engaged in cognitively demanding and challenging learning settings

detrimental to their learning.

The overwhelmingly predominant feature is the word ‘multiple’. Students continually negotiate multiple devices, multiple online resources, multiple hard copy resources and multiple online learning groups and then the formal information and requirements are additional. As a result, students are drowning in information. Some of this information they may have consciously acquired, unpacked and organised themselves, but many rely on pre-digested ICT information. The level of their complexity of study increased due to their attempts to use all the free ICT affordances available and those recommended through the grapevine. Students believed these contributed to their learning, but they mainly contributed to the students’ extraneous cognitive load. However, most students had insight into how they learnt and used traditional handwriting to understand better and form memorable robust long-term memory schemas. In contrast, some students believed their extensive ICT organisation and use of ICT applications to, in fact, be their learning. Therefore, they did not remember well what they learnt.

10. The multiples of ICT pieces of information and resources that students collated often remained as individual pieces and are therefore not processed into the whole knowledge. For this to happen, students may need to take the information out of the ICT format to engage with a more profound level of understanding, for example, through handwriting to remember.

These individual conclusions allow for a more holistic interpretation in response to the research objectives

9.1.3 Research Objectives directly addressed

9.1.3.1 Research Objective 1. Informal ICT affordance and student effectivity behaviours during formal AL.

Contemporary students are not bounded by the formal learning environment provided by the university. ICT affordances enable them to be relatively free from the university constraints and to create personalised tailor-made learning environments based on multiple communities and collaborations. Students can access these anytime, including during formal learning sessions. In these own learning environments, students are in control of the information. They amass vast online and digital resources, but these are predominantly unsearchable as students do not consider ICT applications’ and programs’ compatibility or ICT appropriate indexing systems. They interact with multiple ICT resources on multiple ICT devices and, engage with multiple self-selected and created ICT communities. They have large online libraries consisting of hundreds of pdf textbooks and resources—all free or cheap. This is fundamentally different from the pre-ICT era. When students purchased textbooks, they had fiscal constraints, so they judiciously selected the books they needed. Although contemporary students still use textbooks, they can also collect digital copies and other digital resources and digital notes cheaply or free to potentially use during their face-to-face AL environment. But students do not know very well how to organise these digital resources and notes, and as a result, they cannot search them when required. If

students have enough time, they can find their stored information, but they often prefer to conduct quick online searches under time-constrained environments. Therefore, students are prone to creating increasingly complex yet poorly integrated ICT resource environments.

9.1.3.2 Research Objective 2 Alignment between ICT affordances and AL affordances

The AL affordance of contextualisation sets up purposeful scaffolded scenarios for students to explore their own and each other's prior knowledge. The learning triggers are intentionally designed to challenge students and motivate them to resolve unknowns, learn to cope and manage uncertainty. The AL aim is for students to persevere and work through problems collaboratively. This involves sharing what they know and do not know and taking risks through individual cognitive effort and collective cognition in the safe small group setting. The lure of ICT affordances as a quick conduit to just-in-time information fuels students' need to be correct and inadvertently decreases their tolerance of uncertainty. But the field of medicine is fraught with uncertainties and unknowns, and therefore when ICT affordances quickly relieve uncertainty and unknowns, they do not contribute to students developing skills to be able to handle uncertainties. As such, there is a conflict with AL affordances that leads to a truncation of the time and cognitive effort to understand and build upon prior long-term memories. When students use ICT to replace the brainstorming of ideas, check other students' comments or check their own biological memories before sharing with the group, they are circumventing the role of the AL affordances. On the other hand, if ICT is strategically used in this environment to supplement prior knowledge or quickly resolve unknowns that block the process, the AL environment is enhanced. When such strategic online searches are undertaken under the current AL conditions, students forgo face-to-face interactions to seek the relevant information for the benefit of the group discussion but may miss the continuing group work. Educators and students must consider and know how to accommodate these ICT searches to ensure students do not lose valuable collaborative time.

9.1.3.3 Research Objective 3 Student dependency on ICT affordances and cognitive engagement during AL

Most students recognise that sustained periods of time engaging with ICT leads to a decrease in the ability to focus on the group discussion. However, students are often oblivious to the impact of multiple micro-attentional focus shifts throughout the face-to-face educational process. For example, they quickly and regularly conduct online searches. They assume they can maintain attentional focus between their ICT interactions and group discussion, i.e. task switching. But these regular attentional shifts lead students to make simple errors and make ill-informed judgements of SER, leading to frustration and eventual abandonment of their searches. When students use ICT affordances during AL, their cognitive capacity is split between these tasks resulting in decreased cognitive ability for either task, as highlighted in this research. They divide their attention between tasks and can not contribute sufficiently to their own understanding or groups. So, students may be able to multi-task in terms of operating ICT devices and responding to group interactions, but this does not mean that they can 'multi-attention'. Trying to pay attention to two learning activities simultaneously is not possible without cognitively expensive time-slicing.

9.1.3.4 Research Objective 4 Impact of ICT affordances on cognitive load

Students' biological prior knowledge is of central importance during micro-attentional focus shifts when negotiating ICT affordances under time-constrained and pressured conditions. When students have established prior knowledge, they are better positioned to write succinct keywords, judge which SER is relevant or whether it is sufficiently valid. Students who have less prior knowledge are prone to making simple mistakes from the writing of keywords to selecting SER's when they search for understanding new information during time-constrained tutorials. The lesson to be learnt here is that students must have already developed and established long-term memory schemas to use ICT effectively and efficiently. Upon recall to working memory, these schemas serve as the lens through which students can engage with the new information. Students who have enough prior knowledge are much more able to avoid the learning traps of incorrect or too broad keywords. Both could contribute positively to the AL co-construction of knowledge. But when students become lost because of limited prior knowledge to guide their searches, they fall behind the inherent flow of face-to-face AL affordances, and ICT does not benefit this cohort of students.

9.1.3.5 Research Objective 5 overall influence of ICT affordances on the development of metacognitive strategies for lifelong learning.

Students ICT effectivities honed in their personal lives are not directly transferrable to their academic life. For example, students' social networking know-how is applied to their learning environment by creating multiple online groups with their formal peers and informal self-selected members. Students can choose who they engage with outside of and during the tutorial. They decide whether to question their personal online group members, the ICT knowledge collaboratives (saved links or search engines), or their face-to-face AL group. Students have a broad spectrum of content to draw upon, with a seemingly infinite number of informants, communities and collaboratives at their fingertips. As a result, they can cocoon themselves from the diversity of views and knowledge inherent in the formal AL group and hide behind their ICT devices. This is comfortable as they do not have to engage with uncertainty or differing views and knowledge. But this also means that they are avoiding the challenges of learning to negotiate discordance and uncertainty during face-to-face encounters. The sheer power of creating more comfortable self-selected learning groups and engaging anonymously with the enormous ICT affordances enables a restricted commitment to the simple face-to-face engagement with their formal learning community. Students are then in control of their zone of proximal development, but this does not mean they manage it well. When they engage only with like-minded online groups and pre-select their search terms it also, limits their opportunities for rehearsal and performance of new knowledge. They do not look for nor want diversity as ICT affordances enable them to control their exposure to cognitive challenges. Therefore, the immediacy of ICT answers they seek is preferred and perceived as more manageable than the cognitively challenging road of negotiating the diversity of prior knowledge and interpretations inherent in simply questioning their AL face-to-face group. This perpetuates the advertising mottos of some online learning providers; that learning can be easy and should always be fun. However, such claims run contrary to the literature consensus that achieving high levels of expertise in any domain requires effort and engagement. As my study also illustrates, non-engagement with learning leads to

shallow knowledge and easy forgetting.

9.1.4 Strengths

A strength of this research is the natural learning setting. Students were videoed for several hours, and according to their own and the tutor's statements, after some time, they were not aware of the cameras anymore. It is fair to state that the research was (almost) non-reactive and that the data represents students' true AL and ICT behaviour. Researching students' learning in their routine learning environment has enabled rare insights into their day-to-day functioning and perspectives.

Although the research was purposefully designed to be minimally intrusive to the natural student learning setting, the videos were complemented by other research formats, and unfortunately, less unobtrusive activities to gain data. The aim was to explore students' views from three levels, from the first-year GEMD cohort as a whole to the students as members of the PBL group to the individual student.

This multi-modal data set, which included surveys, videos, VSRTA interviews and ICT history logs, allowed a strong triangulation of information. Also, it allowed a deep analysis using a purpose-build conceptual framework that combined several essential educational theories, both from a logical positivist and social constructionist perspective. This way, the rich data sets provided depth and unique insights into the natural learning world of contemporary students.

The choice to analyse events as nuclei for interpretation and meaning-making rather than analysing the data sets separately led to a deeper understanding of the fundamental issues surrounding ICT in AL. The data sets alone would likely have led to conclusions at the observable behavioural level, whereas I wanted to understand the basic mechanisms behind students' behaviours and the educators' concerns. For example, I did not assume that students' self-reported assessment of the benefits of their ICT by replicating their ICT history logs which really enabled me to gain an insight into the students' struggles. These are the struggles students did not report in the interviews.

9.1.5 Limitations

Several limitations are significant to consider when interpreting my analyses.

Throughout this thesis, I used the terms AL and PBL almost interchangeably. Of course, they are not. PBL is but one mode of AL, and there are many more. So PBL was my 'laboratory' in which I conducted this research, but AL is the domain of generalisation as the tenets of constructive, collaborative and contextual learning underpin all AL modes. So, it is safe to state that my findings have meaning for other AL modes as well. However, inescapably my research was conducted in an established PBL setting, and I cannot be sure that it is always directly transferable to more structured AL instructional designs, such as Team-Based Learning.

The PBL environment was positioned in a university in a western country and in a first-year graduate-entry-medical doctorate course. It is student-driven, whereby the role of the educator is to facilitate

students learning and not to direct. The students were several years out of secondary school, and all had completed a minimum of three-year bachelor's degree. They were established successful higher degree learners, and many had work considerable experience. The transferability to other student cohorts, for example, without prior academic experience, needs to be considered carefully.

The collection of original data occurred in 2016. Due to the part-time nature of my study, it has only now been completed. Therefore, the secondary and postgraduate students entering university today may have different characteristics. However, informally conversing about my findings with academic staff invariably leads to signs of recognition. The ongoing rapid nature of ICT devices may have led to the defining of the more stable ICT affordances commensurate with AL, but this will require continuous vigilance to ensure appropriateness to each generation of students.

Finally, it is important to note that this study did not set out to determine a generalisable truth of what happens to all contemporary ICT-afforded students when they enter university. The aim was to understand and explore how certain behaviours, student ICT effectivities, can positively and negatively impact AL. Consequently, to be more aware of the learning traps and mitigate them or the learning successes, to support and promote them in our education design.

9.1.6 Implications for educational design

Although I did not intend to study the ramification for educational redesign to align ICT with AL better, some conjectures can be made. It is important to directly address this new convergent relationship of students, educators and ICT in AL and accept that a new learning alliance needs to be brokered. This is not to replace the traditional resources as a whole but to interweave ICT with our conventional education modes. This is an important insight I gleaned from this research. Most universities struggle with this and contend themselves with casting traditional educational methods in an ICT format. But such formats do not exploit the enormous affordances of ICT for learning. For this to occur and to successfully interweave ICT and AL, the ICT affordances of communication, communities, collaborations, creation and convergence, and AL of constructive, collaborative and contextual will need to be guiding in all educational design.

In all, I am absolutely not contending that the fundamentals of how people learn have changed with the advent of ICT, but I am contenting that how ICT affordances connect with learning is still to be fully exploited.

Some suggestions for how this could be done are:

Contemporary students are proficient informal ICT consumers. The lines between students, educators and ICT affordances are blurred, and their roles have converged, and so whatever educational design one might propose cannot be put forward in isolation.

Ideally, students and educators must work closely together to broker the educational design that will support learning strategies that resonate and promote incentive for students to explore and develop. This co-design is likely to lead to a better understanding of each other. Educators need to understand that it is incorrect to assume that students' informal ICT know-how is sufficient to enter university courses which must be developed and aligned to the academic environment, commensurate and interwoven throughout all the educational studies. Educators may have some knowledge of ICT affordances but have considerable know-how of education. On the other hand, students may understand that educators are not necessarily digital naive. Students may also understand the educational tenets of AL and know much about ICT affordances outside of academia but unknowingly struggle to apply in academia. Therefore, by acknowledging each other's strengths and weaknesses, the shared knowledge in both areas should be sufficient for successful co-design and negotiation of a learning environment conducive to learning and developing lifelong learning strategies. To aid this orientation and ongoing sessions must address these assumptions and learning traps to advance students' ICT effectivities in academia. Students need to understand that ICT is a tool, not their learning, and these messages may be contrary to the advertising messaging. Likewise, educators need to understand that students are drowning in ICT resources both formal and informally obtained.

In light of this study, online invigilated examinations are not an ideal solution for combining ICT affordances with AL affordances. In fact, they are based on the premise that ICT affordances need to be forbidden rather than encouraged or fostered. This can create the impression of an educational philosophy dating from the pre-internet and pre-AL era, in which the possession of large quantities of factual knowledge was important. In the AL era, education encouraged developing a depth of understanding and good knowledge base but with the caveat of knowing where to source information to support their practice, so in other words, they did not need just to memorise large quantities of factual information. Nowadays, allowing open boo assessment, for example, would not be as risky as often thought. My research illustrates that lack of prior knowledge schemas in a students' biological memory easily hampers or frustrates internet searches. If you don't know it, you are unable to find it under time-constrained and pressure conditions. The widely used affordances of creation could be seen as an invitation for educators to seek a co-design approach to the assessment program. It is an opportunity to interweave important parts of learning, namely the formal and informal assessment contexts.

Although quick internet searches often do not lead to deep learning, more embedding and acknowledgement of such activities and the facilitation of finding these searches can enrich the learning immensely. When students each have scheduled time to search resources for a topic, annotate and share them with their peers, collaborative learning can develop students' abilities to judge the relevance and validity of the SERs. This requires different roles of educators as knowledge brokers, as well informed and expert learning coaches. Of course, this function exists in most AL contexts, but it would also mean expanding educators' roles as knowledge brokers for the informal learning context.

Most learning management systems (LMS) are more *management systems* and less of a *learning* system

from the students' position. In the educational organisation, ways have to be found to connect the official LMS, which contains the formal learning environment, with an unofficial and student-generated learning management system. Both serve a different but related and complementary purpose.

The university's role in this ICT afforded environment should focus on reclaiming the internet's intended role and developing ICT and AL affordances in conjunction with students' and educators' effectivities. Such programs then offer a secure and intuitive learning environment in which the informal context can be incorporated into the university's formal context and thus be optimally aligned with the country's and university's organisational and cultural context. This way, the intellectual university cogency, as creators and contributors of new knowledge, can focus on research and educational benefits of ICT and AL affordances.

The currency of AL is that information is processed biologically by the learner into knowledge and eventual wisdom, and, along the learning journey, the learner can develop life-long learning skills. This takes persistent cognitive effort and time, with repeated rehearsal, performance and reflection. Students must be prepared to devote effort and time and be willing to be wrong and work through one's and each other's understanding and learning needs. Essentially learning takes time and requires students to apply and question themselves and others irrespective of the collaborative space. ICT affordances can supplement this process, but they cannot replace it. Learning is hard work, and it will remain this way even with all the modern ICT affordances. ICT affordances can support and improve learning effectiveness and efficiency, but it does not provide short cuts for learning. Therefore, concerning these research conclusions, contemporary students are no exception, and *the whole is greater than the sum of its parts,* especially in learning.

APPENDICES

Appendix A Invitation and information for participants.

Flow Diagram of participant involvement Project No. 7366

Flinders UNIVERSITY
ADELAIDE • AUSTRALIA

Gillian Kette PhD candidate
Prideaux Centre for Research in Health Professions Education
School of Medicine
Faculty of Health Sciences
GPO Box 2100
Adelaide SA 5001
Tel: + 61 8204 7528
gillian.kette@flinders.edu.au

Participant commitment flow diagram time for research into:
Student-control of Information-Communication-Technologies during active learning: Are there cognitive and metacognitive consequences for learning?

SBREC application submitted 4th July 2016 low risk application: View to commence early August after SBREC approval

Activity	Consents required	Time commitments
Invitation Emailed to ALL first year MD students/tutors in PBL groups semester 2 2016	Questionnaire online – return of completed questionnaire constitutes consent Consent signing ICT history log during PBL	Reading email + responding 5 minutes

Students:

Questionnaire – online 10 questions	return of completed questionnaire constitutes consent	Up to 5 minutes
Video active learning tutorials Routine PBL	Consent waiver	0 extra
Download history log from ICT devices – email to researcher	Signed consent	Up to 5 minutes
Seek volunteers from videoed groups, organise suitable time for interview & sign consent		
Video recall think aloud interviews	Signed consent & confidentiality agreement	45-60 minutes
END OF STUDENT COMMITTMENT		

Tutors:

Video active learning tutorials	Consent waiver	0 extra
Seek volunteers from videoed groups, organise suitable time for interview & sign consent		
Semi-structured interview	Signed consent & confidentiality agreement	45-60 minutes
END OF TUTOR COMMITTMENT		

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7366). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Information sheet for student project 7366

Prideaux Centre for Research in Health Professions Education
School of Medicine
Flinders University
GPO Box 2100
Adelaide SA 5001
Tel: 08 8204 7528
Gillian Kette
gillian.kette@flinders.edu.au
http://www.flinders.edu.au/medicine/research/centres/prideaux-centre/
au.linkedin.com/in/prideauxcentre

INFORMATION SHEET
For first and second year MD students

Title:
Student-control of Information-Communication-Technologies during active learning: Are there cognitive and metacognitive consequences for learning?

Researchers:
Gillian Kette
PhD Candidate
Prideaux Centre for Research in Health Professions Education,
School of Medicine
Flinders University
Ph: +61 8204 7528

Supervisor(s):
Professor Lambert Schuwirth
and
Dr Julie Ash

Prideaux Centre for Research in Health Professions Education,
School of Medicine
Flinders University
Ph: +61 8204 7528
P: | W: www.flinders.edu.au
[au.linkedin.com/in/prideauxcentre/]au.linkedin.com/in/prideauxcentre/

Description of the study:
This study is part of the project entitled '*Student-control of Information and Communication Technologies during active learning: Are there cognitive and metacognitive consequences for learning?*
This project will investigate your thinking, selection and control of your information needs via smart technology devices (eg your smart phone, computer, tablet) during Problem-Based-Learning (an example of active Learning). This project is supported by Flinders University Prideaux Centre for Research in Health Professions Education, School of Medicine.

Purpose of the study:
This project aims to find out how you are individually and collectively using informal information and communication technologies during PB L collaborative sessions and whether information and communication technologies facilitates of interferes with the active learning process.

inspiring achievement

What will I be asked to do?

1. You will be invited to answer a short (10 question) questionnaire about your back ground and Internet usage. Time commitment → 5 – 10 minutes

2. You will be invited to allow me to video record your routine PBL sessions for one or two case cycles. This stage requires you and your group to conduct your normal PBL sessions by totally ignoring my cameras and microphone. Time commitment → nil as normal tutorial time.

3. You will be invited to record your internet usage during PBL tutorial by sending me a copy of your internet history downloaded from all ICT devices used. Time commitment → 2minutes

4. You will then be invited to participate in a one-on-one video recall think aloud interview whereby I will ask you questions about your thoughts and rationale during the PBL when viewing the video recording. The interview will be audio recorded using a digital voice recorder. Time commitment → 45 to 60 minutes.

I will not be present during your PBL tutorial, your normal tutor will be.

Participation is voluntary and requires your PBL group to enter a confidentiality agreement for the video recording of your routine PBL tutorial.
The information from points 1, 3 and 4 require a signed consent.

All recordings (tutorial and interview) will be transcribed (typed-up) by either me or a professional transcription service (subject to signed confidentiality agreement). The professional transcriber will not retain any recordings or documentation at the completion of their service.

What benefit will I gain from being involved in this study?
The sharing of your experiences and thoughts on how you work through problems during PBL and your interactions with each other and the internet will assist in the improvement of the planning and delivery of future programs. Also by questioning and thinking about how you learn can potentially benefit you as a learner.

Will I be identifiable by being involved in this study?
All video recordings will consist of you and your PBL group.
You will only be identifiable briefly to the PBL students who participate in your groups video recall think aloud interviews.
Therefore a confidentiality agreement will be sought prior to videoing.

I have asked for permission, by signed consent, to take still photographs from video recorded PBL tutorials for the purpose of my thesis, however this might not be necessary.

Identifying information will be removed in transcripts and all participants will be allocated a code that will link the questionnaire, internet history, transcripts of the tutorial and transcripts of the audio recording from interview. Your participation will not be linked directly to you.
You are able to withdraw your data contribution to this research up to two weeks after your participation as by this stage all identifiable traces will have been removed.

All original recordings will be retained for 5 years after my PhD has been accepted. These video and audio recordings will only be available to me (Gillian Kette) and my supervisors (Professor Lambert Schuwirth and Dr Julie Ash).

All recordings and transcripts will be password protected and securely stored on the Prideaux Centre dedicated Flinders University computer storage.

Are there any risks or discomforts if I am involved?

The researcher anticipates few risks from your involvement in this study; however given the nature of the project some participants could experience emotional discomfort at being videoed.

I am very conscious of your busy study schedule and have minimised your time contribution. Participation in this research has no bearing on your progress throughout the MD course and all data is for the sole purpose of this research and will only be available to the researcher and supervisors.

Please raise any concern regarding anticipated or actual risks or discomforts with me on gillian.kette@flinders.edu.au or Tel: 8204 7528.
If during our research you do experience emotional discomfort and/or distress you will be referred to the Flinders University Counselling Service, Tel: 8201 2118
Email: counselling@flinders.edu.au (provide your full name, phone number and student ID in the email and a counsellor will contact you by phone). Appointments – Monday to Friday; 8:45am to 5:00pm.

How do I agree to participate?

Participation is voluntary. You may answer 'no comment' or refuse to answer any questions and you are free to withdraw from the think after interview at any time without effect or consequences. A consent form accompanies this information sheet. If you agree to participate please read and sign the form and send it back to me at gillian.kette@flinders.edu.au or in person or drop into MCD operation reception desk where I will leave a collection box.

How will I receive feedback?

On project completion outcomes of the project will be given to all participants via the Prideaux Centre for Research in Health Professions Education website and research forums. We are also able to send details directly to participants via email upon request.

Thank you for taking the time to read this information sheet and we hope that you will accept our invitation to be involved.

Kind regards

Gillian Kette

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7366). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Letter of introduction for research project August 2016

Prideaux Centre for Research in Health Professions Education
School of Medicine
Flinders University
GPO Box 2100
Adelaide SA 5001
Tel: 08 82047528
Gillian.kette@flinders.edu.au
www.flinders.edu.au
CRICOS Provider No. 00114A

Date August 2016

LETTER OF INTRODUCTION

To tutors & students in established first year PBL groups in graduate entry Doctor of Medicine)

Dear PBL group member,

I would like to introduce Gillian Kette a PhD student in the Prideaux Centre for Research in Health Professions Education, School of Medicine at Flinders University. She will produce her student card, which carries a photograph, as proof of identity.

She will be undertaking research leading to the production of a thesis or other publications on the subject of:

How information and communication technology (ICT) seeking students are learning during active learning programs, such as Doctor of Medicine PBL. This project is important as information from semantic web is routinely accessed and incorporated for learning. Educators design ICT from an educationalists perspective however the student perspective has been overlooked. The aim is to inform how we implement higher education courses in this student ICT controlled environment.

We would like to invite you to assist with this project by agreeing to your PBL group, for one or two case cycle (each case consisting of 2 tutorials – 4 hours), be video recorded in your routine tutorial room, completing a short questionnaire pre and post one PBL case cycle, volunteer to record and supply ICT use history associated with tutorial sessions and finally agree to a short interview (audio recorded) with Gillian Kette to ascertain your thinking behind your ICT use and assessment of impact on your learning which covers certain aspects of this topic. The recording of your tutorial will in not interfere with your learning environment (similar to clinical skills recording) and will be unobtrusive – we want to record 'in situ' PBL learning. The Questionnaires will require no more than 30 minutes total. However, if you agree to a follow up once off audio recorded interview this may take 1-2 hours. This Interview will be similar to your reflections post clinical skills recording but have no effect on any treatment of you or your progress in your course of study.

Be assured that any information provided will be treated in the strictest confidence, will have NO impact on your tutorial participation assessment and none of the participants will be individually identifiable in the resulting thesis, report or other publications. You are, of course, entirely free to discontinue your participation at any time or to decline to answer particular questions.

Since we intend to make a video recording of the tutorial sessions and audio recording of the interview, we seek your verbal consent to video record the tutorials and written consent and confidentiality agreement for the interview. We will use the recording for the interviews and all transcriptions of video and interviews will be used in preparing the thesis, report or other publications, on condition that your name or identity is not revealed, and to make the recording available to other researchers on the same conditions (or that the recording will not be made available to any other person). It may be necessary to make the recording available to secretarial assistants (or a transcription service) for transcription, in which case you may be assured that such persons will be asked to sign a confidentiality agreement which outlines the requirement that

your name or identity not be revealed and that the confidentiality of the material is respected and maintained.

Any enquiries you may have concerning this project should be directed to us at the address given above or by telephone on 08 82047528 or e-mail (gillian.kette@flinders.edu.au lambert.schuwirth@flinders.edu.au julie.ash@flinders.edu.au

Thank you for your attention and assistance.

Yours sincerely

Professor Lambert Schuwirth,
Professor of Medical education,
Director Prideaux Centre

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7366). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Student email invitation project 7366

Prideaux Centre for Research in Health Professions Education
School of Medicine
GPO Box 2100
Adelaide SA 5001
Tel: 08 8204 7528
Gillian Kette
gillian.kette@flinders.edu.au
http://www.flinders.edu.au/medicine/research/centres/prideaux-centre/
au.linkedin.com/in/prideauxcentre
CRICOS Provider No. 00114A

Dear first year MD PBL students; PBL groups,

You and your PBL group are invited to participate in an important research project being conducted by the Prideaux Centre for Research in Health Professions Education School of Medicine Flinders University. Please consider participating.

This project is part of my PhD investigating:
Student-control of Information-Communication-Technologies ICT during active learning:
Are there cognitive and metacognitive consequences for learning?

Anticipated time commitments:
Video record your normal PBL tutorials for one or two weeks (1 or 2 cases) - no extra time.
Short Questionnaire -10 questions only

Volunteer ICT history log from PBL tutorial - 2 minutes
Individually volunteer for once off video recall think aloud interview ASAP after tutorials - 45 - 60 minutes

Significance of this project:
This research is educationally important. You the students are able to rapidly navigate access to ICT better than we the educators are. In fact you are controlling your own information needs. So we have to redesign active learning to align with this. The significance of this research is applicable to all level of education both locally and globally.

We look forward to hearing from you. **Please reply only to me on gillian.kette@flinders.edu.au**

Attached is letter of introduction from Prof Lambert Schuwirth.

I am very happy to answer questions, provide information sheet and discuss my exciting research with you.

Kind regards

Gillian Kette
PhD candidate undertaking the research
Supervisors: Prof Lambert Schuwirth & Dr Julie Ash
Prideaux Centre for Research in Health Professions Education
School of Medicine
Flinders University
South Australia

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7366). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

inspiring achievement

Tutor email invitation project 7366

Prideaux Centre for Research in Health Professions Education
School of Medicine
Flinders University

GPO Box 2100
Adelaide SA 5001

Tel: 08 8204 7528
Gillian Kette
gillian.kette@flinders.edu.au

http://www.flinders.edu.au/medicine/research/centres/prideaux-centre/

au.linkedin.com/in/prideauxcentre

Dear first year MD PBL tutors; PBL groups,

You as part of your PBL group are invited to participate in a research project being conducted by the Prideaux Centre for Research in Health Professions Education, School of Medicine, Flinders University.

This project is part of my PhD investigating:
Student-control of Information-Communication-Technologies ICT during active learning: Are there cognitive and metacognitive consequences for learning?

Anticipated time commitments:
Video record your normal PBL tutorials for one or two weeks (1 or 2 cases) - no extra time.
Tutors volunteer for once off semi structured interview - 45 - 60 minutes

Significance of this project:
This research is educationally important. Students are able to rapidly navigate access to ICT better than we are. In fact students are controlling their own information needs. So we as educators have to redesign active learning to align with this. The significance of this research is applicable to all level of education both locally and globally.

We look forward to hearing from you. **Please reply only to me on** gillian.kette@flinders.edu.au

Attached is letter of introduction from Prof Lambert Schuwirth.
I am very happy to answer questions, provide information sheet and discuss my exciting research with you.

Kind regards

Gillian Kette
PhD candidate undertaking the research

Supervisors: Prof Lambert Schuwirth & Dr Julie Ash
Prideaux Centre for Research in Health Professions Education
School of Medicine
Flinders University
South Australia

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7366). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Appendix B Online survey

First Year MD students ICT usage survey 2016 project 7366

First Year MD student's ICT usage survey 2016 project 7366

Please participate in this very brief survey that assesses ICT usage and demographics of the first year MD students at Flinders University.

By completing this survey, you are consenting only to this survey.

Whilst the survey is small it will provide essential background information for my (Gillian Kette) PhD research into active learning (PBL) and ICT during your formal PBL tutorials and follow up interviews assessing your learning techniques in this ubiquitous ICT environment.

You will receive a separate email with information inviting you to participate further into my very exciting PhD research. Please consider participating - there is minimal time commitment required.

Information provided will not be shared with anyone else; information will remain confidential, deidentified and securely stored under password protection that only the researcher can access.

Information will be only used for my PhD research.

This research has been approved by the Flinders University Social and Behavioural Research Ethics Committee and the School of Medicine Evaluation committee.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7366). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Personal information

please indicate you gender

- ○ Female
- ○ Male

How old are you?
Choose one of the following answers

- ○ 19-24
- ○ 24-29
- ○ 30-34
- ○ 35-39
- ○ 40-44
- ○ 45-49
- ○ 50-54
- ○ Other:

What degree(s) you have achieved? Please select the highest achieved degree.

	Arts	Science	Medical Science	Health sciences (allied health)	Medical Science	Veterinary Science	Dentistry	Law	Other
Bachelors degree	Bachelors degree ○	Bachelors degree ○	Bachelors degree ○	Bachelors degree ○	Bachelors degree ○	Bachelors degree ○	Bachelors degree ○	Bachelors degree ○	Bachelors degree ○
Honors degree	Honors degree ○	Honors degree ○	Honors degree ○	Honors degree ○	Honors degree ○	Honors degree ○	Honors degree ○	Honors degree ○	Honors degree ○
Masters degree	Masters degree ○	Masters degree ○	Masters degree ○	Masters degree ○	Masters degree ○	Masters degree ○	Masters degree ○	Masters degree ○	Masters degree ○
PhD	PhD ○	PhD ○	PhD ○	PhD ○	PhD ○	PhD ○	PhD ○	PhD ○	PhD ○
Other	Other ○	Other ○	Other ○	Other ○	Other ○	Other ○	Other ○	Other ○	Other ○

If your degree is not mentioned above, please state

Answer

Internet use

Which of the following devices do you use to connect to the internet?

Check any that apply

- [ ] Computer tablet (eg ipad)
- [ ] Desktop computer at home
- [ ] Desktop computer at University
- [ ] Laptop
- [ ] Smart Phone
- [ ] Other:

In a typical weekday, do you access the internet

- [ ] A great deal more for study
- [ ] Quite a bit more for study
- [ ] Somewhat more for study
- [ ] About an equal amount for study and personal reasons
- [ ] Somewhat more for personal reasons
- [ ] Quite a bit more for personal
- [ ] A great deal more for personal

When presented with a problem, do you immediately

	Yes	Likely	No
Reach for your ICT device	Yes	Likely	No
Think key words for search engine	Yes	Likely	No
Wait until you have ICT access to check response	Yes	Likely	No
Try to think of possibilities from memory	Yes	Likely	No
Have a go at working through	Yes	Likely	No
Ask someone	Yes	Likely	No
Other	Yes	Likely	No

When presented with a question, do you immediately

	Yes	Likely	No
Reach for your ICT device	Yes	Likely	No
Think key words for search engine	Yes	Likely	No
Wait until you have ICT access to check response	Yes	Likely	No
Try to think of possibilities from memory	Yes	Likely	No
Have a go at answering	Yes	Likely	No
Ask someone	Yes	Likely	No
Other	Yes	Likely	No

When presented with an unknown, do you immediately

	Yes	Likely	No
Reach for your ICT device	Yes	Likely	No
Think key words for search engine	Yes	Likely	No
Wait until you have ICT access to check response	Yes	Likely	No
Try to think of possibilities from memory	Yes	Likely	No
Have a go at answering	Yes	Likely	No
Ask someone	Yes	Likely	No
Other	Yes	Likely	No

Do you participate in online study groups? - tick as many as relevant

Check any that apply

- [ ] Yes, I select my own group members from anywhere online
- [ ] Yes, our PBL group has formed one
- [ ] Yes, I'm a member of a group outside of my PBL group but in same course
- [ ] Yes, set up by others and actively participate
- [ ] Yes, set up by others but only read posts
- [ ] Yes, but only because others in group set it up
- [ ] No, I prefer face to face groups
- [ ] Other:

During PBL do you access you smart phone/computer

Check any that apply

- [ ] to check emails, Facebook, messages etc (social)
- [ ] to check my information before i share it
- [ ] to check information presented by other students or tutor
- [ ] search for information to help PBL group understanding
- [ ] search for ideas related to the problem

Does accessing the internet information during PBL by you or by others in the group

	By me		By others	
	Yes	No	Yes	No
Improve understanding	Yes	No	Yes	No
Increase group discussion	Yes	No	Yes	No
Increase board work	Yes	No	Yes	No
Decrease board work	Yes	No	Yes	No
Decrease group discussion	Yes	No	Yes	No
Decrease willingness to discuss	Yes	No	Yes	No
Decrease understanding	Yes	No	Yes	No
Make it a learning issue	Yes	No	Yes	No

In the past 7 days roughly how many hours have you spent using the internet

Only numbers may be entered in these fields.

for learning

for other than learning

Appendix C Consents

Confidentiality agreement transcription services project 7366

Prideaux Centre for Research in Health Professions Education
School of Medicine
GPO Box 2100
Adelaide SA 5001
Tel: 08 8204 7528

gillian.kette@flinders.edu.au

http://www.flinders.edu.au/medicine/research/centres/prideaux-centre/

au.linkedin.com/in/prideauxcentre

CRICOS Provider No. 00114A

CONFIDENTIALITY AGREEMENT
Transcription Services

Student-control of Information-Communication-Technologies during active learning: Are there cognitive and metacognitive consequences for learning?

I, _____, transcriptionist, agree to maintain full confidentiality in regards to any and all audiotapes and documentation received from Gillian Kette related to her doctoral study on Student-control of Information-Communication-Technologies during active learning: Are there cognitive and metacognitive consequences for learning?
Furthermore, I agree:

1. To hold in strictest confidence the identification of any individual that may be inadvertently revealed during the transcription of video recorded tutorials and audio-taped interviews, or in any associated documents;
2. To not make copies of any video recording or audiotapes or computerized files of the transcribed interview texts, unless specifically requested to do so by Gillian Kette
3. To store all study-related video recordings, audiotapes and materials in a safe, secure location as long as they are in my possession;
4. To return all video recordings, audiotapes and study-related documents to Gillian Kette in a complete and timely manner.
5. To delete all electronic files containing study-related documents from my computer hard drive and any backup devices.

I am aware that I can be held legally liable for any breach of this confidentiality agreement, and for any harm incurred by individuals if I disclose identifiable information contained in the audiotapes and/or files to which I will have access.

Transcriber's name (printed) _____

Transcriber's signature _____

Date _____

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7366). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Consent student ICT history project 7366

Prideaux Centre for Research in Health Professions Education

School of Medicine

GPO Box 2100
Adelaide SA 5001

Tel: 08 8204 7528

gillian.kette@flinders.edu.au

http://www.flinders.edu.au/medicine/research/centres/prideaux-centre/

au.linkedin.com/in/prideauxcentre

CRICOS Provider No. 00114A

CONSENT FORM FOR PARTICIPATION IN RESEARCH

(by student, downloading history of all internet usage during PBL tutorial including smart phone, tablet and computer)

Student-control of Information-Communication-Technologies during active learning: Are there cognitive and metacognitive consequences for learning?

I .....

being over the age of 18 years hereby consent to participate as requested in the

..... for the research project on .....

1. I have read the information provided.
2. Details of procedures and any risks have been explained to my satisfaction.
3. I agree to providing my internet history log from smart phone, tablet and computer after each PBL tutorial.
4. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.
5. I understand that:
   - I may not directly benefit from taking part in this research.
   - I am free to withdraw from the project up to 2 weeks after the history log has been provided.
   - While the information gained in this study will be published as explained, I will not be identified, and individual information will remain confidential.
   - Whether I participate or not, or withdraw after participating, will have no effect on any treatment or service that is being provided to me.
   - Whether I participate or not, or withdraw after participating, will have no effect on my progress in my course of study, or results gained.
   - I may ask that I withdraw at any time from the session or the research without disadvantage.
6. I agree/do not agree* to the tape/transcript* being made available to other researchers who are not members of this research team, but who are judged by the research team to be doing related research, on condition that my identity is not revealed. ** delete as appropriate*
7. I have had the opportunity to discuss taking part in this research with a family member or friend.

Participant's signature.....Date.....

I certify that I have explained the study to the volunteer and consider that she/he understands what is involved and freely consents to participation.

Researcher's name.....

Researcher's signature.....Date.....

NB: Two signed copies should be obtained. The copy retained by the researcher.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7366). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Consent student 'think aloud interview' project 7366

Prideaux Centre for Research in Health Professions Education
School of Medicine
GPO Box 2100
Adelaide SA 5001
Tel: 08 8204 7528

gillian.keffe@flinders.edu.au
http://www.flinders.edu.au/medicine/research/centres/prideaux-centre/

au.linkedin.com/in/prideauxcentre

CRICOS Provider No. 00114A

CONSENT FORM FOR PARTICIPATION IN RESEARCH (by student, think aloud interview)

Student-control of Information-Communication-Technologies during active learning: Are there cognitive and metacognitive consequences for learning?

I .....

being over the age of 18 years hereby consent to participate as requested in the

..... for the research project on .....

1. I have read the information provided.
2. Details of procedures and any risks have been explained to my satisfaction.
3. I agree to digital audio recording of my interview.
4. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.
5. I understand that:
   - I may not directly benefit from taking part in this research.
   - I am free to withdraw from the project up to 2 weeks after my interview has been undertaken and I am free to decline to answer particular questions.
   - While the information gained in this study will be published as explained, I will not be identified, and individual information will remain confidential.
   - Whether I participate or not, or withdraw after participating, will have no effect on any treatment or service that is being provided to me.
   - Whether I participate or not, or withdraw after participating, will have no effect on my progress in my course of study, or results gained.
   - I may ask that the audio recording be stopped at any time, and that I may withdraw at any time from the session or the research without disadvantage.
6. I agree/do not agree* to the audio recording/transcript* being made available to other researchers who are not members of this research team, but who are judged by the research team to be doing related research, on condition that my identity is not revealed.
   ** delete as appropriate*
7. I have had the opportunity to discuss taking part in this research with a family member or friend.
8. I agree to confidentiality agreement upon viewing the video recorded PBL tutorial and respect the privacy and anonymity of all members of my PBL group.

Participant's signature.....Date.....

I certify that I have explained the study to the volunteer and consider that she/he understands what is involved and freely consents to participation.

Researcher's name.....

Researcher's signature.....Date.....

NB: Two signed copies should be obtained. The copy retained by the researcher.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7366). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Participant photo request consent project 7366

Prideaux Centre for Research in Health Professions Education
School of Medicine
GPO Box 2100
Adelaide SA 5001
Tel: 08 8204 7528
pilling.kate@flinders.edu.au
http://www.flinders.edu.au/medicine/research/centres/prideaux-centre/
au.linkedin.com/in/prideauxcentre
CRICOS Provider No. 00114A

PARTICIPANT PHOTOGRAPH RELEASE FORM

To all participants of the research project
Student-control of Information-Communication-Technologies during active learning: Are there cognitive and metacognitive consequences for learning?

I .....
agree to still photographs being taken from video recordings for the *research project*

(as requested in the Participant Information Sheet) to be used for:
[please circle whichever applies]

researcher's background analysis only / not for display	agree/don't agree
display in thesis materials	agree/don't agree
display in academic articles and presentations	agree/don't agree

1. I have read the information provided in the Participant Information Sheet.
2. Details of procedures and any risks have been explained to my satisfaction.
3. I am aware that I should retain a copy of the Information Sheet and Participant Photograph Release Form for future reference.
4. I understand that:
   - All photographs will be de-identified using computer editing software
   - Photographs will be numbered not labelled to maintain anonymity.

Participant's signature..... **Date**.....

I certify that I have explained how photographs will be used to the volunteer and consider that she understands what is involved and freely consents to participation.

Researcher's name.....

Researcher's signature..... **Date**.....

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7366). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Appendix D Ethics approvals

Approval from ethics

Appendices

Appendix 1 Ethics approvals:

A) From Social and Behavioural Research Ethics Committee, Flinders University

Dear Gillian,

The Chair of the Social and Behavioural Research Ethics Committee (SBREC) at Flinders University considered your response to conditional approval out of session and your project has now been granted final ethics approval. This means that you now have approval to commence your research. Your ethics final approval notice can be found below.

FINAL APPROVAL NOTICE

Project No.:	7366
Project Title:	Student-control of Information-Communication-Technologies affordances during active learning: Are there cognitive and metacognitive consequences for learning?
Principal Researcher:	Mrs Gillian Kette
Email:	gillian.kette@flinders.edu.au
Approval Date:	29 July 2016
Ethics Approval Expiry Date:	31 December 2017

The above proposed project has been **approved** on the basis of the information contained in the application, its attachments and the information subsequently provided.

RESPONSIBILITIES OF RESEARCHERS AND SUPERVISORS

1. **Participant Documentation**

Please note that it is the responsibility of researchers and supervisors, in the case of student projects, to ensure that:

- all participant documents are checked for spelling, grammatical, numbering and formatting errors. The Committee does not accept any responsibility for the above mentioned errors.
- the Flinders University logo is included on all participant documentation (e.g., letters of Introduction, information Sheets, consent forms, debriefing information and questionnaires – with the exception of purchased research tools) and the current Flinders University letterhead is included in the header of all letters of introduction. The Flinders University international logo/letterhead should be used and documentation should contain international dialling codes for all telephone and fax numbers listed for allresearch to be conducted overseas.

- the SBREC contact details, listed below, are included in the footer of all letters of introduction and information sheets.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project Number 'INSERT PROJECT No. here following approval'). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au.

2. Annual Progress / Final Reports

In order to comply with the monitoring requirements of the *National Statement on Ethical Conduct in Human Research (March 2007)* an annual progress report must be submitted each year on the **29 July** (approval anniversary date) for the duration of the ethics approval using the report template available from the Managing Your Ethics Approval SBREC web page. *Please retain this notice for reference when completing annual progress or final reports.*

If the project is completed *before* ethics approval has expired please ensure a final report is submitted immediately. If ethics approval for your project expires please submit either (1) a final report; or (2) an extension of time request and an annual report.

Student Projects

The SBREC recommends that current ethics approval is maintained until a student's thesis has been submitted, reviewed and approved. This is to protect the student in the event that reviewers recommend some changes that may include the collection of additional participant data.

Your first report is due on **29 July 2017** or on completion of the project, whichever is the earliest.

3. Modifications to Project

Modifications to the project must not proceed until approval has been obtained from the Ethics Committee. Such proposed changes / modifications include:

- change of project title;
- change to research team (e.g., additions, removals, principal researcher or supervisor change);
- changes to research objectives;
- changes to research protocol;
- changes to participant recruitment methods;
- changes / additions to source(s) of participants;
- changes of procedures used to seek informed consent;
- changes to reimbursements provided to participants;
- changes / additions to information and/or documentation to be provided to potential participants;
- changes to research tools (e.g., questionnaire, interview questions, focus group questions);
- extensions of time.

To notify the Committee of any proposed modifications to the project please complete and submit the *Modification Request Form* which is available from the Managing Your Ethics Approval SBREC web page. Download the form from the website every time a new modification request is submitted to ensure that the most recent form is used. Please note that extension of time requests should be submitted prior to the Ethics Approval Expiry Date listed on this notice.

Change of Contact Details

Please ensure that you notify the Committee if either your mailing or email address changes to ensure that correspondence relating to this project can be sent to you. A modification request is not required to change your contact details.

4. **Adverse Events and/or Complaints**

Researchers should advise the Executive Officer of the Ethics Committee on 08 8201-3116 orhuman.researchethics@flinders.edu.au immediately if:

- any complaints regarding the research are received;
- a serious or unexpected adverse event occurs that effects participants;
- an unforeseen event occurs that may affect the ethical acceptability of the project.

Kind regards
Rae

Mrs Andrea Fiegert and Ms Rae Tyler
Ethics Officers and Executive Officer, Social and Behavioural Research Ethics Committee
Andrea - Telephone: +61 8 8201-3116 | Monday, Tuesday and Wednesday
Rae – Telephone: +61 8 8201-7938 | ½ day Wednesday, Thursday and Friday

Email: human.researchethics@flinders.edu.au
Web: Social and Behavioural Research Ethics Committee (SBREC)

Manager, Research Ethics and Integrity – Dr Peter Wigley
Telephone: +61 8 8201-5466 | email: peter.wigley@flinders.edu.au
Research Services Office | Union Building Basement
Flinders University
Sturt Road, Bedford Park | South Australia | 5042
GPO Box 2100 | Adelaide SA 5001

B) From School of Medicine Evaluation Reference Group, Flinders University

Evaluation Coordinator | Medical Course Directorate
School of Medicine
Flinders University
Sturt Road | Bedford Park | SA | 5042
GPO Box 2100 | Adelaide SA 5001

Dear Gillian,

The Evaluation Reference Group considered your research proposal on Wednesday 6th July.

The Group is supportive of your project, and wishes to convey the following feedback:

- With regards to the recruitment of students, video recording and follow up interviews – please avoid the 2 weeks prior to exam periods
- Efforts should ensure that interviews are conducted in a timely manner following recording
- While it is apparent that Adelaide PBL groups and students are the focus of the initial phase of research, you would be welcome to include PBL groups in the Northern Territory if needed.

Please let me know if you have any questions or would like to clarify the points above.

Kind regards,
Laura

Laura Spencer
Evaluation Coordinator | Medical Course Directorate
School of Medicine
Flinders University
Sturt Road | Bedford Park | SA | 5042
GPO Box 2100 | Adelaide SA 5001

Ph: +61 8 8204 5861
e: laura.spencer@flinders.edu.au
Web: [www.flinders.edu.au]www.flinders.edu.au

Appendix E Avery ICT history log

Avery ICT history log

Avery

Day 2 - 23/09/2016 (Latest accessed to earliest accessed)

1. 10:33
   Myogenic mechanism - Wikipedia, the free encyclopedia
   en.wikipedia.org
2. 10:33
   kidney autoregulation myogenic - Google Search
   www.google.com.au
3. 10:33
   Google
   www.google.com.au
4. 10:13
   PBL 14 - Sem 2
   www.facebook.com
5. 10:13
   Facebook
   www.facebook.com
6. 10:11
   https://www.google.com.au/#q=brs+physiology
   www.google.com.au
7. 09:53
   Mechanisms of pressure natriuresis: how blood pressure regulates renal sodium transport. - PubMed - NCBI
   www.ncbi.nlm.nih.gov
8. 09:53
   pressure natriuesis - Google Search
   www.google.com.au
9. 09:53
   Mechanisms of pressure natriuresis. - PubMed - NCBI
   www.ncbi.nlm.nih.gov
10. 09:52
    Pressure natriuresis. Role of renal interstitial hydrostatic pressure. - PubMed - NCBI
    www.ncbi.nlm.nih.gov
11. 09:03
    Uroplakins in urothelial biology, function, and disease. - PubMed - NCBI
    www.ncbi.nlm.nih.gov
12. 09:00
    uroplakins - Google Search
    www.google.com.au
13. 08:56
    Mesangial cell - Wikipedia, the free encyclopedia
    en.wikipedia.org
14. 08:55
    https://www.google.com.au/#q=mesangial+cells
    www.google.com.au

Day 1 - 20/09/2016 (Latest accessed to earliest accessed)

1. 10:24
   PBL 14 - Sem 2
   www.facebook.com
2. 10:14
   https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f713
   flextra.flinders.edu.au
3. 10:14
   https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f712
   flextra.flinders.edu.au
4. 10:14
   https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f711

flextra.flinders.edu.au
5. 10:08
What Is Fistula? | Fistula Foundation
www.fistulafoundation.org
6. 10:07
uraemia - Google Search
www.google.com.au
7. 10:07
Fistula - Wikipedia, the free encyclopedia
en.wikipedia.org
8. 10:07
Urethral fistula - Wikipedia, the free encyclopedia
en.wikipedia.org
9. 10:06
https://en.wikipedia.org/wiki/Fistula#N:_Diseases_of_the_urogenital_system
en.wikipedia.org
10. 10:05
fistule - Google Search
www.google.com.au
11. 10:05
https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f710
flextra.flinders.edu.au
12. 09:59
uraemia - Google Search
www.google.com.au
13. 09:52
https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f709
flextra.flinders.edu.au
14. 09:50
https://www.google.com.au/search?q=hyaline+and+granular+casts&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiD8d-b1pzPAhWJNpQKHeTSC44Q_AUICCgB&biw=1366&bih=648#imgrc=K59S456LFgTw8M%3A
www.google.com.au
15. 09:49
hyaline and granular casts - Google Search
www.google.com.au
16. 09:47
https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f708
flextra.flinders.edu.au

17. 09:47
https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f707
flextra.flinders.edu.au
18. 09:46
https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f706
flextra.flinders.edu.au
19. 09:44
Glomerular Filtration Rate (GFR) Calculators
www.niddk.nih.gov
20. 09:44
estimated glomerular filtration rate units - Google Search
www.google.com.au
21. 09:43
egfr /km2 - Google Search
www.google.com.au
22. 09:43
Assessing Kidney Function — Measured and Estimated Glomerular Filtration Rate — NEJM
www.nejm.org
23. 09:42
Estimated glomerular filtration rate in patients with type 2 diabetes mellitus
www.scielo.br
24. 09:42
estimated glomerular filtration rate /km2 - Google Search
www.google.com.au
25. 09:42

estimate glomerular filtration rate /km2 - Google Search
www.google.com.au
26. 09:42
egfr /km2 - Google Search
www.google.com.au
27. 09:41
Egfr simple - BioNetWiki
bionetgen.org
28. 09:41
Facebook
www.facebook.com
29. 09:36
https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f705
flextra.flinders.edu.au
30. 09:30
https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f704
flextra.flinders.edu.au
31. 09:29
https://flextra.flinders.edu.au/flex/flo-ocf/pblcase/d01f150e-5d67-40e6-b83b-d534c03c033d/1#a5f703
flextra.flinders.edu.au
32. 09:27
renal calculi - Google Search
www.google.com.au
33. 09:27
calculi - Google Search
www.google.com.au
34. 09:23
http://www.uptodate.com/contents/nsaids-acute-kidney-injury-acute-renal-failure#H2
www.uptodate.com
35. 09:22
NSAIDs: Acute kidney injury (acute renal failure)
www.uptodate.com
36. 09:21
nsaids kidney damage - Google Search
www.google.com.au
37. 09:10
PBL Case
flextra.flinders.edu.au
38. 09:02
Rhabdomyolysis - Wikipedia, the free encyclopedia
en.wikipedia.org
39. 09:01
Rhabdomyolysis - Wikipedia, the free encyclopedia
en.wikipedia.org
40. 09:00
rhabdomyolysis - Google Search
www.google.com.au
41. 08:43
PBL Case
flextra.flinders.edu.au
42. 08:42
PBL Case
flextra.flinders.edu.au
43. 08:38
PBL Case::Bob De Costa
flextra.flinders.edu.au
44. 08:36
Activity Group::Renal Blood Flow, Acute Renal Failure
flextra.flinders.edu.au
45. 08:36
https://flo.flinders.edu.au/mod/lti/launch.php?id=1147726
flo.flinders.edu.au
46. 08:35
Topic: MMED8104 Knowledge of Health and Illness 1B - 2016

flo.flinders.edu.au
47. 08:35
My FLO
flo.flinders.edu.au
48. 08:35
Flinders University - Signing in...
flinders.okta.com

49. 08:34
Flinders University - Sign In
flinders.okta.com
50. 08:34
Okta SSO
iwa2.flinders.edu.au
51. 08:34
Flinders University - Signing in...
flinders.okta.com

REFERENCES

ACKERMAN, R., & LAUTERMAN, T. (2012). TAKING READING COMPREHENSION EXAMS ON SCREEN OR ON PAPER? A METACOGNITIVE ANALYSIS OF LEARNING TEXTS UNDER TIME PRESSURE. *COMPUTERS IN HUMAN BEHAVIOR, 28*, 1816-1828. DOI:HTTP://DX.DOI.ORG/10.1016/J.CHB.2012.04.023

ADLER, R. F., & BENBUNAN-FICH, R. (2012). JUGGLING ON A HIGH WIRE: MULTITASKING EFFECTS ON PERFORMANCE. *INTERNATIONAL JOURNAL OF HUMAN-COMPUTER STUDIES, 70*(2), 156-168. DOI:10.1016/J.IJHCS.2011.10.003

AGRAWAL, P., SAHANA, H., & DE', R. (2017, MARCH 07 - 09). *DIGITAL DISTRACTION.* PAPER PRESENTED AT THE PROCEEDINGS OF THE 10TH INTERNATIONAL CONFERENCE ON THEORY AND PRACTICE OF ELECTRONIC GOVERNANCE, NEW DELHI , AA, INDIA.

ALBANESE, M. A., & MITCHELL, S. (1993). PROBLEM-BASED LEARNING: A REVIEW OF LITERATURE ON ITS OUTCOMES AND IMPLEMENTATION ISSUES. *ACADEMIC MEDICINE, 68*(1), 52-81.

ALI, A. (2016). MEDICAL STUDENTS' USE OF FACEBOOK FOR EDUCATIONAL PURPOSES. *PERSPECTIVES ON MEDICAL EDUCATION, 5*(3), 163-169.

ANAND, A., & ESWARAN, S. (2018). A SURVEY OF OPEN SOURCE LEARNING MANAGEMENT SYSTEMS *ANNALS. COMPUTER SCIENCE SERIES, 16*(1).

ANDERSON, L. W., KRATHWOHL, D. R., & BLOOM, B. S. (2001). *A TAXONOMY FOR LEARNING, TEACHING, AND ASSESSING: A REVISION OF BLOOM'S TAXONOMY OF EDUCATIONAL OBJECTIVES* (L. W. ANDERSON, D. R. KRATHWOHL, P. W. AIRASIAN, K. A. CRUIKSHANK, R. E. MAYER, P. P. R, J. RATHS, & M. C. WITTROCK EDS.): ALLYN & BACON.

ANMARKRUD, Ø., ANDRESEN, A., & BRÅTEN, I. (2019). COGNITIVE LOAD AND WORKING MEMORY IN MULTIMEDIA LEARNING: CONCEPTUAL AND MEASUREMENT ISSUES. *EDUCATIONAL PSYCHOLOGIST, 54*(2), 61-83.

ANTONENKO, P., PAAS, F., GRABNER, R., & VAN GOG, T. (2010). USING ELECTROENCEPHALOGRAPHY TO MEASURE COGNITIVE LOAD. *EDUCATIONAL PSYCHOLOGY REVIEW, 22*(4), 425-438.

ATKINSON, R. C., & SHIFFRIN, R. M. (1968). HUMAN MEMORY: A PROPOSED SYSTEM AND ITS CONTROL PROCESSES. IN K. SPENCE & J. SPENCE (EDS.), *THE PSYCHOLOGY OF LEARNING AND MOTIVATION: ADVANCES IN RESEARCH AND THEORY* (VOL. 2, PP. 89-195). NEW YORK: ACADEMIC PRESS.

AWAN, O., DEY, C., SALTS, H., BRIAN, J., FOTOS, J., ROYSTON, E., . . . CHUNG, C. (2019). MAKING LEARNING FUN: GAMING IN RADIOLOGY EDUCATION. *ACADEMIC RADIOLOGY, 26*(8), 1127-1136.

AZER, S. A. (2004). TWELVE TIPS BECOMING A STUDENT IN A PBL COURSE: TWELVE TIPS FOR SUCCESSFUL GROUP DISCUSSION. *MEDICAL TEACHER, 26*(1), 12-15.

AZER, S. A. (2005). FACILITATION OF STUDENTS' DISCUSSION IN PROBLEM-BASED LEARNING TUTORIALS TO CREATE MECHANISMS: THE USE OF FIVE KEY QUESTIONS. *ANNALS ACADEMIC MEDICINE SINGAPORE, 34*, 492-498.

AZER, S. A. (2009). INTERACTIONS BETWEEN STUDENTS AND TUTOR IN PROBLEM-BASED LEARNING: THE SIGNIFICANCE OF DEEP LEARNING. *KAOHSIANG JOURNAL MEDICAL SCIENCE, 25*(5).

AZER, S. A., & AZER, D. (2015). GROUP INTERACTION IN PROBLEM-BASED LEARNING TUTORIALS: A SYSTEMATIC REVIEW. *EUROPEAN JOURNAL OF DENTAL EDUCATION, 19*(4), 194-208.

AZER, S. A., PETERSON, R., GUERRERO, A. P., & EDGREN, G. (2012). TWELVE TIPS FOR CONSTRUCTING PROBLEM-BASED LEARNING CASES. *MEDICAL TEACHER, 34*(5), 361-367.

BADDELEY, A. D. (2003A). WORKING MEMORY AND LANGUAGE: AN OVERVIEW. *JOURNAL OF COMMUNICATION DISORDERS, 36*, 189-208.

BADDELEY, A. D. (2003B). WORKING MEMORY: LOOKING BACK AND LOOKING FORWARD. *NATURE REVIEWS, 4*, 829-839. DOI:10.1038/NRN1201

BADDELEY, A. D. (2011). WORKING MEMORY. *CURRENT BIOLOGY, 20*(4), 136-140.

BADDELEY, A. D., & HITCH, G. J. (1974). WORKING MEMORY. *THE PSYCHOLOGY OF LEARNING AND MOTIVATION, 8*, 47-89.

BANDURA, A. (1971). *SOCIAL LEARNING THEORY.* NEW YORK: GENERAL LEARNING PRESS.

BANDURA, A. (1982). SELF-EFFICACY MECHANISM IN HUMAN AGENCY. *AMERICAN PSYCHOLOGIST, 37*(2), 122-147.

BANDURA, A. (1986). *SOCIAL FOUNDATIONS OF THOUGHT AND ACTION: A SOCIAL COGNITIVE THEORY.* (E. CLIFFS ED.). NJ: PRENTICE-HALL. .

BANDURA, A. (1993). PERCEIVED SELF-EFFICACY IN COGNITIVE DEVELOPMENT AND FUNCTIONING. *EDUCATIONAL PSYCHOLOGIST, 28*(2), 117-148.

BANDURA, A. (1995). *SELF-EFFICACY IN CHANGING SOCIETIES.* CAMBRIDGE UK: CAMBRIDGE UNIVERSITY PRESS.

BANDURA, A. (2001A). SOCIAL COGNITIVE THEORY OF MASS COMMUNICATION. *MEDIA PSYCHOLOGY, 3*(3), 265-299. DOI:10.1207/S1532785XMEP0303_03

BANDURA, A. (2001B). SOCIAL COGNITIVE THEORY: AN AGENTIC PERSPECTIVE. *ANNUAL REVIEW OF PSYCHOLOGY, 52*, 1-26.

BANDURA, A. (2002). SOCIAL COGNITIVE THEORY IN CULTURAL CONTEXT. *APPLIED PSYCHOLOGY: AN INTERNATIONAL REVIEW, 51*(2), 269-290.

BANDURA, A. (2006). GUIDE FOR CONSTRUCTING SELF-EFFICACY SCALES. *SELF-EFFICACY BELIEFS OF ADOLESCENTS, 5*(307-337).

BARR, N., PENNYCOOK, G., STOLZ, J. A., & FUGELSANG, J. A. (2015). THE BRAIN IN YOUR POCKET: EVIDENCE THAT SMARTPHONES ARE USED TO SUPPLANT THINKING. *COMPUTERS IN HUMAN BEHAVIOR, 48*, 473-480.

BARROWS, H. S. (1983). PROBLEM-BASED, SELF-DIRECTED LEARNING. *JAMA, 250*(22), 3077-3080.
BARROWS, H. S. (1996). PROBLEM-BASED LEARNING IN MEDICINE AND BEYOND: A BRIEF OVERVIEW. *NEW ACTIONS FOR TEACHING LEARNING AND INSTRUCTION, 1996*(68), 3-12.
BARROWS, H. S., & TAMBLYN, R. M. (1980). *PROBLEM-BASED LEARNING AN APPROACH TO MEDICAL EDUCATION*. NEW YORK: SPRINGER PUBLISHING COMPANY.
BARRY, S., MURPHY, K., & DREW, S. (2015). FROM DECONSTRUCTIVE MISALIGNMENT TO CONSTRUCTIVE ALIGNMENT: EXPLORING STUDENT USES OF MOBILE TECHNOLOGIES IN UNIVERSITY CLASSROOMS. *COMPUTERS & EDUCATION, 81*, 202-210.
BATE, E., HOMMES, J., DUVIVIER, R., & TAYLOR, D. C. (2014). PROBLEM-BASED LEARNING (PBL): GETTING THE MOST OUT OF YOUR STUDENTS – THEIR ROLES AND RESPONSIBILITIES: AMEE GUIDE NO. 84. *MEDICAL TEACHER, 36*, 1-12.
BENNETT, S., & MATON, K. (2010). BEYOND THE 'DIGITAL NATIVES' DEBATE: TOWARDS A MORE NUANCED UNDERSTANDING OF STUDENTS' TECHNOLOGY EXPERIENCES. *JOURNAL OF COMPUTER ASSISTED LEARNING, 26*(5), 321-331.
BENSON, T. (2019). DIGITAL INNOVATION EVALUATION: USER PERCEPTIONS OF INNOVATION READINESS, DIGITAL CONFIDENCE, INNOVATION ADOPTION, USER EXPERIENCE AND BEHAVIOUR CHANGE. *BMJ HEALTH CARE INFORM, 26*(1), 1-6. DOI:10.1136/BMJHCI-2019-000018
BERGERON, B. (2005). *DEVELOPING SERIOUS GAMES (GAME DEVELOPMENT SERIES)*: CHARLES RIVER MEDIA, INC.
BERGMAN, E. M., SIEBEN, J. M., SMAILBEGOVIC, I., BH, D. B. A., SHERPBIER, A. J., & VAN DER VLEUTEN, C. P. (2013). CONSTRUCTIVE, COLLABORATIVE, CONTEXTUAL, AND SELF-DIRECTED LEARNING IN SURFACE ANATOMY EDUCATION. *ANATOMICAL SCIENCES EDUCATION, 6*, 114-124.
BERKHOUT, J. J., HELMICH, E., TEUNISSEN, P. W., VAN DER VLEUTEN, C. P., & JAARSMA, A. D. C. (2018). CONTEXT MATTERS WHEN STRIVING TO PROMOTE ACTIVE AND LIFELONG LEARNING IN MEDICAL EDUCATION. *MEDICAL EDUCATION, 52*(1), 34-44.
BERRY, E., KAPUR, N., WILLIAMS, L., HODGES, S., WATSON, P., SMYTH, G., . . . WOOD, K. (2007). THE USE OF A WEARABLE CAMERA, SENSECAM, AS A PICTORIAL DIARY TO IMPROVE AUTOBIOGRAPHICAL MEMORY IN A PATIENT WITH LIMBIC ENCEPHALITIS: A PRELIMINARY REPORT. *NEUROPSYCHOLOGICAL REHABILITATION, 17*(4-5), 582-601.
BETTMAN, J. R., JOHNSON, E. J., & PAYNE, J. W. (1990). A COMPONENTIAL ANALYSIS OF COGNITIVE EFFORT IN CHOICE. *ORGANIZATIONAL BEHAVIOR AND HUMAN DECISION PROCESSES, 45*(1), 111-139.
BIGGS, J. B. (1987). *STUDENT APPROACHES TO LEARNING AND STUDYING. RESEARCH MONOGRAPH*. FREDERICK ST., HAWTHORN 3122, AUSTRALIA.: RADFORD HOUSE.
BLAUM, W. E., JARCZWESKI, A., BALZER, F., STÖTZNER, P., & AHLERS, O. (2013). TOWARDS WEB 3.0: TAXONOMIES AND ONTOLOGIES FOR MEDICAL EDUCATION-A SYSTEMATIC REVIEW. *GMS ZEITSCHRIFT FÜR MEDIZINISCHE AUSBILDUNG, 30*(1).
BLOOM, B. S. (1956). *TAXONOMY OF EDUCATIONAL OBJECTIVES.* (VOL. VOL. 1: COGNITIVE DOMAIN). NEW YORK LONGMAN.
BLUMBERG, P., MICHAEL, J. A., & ZEITZ, H. (1990). ROLES OF STUDENT-GENERATED LEARNING ISSUES IN PROBLEM-BASED LEARNING. *TEACHING AND LEARNING IN MEDICINE: AN INTERNATIONAL JOURNAL, 2*(3), 149-154.
BONWELL, C. C., & EISON, J. A. (1991). ACTIVE LEARNING: CREATING EXCITEMENT IN THE CLASSROOM. ERIC DIGEST. IN *ASHE-ERIC HIGHER EDUCATION REPORT* (VOL. DC.1 FGK28050). GEORGE WASHINGTON UNIV. WASHINGTON DC.: ERIC CLEARINGHOUSE ON HIGHER EDUCATION WASHINGTON
BORUFF, J. T., & STORIE, D. (2014). MOBILE DEVICES IN MEDICINE: A SURVEY OF HOW MEDICAL STUDENTS, RESIDENTS, AND FACULTY USE SMARTPHONES AND OTHER MOBILE DEVICES TO FIND INFORMATION. *JOURNAL OF MEDICAL LIBRARY ASOCIATION, 102*(1), 22-29. DOI:HTTP://DX.DOI.ORG/10.3163/1536-5050.102.1.006
BOYLE, T., & COOK, J. (2004). UNDERSTANDING AND USING TECHNOLOGICAL AFFORDANCES: A COMMENTARY ON CONOLE AND DYKE. *RESEARCH IN LEARNING TECHNOLOGY, 12*(3).
BRASEL, S. A., & GIPS, J. (2011). MEDIA MULTITASKING BEHAVIOR: CONCURRENT TELEVISION AND COMPUTER USAGE. *CYBERPSYCHOLOGY, BEHAVIOR, AND SOCIAL NETWORKING, 14*(9), 527-534.
BREHAUT, J. C., & EVA, K. W. (2012). BUILDING THEORIES OF KNOWLEDGE TRANSLATION INTERVENTIONS: USE THE ENTIRE MENU OF CONSTRUCTS. *IMPLEMENTATION SCIENCE, 7*(1), 1-10.
BROADBENT, J. (2016). ACADEMIC SUCCESS IS ABOUT SELF-EFFICACY RATHER THAN FREQUENCY OF USE OF THE LEARNING MANAGEMENT SYSTEM. *AUSTRALASIAN JOURNAL OF EDUCATIONAL TECHNOLOGY, 32*(4).
BROADBENT, J. (2017). COMPARING ONLINE AND BLENDED LEARNER'S SELF-REGULATED LEARNING STRATEGIES AND ACADEMIC PERFORMANCE. *THE INTERNET HIGHER EDUCATION, 33*, 24-32.
BRUNER, J. (1997). CELEBRATING DIVERGENCE: PIAGET AND VYGOTSKY. *HUMAN DEVELOPMENT, 40*(2).
BRUNER, J. (2004). A SHORT HISTORY OF PSYCHOLOGICAL THEORIES OF LEARNING. *DAEDALUS, 133*(1), 13-20.
BURTSCHER, M., WACKER, J., GROTE, G., & MANSER, T. (2010). MANAGING NONROUTINE EVENTS IN ANESTHESIA: THE ROLE OF ADAPTIVE COORDINATION. *HUM FACTORS, 52*(2), 282-294.
CABERO-ALMENARA, J., ARANCIBIA, M., & DEL PRETE, A. (2019). TECHNICAL AND DIDACTIC KNOWLEDGE OF THE MOODLE LMS IN HIGHER EDUCATION. BEYOND FUNCTIONAL USE. *JOURNAL OF NEW APPROACHES IN EDUCATIONAL RESEARCH, 8*(1), 25-33.
CANTOR, J., & ENGLE, R. W. (1993). WORKING-MEMORY CAPACITY AS LONG-TERM MEMORY ACTIVATION: AN INDIVIDUAL-DIFFERENCES APPROACH. *JOURNAL OF EXPERIMENTAL PSYCHOLOGY: LEARNING, MEMORY, COGNITION, 19*(5), 1101.
CARR, R., PALMER, S., & HAGEL, P. (2015). ACTIVE LEARNING: THE IMPORTANCE OF DEVELOPING A COMPREHENSIVE MEASURE. *ACTIVE LEARNING IN HIGHER EDUCATION, 16*(3), 173-186.
CARRASCO, G. A., BEHLING, K. C., & LOPEZ, O. J. (2018). EVALUATION OF THE ROLE OF INCENTIVE STRUCTURE ON STUDENT PARTICIPATION AND PERFORMANCE IN ACTIVE LEARNING STRATEGIES: A COMPARISON OF

CASE-BASED AND TEAM-BASED LEARNING. *MEDICAL TEACHER, 40*(4), 379-386.
CARRIER, L. M., ROSEN, L. D., CHEEVER, N. A., & LIM, A. F. (2015). CAUSES, EFFECTS, AND PRACTICALITIES OF EVERYDAY MULTITASKING. *DEVELOPMENTAL REVIEW*.
CASTELLS, M. (1997). AN INTRODUCTION TO THE INFORMATION AGE. *CITY: ANALYSIS OF URBAN TRENDS, CULTURE, THEORY, POLICY, ACTION, 2*(7), 6-16. DOI:HTTP://DX.DOI.ORG/10.1080/13604819708900050
CHANDLER, D. (1995). TECHNOLOGICAL OR MEDIA DETERMINISM. RETRIEVED FROM HTTP://WWW.ABER.AC.UK/MEDIA/DOCUMENTS/TECDET/TECDET.HTML WEBSITE:
CHANDLER, P., & SWELLER, J. (1991). COGNITIVE LOAD THEORY AND THE FORMAT OF INSTRUCTION. *COGNITION AND INSTRUCTION, 8*(4), 293-332.
CHANG, C.-S., CHUNG, C.-H., & CHANG, J. A. (2020). INFLUENCE OF PROBLEM-BASED LEARNING GAMES ON EFFECTIVE COMPUTER PROGRAMMING LEARNING IN HIGHER EDUCATION. *EDUCATIONAL TECHNOLOGY RESEARCH DEVELOPMENTAL REVIEW, 68*(5), 2615-2634.
CHEMERO, A. (2003). AN OUTLINE OF A THEORY OF AFFORDANCES. *ECOLOGICAL PSYCHOLOGY, 15*(2), 181-195.
CHEMERO, A., & TURVEY, M. T. (2007). GIBSONIAN AFFORDANCES FOR ROBOTICISTS. *ADAPTIVE BEHAVIOR, 15*(4), 473-480.
CHEN, Z., & COWAN, N. (2005). CHUNK LIMITS AND LENGTH LIMITS IN IMMEDIATE RECALL: A RECONCILIATION. *JOURNAL OF EXPERIMENTAL PSYCHOLOGY, 31*(6), 1235-1249.
CHI, M. T., DE LEEUW, N., CHIU, M.-H., & LAVANCHER, C. (1994). ELICITING SELF-EXPLANATIONS IMPROVES UNDERSTANDING. *COGNITIVE SCIENCE, 18*(3), 439-477.
CHI, M. T., GLASER, R., & REES, E. (1981). *EXPERTISE IN PROBLEM SOLVING*. RETRIEVED FROM
CHICKERING, A., & GAMSON, A. (1987). SEVEN PRINCIPLES FOR GOOD PRACTICE IN UNDERGRADUATE EDUCATION. RETRIEVED 10/04/2014 1:49PM, FROM RACINE, WI: THE JOHNSON FOUNDATION
COLBERT, C. Y., GRAHAM, L., WEST, C., WHITE, B. A., ARROLIGA, A. C., MYERS, J. D., . . . CLARK, J. (2014). TEACHING METACOGNITIVE SKILLS: HELPING YOUR PHYSICIAN TRAINEES IN THE QUEST TO "KNOW WHAT THEY DON'T KNOW" SHORT TITLE: TEACHING METACOGNITIVE SKILLS. *THE AMERICAN JOURNAL OF MEDICINE*. DOI:10.1016/J.AMJMED.2014.11.001
CONOLE, G., & DYKE, M. (2004). WHAT ARE THE AFFORDANCES OF INFORMATION AND COMMUNICATION TECHNOLOGIES? *ASSOCIATION FOR LEARNING TECHNOLOGY JOURNAL, 12*(2), 113-124.
CONOLE, G., DYKE, M., OLIVER, M., & SEALE, J. (2004). MAPPING PEDAGOGY AND TOOLS FOR EFFECTIVE LEARNING DESIGN. *COMPUTERS AND EDUCATION, 43*, 17-33.
COURAGE, M. L., BAKHTIAR, A., FITZPATRICK, C., KENNY, S., & BRANDEAU, K. (2015). GROWING UP MULTITASKING: THE COSTS AND BENEFITS FOR COGNITIVE DEVELOPMENT. *DEVELOPMENTAL REVIEW, 35*, 5-41.
COUTINHO, S. A. (2007). THE RELATIONSHIP BETWEEN GOALS, METACOGNITION, AND ACADEMIC SUCCESS. *EDUCATE, 7*(1), 39-47.
COUTINHO, S. A. (2008). SELF-EFFICACY, METACOGNITION, AND PERFORMANCE. *NORTH AMERICAN JOURNAL OF PSYCHOLOGY, 10*(1).
COWAN, N. (2011). THE FOCUS OF ATTENTION AS OBSERVED IN VISUAL WORKING MEMORY TASKS: MAKING SENSE OF COMPETING CLAIMS. *NEUROPSYCHOLOGIA, 49*, 1401-1406. DOI:10.1016/J.NEUROPSYCHOLOGIA.2011.01.035
COWAN, N., ELLIOTT, E., SCOTT SAULTS, J., MOREY, C., MATTOX, S., HISMJATULLINA, A., & CONWAY, A. (2005). ON THE CAPACITY OF ATTENTION: ITS ESTIMATION AND ITS ROLE IN WORKING MEMORY AND COGNITIVE APTITUDES. *COGNITIVE PSYCHOLOGY, 51*(1), 42-100. DOI:10.1016/J.COGPSYCH.2004.12.001
CRESWELL, J. W. (2013). *QUALITATIVE INQUIRY AND RESEARCH DESIGN: CHOOSING AMONG FIVE APPROACHES*. THOUSAND OAKS, CALIFORNIA: SAGE.
DAHLGREN, M. A., & ÖBERG, G. (2001). QUESTIONING TO LEARN AND LEARNING TO QUESTION: STRUCTURE AND FUNCTION OF PROBLEM-BASED LEARNING SCENARIOS IN ENVIRONMENTAL SCIENCE EDUCATION. *HIGHER EDUCATION, 41*(3), 263-282.
DALEY, B. J., DURNING, S. J., & TORRE, D. M. (2016). USING CONCEPT MAPS TO CREATE MEANINGFUL LEARNING IN MEDICAL EDUCATION. *MEDEDPUBLISH, 5*.
DE JONG, T., & FERGUSON-HESSLER, M. G. (1996). TYPES AND QUALITIES OF KNOWLEDGE. *EDUCATIONAL PSYCHOLOGIST, 31*(2), 105-113.
DEBUE, N., OU, N., & VAN DE LEEMPUT, C. (2020). AN INVESTIGATION OF USING A TABLET COMPUTER FOR SEARCHING ON THE WEB AND THE INFLUENCE OF COGNITIVE LOAD. *TUTORIALS IN QUANTITATIVE METHODS FOR PSYCHOLOGY, 16*, 226-239.
DECI, E. L., & RYAN, R. M. (1991). A MOTIVATIONAL APPROACH TO SELF: INTEGRATION IN PERSONALITY. *EDUCATIONAL PSYCHOLOGIST, 26*(3-4), 325-346.
DEEDS, C., & EDWARDS, A. (2011). THE ROLE OF OUTSIDE AFFORDANCES IN DEVELOPING EXPERTISE IN ONLINE COLLABORATIVE LEARNING. *INTERNATIONAL JOURNAL OF KNOWLEDGE SOCIETY RESEARCH, 2*(2), 25-36.
DENG, L., HINTON, G., & KINGSBURY, B. (2013). *NEW TYPES OF DEEP NEURAL NETWORK LEARNING FOR SPEECH RECOGNITION AND RELATED APPLICATIONS: AN OVERVIEW.* PAPER PRESENTED AT THE IEEE INTERNATIONAL CONFERENCE ON ACOUSTICS, SPEECH AND SIGNAL PROCESSING.
DEWEY, J. (1929). *EXPERIENCE AND NATURE*. LONDON: GEORGE ALLEN & UNWIN LTD.
DIAS, P. C., CADIME, I., RJA, G. D. C., MARZO, J. C., GARCÍA DEL CASTILLO LÓPEZ, Á., & LÓPEZ-SÁNCHEZ, C. (2020). PROBLEMATIC INTERNET AND FACEBOOK USE AND ONLINE GAMING AMONG UNIVERSITY STUDENTS: AN EXPLORATORY STUDY. *PSIHOLOGIJA, 53*(4), 319-340.
. DIGITAL NATIVE (2021). IN O. U. PRESS (ED.), OXFORD ADVANCED LEARNERS DICTIONARY: OXFORD UNIVERSITY. RETRIEVED FROM HTTPS://WWW.OXFORDLEARNERSDICTIONARIES.COM/DEFINITION/ENGLISH/DIGITAL-NATIVE?Q=DIGITAL+NATIVE.
DOCHY, F., & ALEXANDER, P. (1995). MAPPING PRIOR KNOWLEDGE: A FRAMEWORK FOR DISCUSSION AMONG RESEARCHERS. *EUROPEAN JOURNAL OF PSYCHOLOGY OF EDUCATION, 10*(3), 225-242.
DOLMANS, D. H., & (2019). HOW THEORY AND DESIGN-BASED RESEARCH CAN MATURE PBL PRACTICE AND

RESEARCH. *ADVANCES IN HEALTH SCIENCES EDUCATION, 24*(5), 879-891.
DOLMANS, D. H., DE GRAVE, W., WOLFHAGEN, I. H., & VAN DER VLEUTEN, C. P. (2005). PROBLEM-BASED LEARNING: FUTURE CHALLENGES FOR EDUCATIONAL PRACTICE AND RESEARCH. *MEDICAL EDUCATION, 39*(7), 732-741.
DOLMANS, D. H., GIJSELAERS, W. H., MOUST, J. H., DE GRAVE, W. S., WOLFHAGEN, I. H., & VAN DER VLEUTEN, C. P. (2002). TRENDS IN RESEARCH ON THE TUTOR IN PROBLEM-BASED LEARNING: CONCLUSIONS AND IMPLICATIONS FOR EDUCATIONAL PRACTICE AND RESEARCH. *MEDICAL TEACHER, 24*(2), 173-180.
DOLMANS, D. H., MICHAELSEN, L., VAN MERRIENBOER, J., & VAN DER VLEUTEN, C. (2015). SHOULD WE CHOOSE BETWEEN PROBLEM-BASED LEARNING AND TEAM-BASED LEARNING? NO, COMBINE THE BEST OF BOTH WORLDS! *MEDICAL TEACHER, 37*(4), 354-359.
DOLMANS, D. H., SNELLEN-BALENDONG, H., & VAN DER VLEUTEN, C. P. (1997). SEVEN PRINCIPLES OF EFFECTIVE CASE DESIGN FOR A PROBLEM-BASED CURRICULUM. *MEDICAL TEACHER, 19*(3), 185-189.
DONNELLY, R. (2010). HARMONIZING TECHNOLOGY WITH INTERACTION IN BLENDED PROBLEM-BASED LEARNING. *COMPUTERS AND EDUCATION, 54*, 350-359.
DOTOV, D. G., NIE, L., & DE WIT, M. M. (2012). UNDERSTANDING AFFORDANCES: HISTORY AND CONTEMPORARY DEVELOPMENT OF GIBSON'S CENTRAL CONCEPT. *AVANT: THE JOURNAL OF THE PHILOSOPHICAL-INTERDISCIPLINARY VANGUARD*.
DREW, V., & MACKIE, L. (2011). EXTENDING THE CONSTRUCTS OF ACTIVE LEARNING: IMPLICATIONS FOR TEACHERS' PEDAGOGY AND PRACTICE. *THE CURRICULUM JOURNAL, 22*(4), 451-467. DOI:HTTP://WWW.TANDFONLINE.COM/ACTION/SHOWCITFORMATS?DOI=10.1080/09585176.2011.627204
DUMAS, D., ALEXANDER, P. A., & GROSSNICKLE, E. M. (2013). RELATIONAL REASONING AND ITS MANIFESTATIONS IN THE EDUCATIONAL CONTEXT: A SYSTEMATIC REVIEW OF THE LITERATURE. *EDUCATIONAL PSYCHOLOGICAL REVIEW, 25*, 391-427.
DUNLOSKY, J., & RAWSON, K. A. (2012). OVERCONFIDENCE PRODUCES UNDERACHIEVEMENT: INACCURATE SELF EVALUATIONS UNDERMINE STUDENTS' LEARNING AND RETENTION. *LEARNING AND INSTRUCTION, 22*, 271-280.
DURAN-NELSON, A., GLADDING, S., BEATTIE, J., & NIXON, L. J. (2013). SHOULD WE GOOGLE IT? RESOURCE USE BY INTERNAL MEDICINE RESIDENTS FOR POINT-OF-CARE CLINICAL DECISION MAKING. *ACADEMIC MEDICINE, 88*(6), 788-794. DOI:10.1097/ACM.0B013E31828FFDB7
DURNING, S. J., & ARTINO, A. R. (2011). SITUATIVITY THEORY: A PERSPECTIVE ON HOW PARTICIPANTS AND THE ENVIRONMENT CAN INTERACT: AMEE GUIDE NO. 52. *MEDICAL TEACHER, 33*(3), 188-199.
DURNING, S. J., ARTINO JR, A. R., BECKMAN, T. J., GRANER, J., VAN DER VLEUTEN, C., HOLMBOE, E., & SCHUWIRTH, L. (2013). DOES THE THINK-ALOUD PROTOCOL REFLECT THINKING? EXPLORING FUNCTIONAL NEUROIMAGING DIFFERENCES WITH THINKING (ANSWERING MULTIPLE CHOICE QUESTIONS) VERSUS THINKING ALOUD. *MEDICAL TEACHER, 35*(9), 720-726.
DUX, P. E., IVANOFF, J., ASPLUND, C. L., & MAROIS, R. (2006). ISOLATION OF A CENTRAL BOTTLENECK OF INFORMATION PROCESSING WITH TIME-RESOLVED FMRI. *NEURON, 52*, 1109-1120. DOI:DOI 10.1016/J.NEURON.2006.11.009
DWECK, C. S., & LEGGETT, E. L. (1988). A SOCIAL-COGNITIVE APPROACH TO MOTIVATION AND PERSONALITY. *PSYCHOLOGICAL REVIEW, 95*(2), 256.
EKEOCHA, J., & BRENNAN, S. (2008). COLLABORATIVE RECALL IN FACE-TO-FACE AND ELECTRONIC GROUPS. *MEMORY, 16*(3), 245-261. DOI:10.1080/09658210701807480
ELEKES, K. (2000). PLEASE, KEEP TALKING": THE 'THINK-ALOUD'METHOD IN SECOND LANGUAGE READING RESEARCH. *NOVELTY VII, 3*. HTTP://DEAL.ELTE.HU/PAGES/NOVELTY/HTM2/VOL73/ELEKES.HTM.
ELLIOTT, E. S., & DWECK, C. S. (1988). GOALS: AN APPROACH TO MOTIVATION AND ACHIEVEMENT. *JOURNAL OF PERSONALITY SOCIAL PSYCHOLOGY, 54*(1), 5.
ELLIS, A. K., DENTON, D. W., & BOND, J. B. (2014). AN ANALYSIS OF RESEARCH ON METACOGNITIVE TEACHING STRATEGIES. *PROCEDIA - SOCIAL AND BEHAVIORAL SCIENCES, 116*, 4015-4024. DOI:10.1016/J.SBSPRO.2014.01.883
ENTWISTLE, N. J., & PETERSON, E. R. (2004). CONCEPTIONS OF LEARNING AND KNOWLEDGE IN HIGHER EDUCATION: RELATIONSHIPS WITH STUDY BEHAVIOUR AND INFLUENCES OF LEARNING ENVIRONMENTS. *INTERNATIONAL JOURNAL OF EDUCATIONAL RESEARCH, 41*(6), 407-428.
ERICSSON, K. A., & KINTSCH, W. (1995). LONG-TERM WORKING MEMORY. *PSYCHOLOGICAL REVIEW, 102*(2), 211.
ERICSSON, K. A., & SIMON, H. A. (1980). VERBAL REPORTS AS DATA. *PSYCHOLOGICAL REVIEW, 87*(3), 215.
ERICSSON, K. A., & SIMON, H. A. (1998). HOW TO STUDY THINKING IN EVERYDAY LIFE: CONTRASTING THINK-ALOUD PROTOCOLS WITH DESCRIPTIONS AND EXPLANATIONS OF THINKING. *MIND, CULTURE, AND ACTIVITY, 5*(3), 178-186.
ERTMER, P. A., & GLAZEWSKI, K. D. (2015). ESSENTIALS FOR PBL IMPLEMENTATION: FOSTERING COLLABORATION, TRANSFORMING ROLES, AND SCAFFOLDING LEARNING. IN H. L. ANDREW WALKER, CINDY HMELO-SILVER (ED.), *ESSENTIAL READINGS IN PROBLEM-BASED LEARNING* (VOL. 58, PP. 89-106). WEST LAFAYETTE, INDIANA: PURDUE UNIVERSITY PRESS.
ERTMER, P. A., & NEWBY, T. J. (1993). BEHAVIORISM, COGNITIVISM, CONSTRUCTIVISM: COMPARING CRITICAL FEATURES FROM AN INSTRUCTIONAL DESIGN PERSPECTIVE. *PERFORMANCE IMPROVEMENT QUARTERLY, 6*(4), 50-72.
ERTMER, P. A., & NEWBY, T. J. (1996). THE EXPERT LEARNER: STRATEGIC, SELF-REGULATED, AND REFLECTIVE. *INSTRUCTIONAL SCIENCE, 24*, 1-24.
EVA, K., NEVILLE, A., & NORMAN, G. (1998). EXPLORING THE ETIOLOGY OF CONTENT SPECIFICITY: FACTORS INFLUENCING ANALOGIC TRANSFER AND PROBLEM SOLVING. *ACADEMIC MEDICINE, 73*(10 SUPPL), S1-5. DOI:10.1097/00001888-199810000-00028
EVANO, C. (2013). TECHNOLOGICAL OR MEDIA DETERMINISM.
EVANS, M. P. (2007). ANALYSING GOOGLE RANKINGS THROUGH SEARCH ENGINE OPTIMIZATION DATA. *INTERNET*

RESEARCH, 17(1), 21-37.
FERGUSON, A. M., MCLEAN, D., & RISKO, E. F. (2015). ANSWERS AT YOUR FINGERTIPS: ACCESS TO THE INTERNET INFLUENCES WILLINGNESS TO ANSWER QUESTIONS. *CONSCIOUSNESS AND COGNITION, 37*, 91-102.
FERNANDEZ-DUQUE, D., BAIRD, J. A., & POSNER, M. I. (2000). EXECUTIVE ATTENTION AND METACOGNITIVE REGULATION. *CONSCIOUSNESS AND COGNITION, 9*(2), 288-307.
FINUCANE, P., NICHOLAS, T., & PRIDEAUX, D. (2001). THE NEW MEDICAL CURRICULUM AT FLINDERS UNIVERSITY, SOUTH AUSTRALIA: FROM CONCEPT TO REALITY. *MEDICAL TEACHER, 23*(1), 76-79.
FIRTH, J., TOROUS, J., STUBBS, B., FIRTH, J. A., STEINER, G. Z., SMITH, L., . . . ARMITAGE, C. (2019). THE "ONLINE BRAIN": HOW THE INTERNET MAY BE CHANGING OUR COGNITION. *WORLD PSYCHIATRY, 18*(2), 119-129.
FISHER, M., GODDU, M. K., & KEIL, F. C. (2015). SEARCHING FOR EXPLANATIONS: HOW THE INTERNET INFLATES ESTIMATES OF INTERNAL KNOWLEDGE. *JOURNAL OF EXPERIMENTAL PSYCHOLOGY: GENERAL, 144*(3), 674.
FLAVELL, J. H. (1979). METACOGNITION AND COGNITIVE MONITORING A NEW AREA OF COGNITIVE—DEVELOPMENTAL INQUIRY. *AMERICAN PSYCHOLOGIST, 34*(10), 906-911.
FONTEIJN, H. T., & DOLMANS, D. H. (2019). GROUP WORK AND GROUP DYNAMICS IN PBL. IN M. MOALLEM, W. HUNG, & N. DABBAGH (EDS.), *THE WILEY HANDBOOK OF PROBLEM-BASED LEARNING* (PP. 199-220). INDIA: JOHN WILEY AND SONS INC.
FRIEDMAN, L. W., & FRIEDMAN, H. H. (2008). HIGH IMPACT AREAS OF THE NEW MEDIA TECHNOIOGIES: A REVIEW. *MANAGEMENT ONLINE REVIEW, JULY*.
FRIEDMAN, L. W., & FRIEDMAN, H. H. (2013). USING SOCIAL MEDIA TECHNOLOGIES TO ENHANCE ONLINE LEARNING. *JOURNAL OF EDUCATORS ONLINE, 10*(1), N1.
GAVER, W. W. (1991). *TECHNOLOGY AFFORDANCES.* PAPER PRESENTED AT THE PROCEEDINGS OF THE SIGCHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS.
GEORGE, P., DUMENCO, L., DOLLASE, R., SCOTT TAYLOR, J., WALD, H. S., & REIS, S. P. (2013). INTRODUCING TECHNOLOGY INTO MEDICAL EDUCATION: TWO PILOT STUDIES. *PATIENT EDUCATION AND COUNSELLING, 93*, 522-524.
GHOSH, V. E., & GILBOA, A. (2014). WHAT IS A MEMORY SCHEMA? A HISTORICAL PERSPECTIVE ON CURRENT NEUROSCIENCE LITERATURE. *NEUROPSYCHOLOGIA, 53*, 104-114.
GIBSON, J. (1977). *THE THEORY OF AFFORDANCES.* (R. E. SHAW & J. BRANSFORD EDS.): LAWRENCE ERLBAUM ASSOCIATES.
GIBSON, J. (1986). THE THEORY OF AFFORDANCES IN *THE ECOLOGICAL APPROACH TO VISUAL PERCEPTION* (PP. 127-143): BOSTON: HOUGHTON MIFFIN.
GIJLERS, H., & DE JONG, T. (2005). THE RELATION BETWEEN PRIOR KNOWLEDGE AND STUDENTS' COLLABORATIVE DISCOVERY LEARNING PROCESSES. *JOURNAL OF RESEARCH IN SCIENCE TEACHING, 42*(3), 264-282.
GIJLERS, H., & DE JONG, T. (2009). SHARING AND CONFRONTING PROPOSITIONS IN COLLABORATIVE INQUIRY LEARNING. *COGNITION INSTRUCTIONAL SCIENCE, 27*(3), 239-268.
GORBANEV, I., AGUDELO-LONDOÑO, S., GONZÁLEZ, R. A., CORTES, A., POMARES, A., DELGADILLO, V., . . . MUÑOZ, Ó. (2018). A SYSTEMATIC REVIEW OF SERIOUS GAMES IN MEDICAL EDUCATION: QUALITY OF EVIDENCE AND PEDAGOGICAL STRATEGY. *MEDICAL EDUCATION ONLINE, 23*(1), 1438718.
GRABINGER, R. S., & DUNLAP, J. C. (1995). RICH ENVIRONMENTS FOR ACTIVE LEARNING: A DEFINITION. *ASSOCIATION FOR LEARNING TECHNOLOGY JOURNAL, 3*(2), 5-34.
GRAESSER, A. C., & PERSON, N. K. (1994). QUESTION ASKING DURING TUTORING. *AMERICAN EDUCATIONAL RESEARCH JOURNAL, 31*(1), 104-137.
GRAY, K., ANNABELL, L., & KENNEDY, G. (2010). MEDICAL STUDENTS' USE OF FACEBOOK TO SUPPORT LEARNING: INSIGHTS FROM FOUR CASE STUDIES. *MEDICAL TEACHER, 32*(12), 971-976. DOI:10.3109/0142159X.2010.497826
GRAY, K., CHANG, S., & KENNEDY, G. (2010). USE OF SOCIAL WEB TECHNOLOGIES BY INTERNATIONAL AND DOMESTIC UNDERGRADUATE STUDENTS: IMPLICATIONS FOR INTERNATIONALISING LEARNING AND TEACHING IN AUSTRALIAN UNIVERSITIES. *TECHNOLOGY, PEDAGOGY AND EDUCATION, 19*(1), 31-46.
GREENHALGH, T., THORNE, S., & MALTERUD, K. (2018). TIME TO CHALLENGE THE SPURIOUS HIERARCHY OF SYSTEMATIC OVER NARRATIVE REVIEWS? *EUROPEAN JOURNAL OF CLINICAL INVESTIGATION, 48*(6).
GREENO, J. (1994). GIBSON'S AFFORDANCES. *PSYCHOLOGICAL REVIEW, 101*(2), 336-342. DOI:10.1037/0033-295X.101.2.336
GUAN, Z., LEE, S., CUDDIHY, E., & RAMEY, J. (2006). *THE VALIDITY OF THE STIMULATED RETROSPECTIVE THINK-ALOUD METHOD AS MEASURED BY EYE TRACKING.* PAPER PRESENTED AT THE PROCEEDINGS OF THE SIGCHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS.
HAMMOND, M. (2010). WHAT IS AN AFFORDANCE AND CAN IT HELP US UNDERSTAND THE USE OF ICT IN EDUCATION? *EDUCATION AND INFORMATION TECHNOLOGIES, 15*(3), 205-217.
HAORAN, G., BAZAKIDI, E., & ZARY, N. (2019). SERIOUS GAMES IN HEALTH PROFESSIONS EDUCATION: REVIEW OF TRENDS AND LEARNING EFFICACY. *YEARBOOK OF MEDICAL INFORMATICS, 28*(1), 240.
HARRISON, B. (2002). PHOTOGRAPHIC VISIONS AND NARRATIVE INQUIRY. *NARRATIVE INQUIRY, 12*(1), 87-111.
HELSPER, E. J., & EYNON, R. (2010). DIGITAL NATIVES: WHERE IS THE EVIDENCE? *BRITISH EDUCATIONAL RESEARCH JOURNAL, 36*(3), 503-520.
HENDRY, G. D., RYAN, G., & HARRIS, J. (2003). GROUP PROBLEMS IN PROBLEM-BASED LEARNING. *MEDICAL TEACHER, 25*(6), 609-616.
HENKEL, L. A. (2014). POINT-AND-SHOOT MEMORIES: THE INFLUENCE OF TAKING PHOTOS ON MEMORY FOR A MUSEUM TOUR. *PSYCHOLOGICAL SCIENCE, 25*(2), 396-402. DOI:10.1177/0956797613504438
HMELO-SILVER, C. E. (2004). PROBLEM-BASED LEARNING: WHAT AND HOW DO STUDENTS LEARN? *EDUCATIONAL PSYCHOLOGICAL REVIEWS, 16*(3).
HMELO-SILVER, C. E., & BARROWS, H. S. (2006). GOALS AND STRATEGIES OF A PROBLEM-BASED LEARNING

FACILITATOR. *INTERDISCIPLINARY JOURNAL OF PROBLEM-BASED LEARNING, 1*(1).
HMELO-SILVER, C. E., CHERNOBILSKY, E., & JORDAN, R. (2008). UNDERSTANDING COLLABORATIVE LEARNING PROCESSES IN NEW LEARNING ENVIRONMENTS. *INSTRUCTIONAL SCIENCE, 36*, 409-430.
HMELO-SILVER, C. E., DUNCAN, R. G., & CHINN, C. A. (2007). SCAFFOLDING AND ACHIEVEMENT IN PROBLEM-BASED AND INQUIRY LEARNING: A RESPONSE TO KIRSCHNER, SWELLER AND CLARK (2006). *EDUCATIONAL PSYCHOLOGIST, 42*(2), 99-107.
HMELO-SILVER, C. E., KAPUR, M., & HAMSTRA, M. (2018). LEARNING THROUGH PROBLEM SOLVING. IN F. FISCHER, HMELO-SILVER,CINDY E., GOLDMAN, SUSAN R., AND REIMANN, PETER (ED.), *INTERNATIONAL HANDBOOK OF THE LEARNING SCIENCES* (PP. 210-220). NEW YORK & LONDON: ROUTLEDGE TAYLOR & FRANCIS GROUP.
HOLEN, A., MANANDHAR, K., PANT, D., KARMACHARYA, B., OLSON, L., KOJU, R., & MANSUR, D. (2015). MEDICAL STUDENTS' PREFERENCES FOR PROBLEM-BASED LEARNING IN RELATION TO CULTURE AND PERSONALITY: A MULTICULTURAL STUDY. *INT J MED EDUC, 6*, 84-92. DOI:10.5116/IJME.558E.6451
HOMMES, J., VAN DEN BOSSCHE, P., DE GRAVE, W., BOS, G., SCHUWIRTH, L., & SCHERPBIER, A. (2014). UNDERSTANDING THE EFFECTS OF TIME ON COLLABORATIVE LEARNING PROCESSES IN PROBLEM BASED LEARNING: A MIXED METHODS STUDY. *ADVANCES IN HEALTH SCIENCES EDUCATION, 19*(4), 541-563.
HONICKE, T., & BROADBENT, J. (2016). THE INFLUENCE OF ACADEMIC SELF-EFFICACY ON ACADEMIC PERFORMANCE: A SYSTEMATIC REVIEW. *EDUCATIONAL RESEARCH REVIEW, 17*, 63-84.
HONICKE, T., BROADBENT, J., & FULLER-TYSZKIEWICZ, M. (2020). LEARNER SELF-EFFICACY, GOAL ORIENTATION, AND ACADEMIC ACHIEVEMENT: EXPLORING MEDIATING AND MODERATING RELATIONSHIPS. *HIGHER EDUCATION RESEARCH AND DEVELOPMENTAL REVIEW, 39*(4), 689-703.
HOOD, M. (2013). BRICKS OR CLICKS? PREDICTING STUDENT INTENTIONS IN A BLENDED LEARNING BUFFET. *AUSTRALASIAN JOURNAL OF EDUCATIONAL TECHNOLOGY., 29*(6), 762-776.
HOWE, N., & STRAUSS, W. (2000). *MILLENNIALS RISING: THE NEXT GREAT GENERATION*: VINTAGE.
HUDSON, L. A., & OZANNE, J. L. (1988). ALTERNATIVE WAYS OF SEEKING KNOWLEDGE IN CONSUMER RESEARCH. *JOURNAL OF CONSUMER RESEARCH, 14*(4), 508-521.
HUNG, W., DOLMANS, D. H., & VAN MERRIËNBOER, J. J. (2019). A REVIEW TO IDENTIFY KEY PERSPECTIVES IN PBL META-ANALYSES AND REVIEWS: TRENDS, GAPS AND FUTURE RESEARCH DIRECTIONS. *ADVANCES IN HEALTH SCIENCES EDUCATION*, 1-15.
JASPERS, M. W., STEEN, T., VAN DEN BOS, C., & GEENEN, M. (2004). THE THINK ALOUD METHOD: A GUIDE TO USER INTERFACE DESIGN. *INTERNATIONAL JOURNAL OF MEDICAL INFORMATICS, 73*(11), 781-795.
JOHNSON, D. W., & JOHNSON, R. T. (2002). SOCIAL INTERDEPENDENCE THEORY AND UNIVERSITY INSTRUCTION: THEORY INTO PRACTICE. *SWISS JOURNAL OF PSYCHOLOGY, 61*(3), 119.
JOHNSON, D. W., JOHNSON, R. T., & SMITH, K. (2007). THE STATE OF COOPERATIVE LEARNING IN POSTSECONDARY AND PROFESSIONAL SETTINGS. *EDUCATIONAL PSYCHOLOGICAL REVIEWS, 19*, 15-29.
JUDD, T. (2013). MAKING SENSE OF MULTITASKING: KEY BEHAVIOURS. *COMPUTERS & EDUCATION, 63*, 358-367.
JUDD, T. (2015). TASK SELECTION, TASK SWITCHING AND MULTITASKING DURING COMPUTER-BASED INDEPENDENT STUDY. *AUSTRALASIAN JOURNAL OF EDUCATIONAL TECHNOLOGY*.
JUDD, T. (2018). THE RISE AND FALL (?) OF THE DIGITAL NATIVES. *AUSTRALASIAN JOURNAL OF EDUCATIONAL TECHNOLOGY, 34*(5).
JUDD, T., & KENNEDY, G. (2011). EXPEDIENCY-BASED PRACTICE? MEDICAL STUDENTS' RELIANCE ON GOOGLE AND WIKIPEDIA FOR BIOMEDICAL INQUIRIES. *BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY, 42*(2), 351-360.
KALYUGA, S., CHANDLER, P., TUOVINEN, J., & SWELLER, J. (2001). WHEN PROBLEM SOLVING IS SUPERIOR TO STUDYING WORKED EXAMPLES. *JOURNAL OF EDUCATIONAL PSYCHOLOGY, 93*(3), 579.
KEMP, S. (2021). DIGITAL 2021 APRIL GLOBAL STATSHOT REPORT. *DATAREPORTAL.* RETRIEVED FROM HTTPS://DATAREPORTAL.COM/REPORTS/DIGITAL-2021-APRIL-GLOBAL-STATSHOT
KENNEDY, G., GRAY, K., & TSE, J. (2008). 'NET GENERATION' MEDICAL STUDENTS: TECHNOLOGICAL EXPERIENCES OF PRE-CLINICAL AND CLINICAL STUDENTS. *MEDICAL TEACHER, 30*, 10-16.
KIRSCHNER, P., SWELLER, J., & CLARK, R. E. (2006). WHY UNGUIDED LEARNING DOES NOT WORK: AN ANALYSIS OF THE FAILURE OF DISCOVERY LEARNING, PROBLEM-BASED LEARNING, EXPERIENTIAL LEARNING AND INQUIRY-BASED LEARNING. *EDUCATIONAL PSYCHOLOGIST, 41*(2), 75-86.
KIRSCHNER, P. A. (2002). COGNITIVE LOAD THEORY: IMPLICATIONS OF COGNITIVE LOAD THEORY ON THE DESIGN OF LEARNING. *LEARNING AND INSTRUCTION, 12*, 1-10.
KIRSCHNER, P. A., & DE BRUYCKERE, P. (2017). THE MYTHS OF THE DIGITAL NATIVE AND THE MULTITASKER. *TEACHING TEACHER EDUCATION, 67*, 135-142.
KIRSCHNER, P. A., & KARPINSKI, A. C. (2010). FACEBOOK AND ACADEMIC PERFORMANCE. *COMPUTERS IN HUMAN BEHAVIOR, 26*, 1237-1245.
KITCHENHAM, A. (2008). THE EVOLUTION OF JOHN MEZIROW'S TRANSFORMATIVE THEORY. *JOURNAL OF TRANSFORMATIVE EDUCATION, 6*, 104- 122. DOI:HTTP://JTD.SAGEPUB.COM/CONTENT/6/2/104
KOFFKA, K. (1922). PERCEPTION: AN INTRODUCTION TO THE GESTALT-THEORIE. *PSYCHOLOGICAL BULLETIN, 19*(10), 531.
KOLB, D. A., BOYATZIS, R. E., & MAINEMELIS, C. (2001). EXPERIENTIAL LEARNING THEORY: PREVIOUS RESEARCH AND NEW DIRECTIONS. *PERSPECTIVES ON THINKING, LEARNING, COGNITIVE STYLES, 1*(8), 227-247.
KRATHWOHL, D. R. (2002). A REVISION OF BLOOM'S TAXONOMY: AN OVERVIEW. *THEORY INTO PRACTICE, 41*(4), 212-218.
DOI:HTTP://WWW.TANDFONLINE.COM/ACTION/SHOWCITFORMATS?DOI=10.1207/S15430421TIP4104_2
KRAWCZK, D. C. (2012). THE COGNITION AND NEUROSCIENCE OF RELATIONAL REASONING. *BRAIN RESEARCH, 1428*, 13-23.

KROSNICK, J. A., & PRESSER, S. (2010). QUESTION AND QUESTIONNAIRE DESIGN. IN P. V. MARSDEN & J. D. WRIGHT (EDS.), *HANDBOOK OF SURVEY RESEARCH* (SECOND EDITION ED., PP. 263-313). HOWARD HOUSE, WAGON LANE, BINGLEY, UK: EMERALD GROUP PUBLISHING.
KUSURKAR, R., TEN CATE, O., VOS, C., WESTERS, P., & CROISET, G. (2013). HOW MOTIVATION AFFECTS ACADEMIC PERFORMANCE: A STRUCTURAL EQUATION MODELLING ANALYSIS. *ADVANCES IN HEALTH SCIENCE EDUCATION, 18*, 57-69.
LICKLIDER, J. (1960). MAN-COMPUTER SYMBIOSIS. *IRE TRANSACTIONS ON HUMAN FACTORS IN ELECTRONICS,, 1*(MARCH), 4-11.
LIETZ, P. (2010). RESEARCH INTO QUESTIONNAIRE DESIGN: A SUMMARY OF THE LITERATURE. *INTERNATIONAL JOURNAL OF MARKET RESEARCH, 52*(2), 249-272.
LINCOLN, Y. S., & GUBA, E. G. (1985). *NATURALISTIC INQUIRY* (VOL. 75): SAGE.
LOH, K. K., & KANAI, R. (2015). HOW HAS THE INTERNET RESHAPED HUMAN COGNITION? *THE NEUROSCIENTIST*, 1073858415595005.
LÓPEZ-MENESES, E., SIRIGNANO, F. M., VÁZQUEZ-CANO, E., & RAMÍREZ-HURTADO, J. M. (2020). UNIVERSITY STUDENTS' DIGITAL COMPETENCE IN THREE AREAS OF THE DIGCOM 2.1 MODEL: A COMPARATIVE STUDY AT THREE EUROPEAN UNIVERSITIES. *AUSTRALASIAN JOURNAL OF EDUCATIONAL TECHNOLOGY*, 69-88.
LOYENS, S. M., MAGDA, J., & RIKERS, R. M. (2008). SELF-DIRECTED LEARNING IN PROBLEM-BASED LEARNING AND ITS RELATIONSHIPS WITH SELF-REGULATED LEARNING. *EDUCATIONAL PSYCHOLOGY REVIEW, 20*(4), 411-427. DOI:10.1007/S10648-008-9082-7
LOYENS, S. M., RIKERS, R. M., & SCHMIDT, H. G. (2008). RELATIONSHIPS BETWEEN STUDENTS' CONCEPTIONS OF CONSTRUCTIVIST LEARNING AND THEIR REGULATION AND PROCESSING STRATEGIES. *INSTRUCTIONAL SCIENCE, 36*.
MADGE, C., MEEK, J., WELLENS, J., & HOOLEY, T. (2009). FACEBOOK, SOCIAL INTEGRATION AND INFORMAL LEARNING AT UNIVERSITY: 'IT IS MORE FOR SOCIALISING AND TALKING TO FRIENDS ABOUT WORK THAN FOR ACTUALLY DOING WORK'. *LEARNING, MEDIA AND TECHNOLOGY, 32*(2), 141-155. DOI:10.1080/17439880902923606
MANASIJEVIĆ, D., ŽIVKOVIĆ, D., ARSIĆ, S., & MILOŠEVIĆ, I. (2016). EXPLORING STUDENTS' PURPOSES OF USAGE AND EDUCATIONAL USAGE OF FACEBOOK. *COMPUTERS IN HUMAN BEHAVIOR, 60*, 441-450.
MANCA, S. (2020). SNAPPING, PINNING, LIKING OR TEXTING: INVESTIGATING SOCIAL MEDIA IN HIGHER EDUCATION BEYOND FACEBOOK. *THE INTERNET HIGHER EDUCATION, 44*, 100707.
MANCA, S., & RANIERI, M. (2013). IS IT A TOOL SUITABLE FOR LEARNING? A CRITICAL REVIEW OF THE LITERATURE ON FACEBOOK AS A TECHNOLOGY-ENHANCED LEARNING ENVIRONMENT. *JOURNAL OF COMPUTER ASSISTED LEARNING, 29*(6), 487-504.
MANGEN, A., & VELAY, J.-L. (2010). DIGITIZING LITERACY: REFLECTIONS ON THE HAPTICS OF WRITING. *ADVANCES IN HAPTICS*, 385-401.
MANGEN, A., WALGERMO, B. R., & BRØNNICK, K. (2013). READING LINEAR TEXTS ON PAPER VERSUS COMPUTER SCREEN: EFFECTS ON READING COMPREHENSION. *INTERNATIONAL JOURNAL OF EDUCATIONAL RESEARCH, 58*, 61-68.
MARTIN, S. (2003). IMPACT OF A GRADUATE ENTRY PROGRAMME ON A MEDICAL SCHOOL LIBRARY SERVICE. *HEALTH INFORMATION AND LIBRARIES JOURNAL, 20*, 42-49.
MARTÍNEZ RIVERA, Ó., & DUȚĂ, N. (2015). BETWEEN THEORY AND PRACTICE: THE IMPORTANCE OF ICT IN HIGHER EDUCATION AS A TOOL FOR COLLABORATIVE LEARNING. *PROCEDIA-SOCIAL BEHAVIORAL SCIENCES,, 180*.
MARTON, F., & SÄLJÖ, R. (1976). ON QUALITATIVE DIFFERENCES IN LEARNING: I—OUTCOME AND PROCESS. *BRITISH JOURNAL OF EDUCATIONAL PSYCHOLOGY, 46*(1), 4-11.
MAUDSLEY, G. (1999). DO WE ALL MEAN THE SAME THING BY" PROBLEM-BASED LEARNING"? A REVIEW OF THE CONCEPTS AND A FORMULATION OF THE GROUND RULES. *ACADEMIC MEDICINE, 74*(2), 178-185.
MAUDSLEY, G. (2003). THE LIMITS OF TUTORS' COMFORT ZONES WITH FOUR INTEGRATED KNOWLEDGE THEMES IN A PROBLEM-BASED UNDERGRADUATE MEDICAL CURRICULUM (INTERVIEW STUDY). *MEDICAL EDUCATION, 37*(5), 417-423.
MAYER, R. E. (1992). COGNITION AND INSTRUCTION: THEIR HISTORIC MEETING WITHIN EDUCATIONAL PSYCHOLOGY. *JOURNAL OF EDUCATIONAL PSYCHOLOGY, 84*(4), 405.
MAYER, R. E. (1996). LEARNERS AS INFORMATION PROCESSORS: LEGACIES AND LIMITATIONS OF EDUCATIONAL PSYCHOLOGY'S SECOND. *EDUCATIONAL PSYCHOLOGIST, 31*(3-4), 151-161.
MAYER, R. E. (2008). APPLYING THE SCIENCE OF LEARNING: EVIDENCE-BASED PRINCIPLES FOR THE DESIGN OF MULTIMEDIA INSTRUCTION. *AMERICAN PSYCHOLOGIST, NOVEMBER*, 760-769.
MAYER, R. E. (2010). ROTE VERSUS MEANINGFUL LEARNING. *THEORY INTO PRACTICE, 41*(4), 226-232. DOI:HTTP://DX.DOI.ORG/10.1207/S15430421TIP4104_4
MAYER, R. E. (2012). APPLYING THE SCIENCE OF LEARNING TO MEDICAL EDUCATION. *MEDICAL EDUCATION, 44*, 543-549.
MAYER, R. E. (2014). *THE CAMBRIDGE HANDBOOK OF MULTIMEDIA LEARNING* (R. E. MAYER ED. 2 ED.): CAMBRIDGE UNIVERSITY PRESS.
MAYER, R. E. (2019). THIRTY YEARS OF RESEARCH ON ONLINE LEARNING. *APPLIED COGNITIVE PSYCHOLOGY, 33*(2), 152-159.
MAYER, R. E., & MORENO, R. (2002). ANIMATION AS AN AID TO MULTIMEDIA LEARNING. *EDUCATIONAL PSYCHOLOGICAL REVIEW, 14*(1), 87-99.
MAYER, R. E., & MORENO, R. (2003). NINE WAYS TO REDUCE COGNITIVE LOAD IN MULTIMEDIA LEARNING. *EDUCATIONAL PSYCHOLOGIST, 38*(1), 43-52.
MAYER, R. E., MORENO, R., BOIRE, M., & VAGGE, S. (1999). MAXIMIZING CONSTRUCTIVIST LEARNING FROM MULTIMEDIA COMMUNICATIONS BY MINIMIZING COGNITIVE LOAD. *JOURNAL OF EDUCATIONAL PSYCHOLOGY, 91*(4), 638-643.

MCKEE, M., VAN SCHALKWYK, M. C., & STUCKLER, D. (2019). THE SECOND INFORMATION REVOLUTION: DIGITALIZATION BRINGS OPPORTUNITIES AND CONCERNS FOR PUBLIC HEALTH. *EUROPEAN JOURNAL OF PUBLIC HEALTH, 29*(SUPPLEMENT_3), 3-6.
MERRIAM, S. B. (1998). *QUALITATIVE RESEARCH AND CASE STUDY APPLICATIONS IN EDUCATION. REVISED AND EXPANDED FROM*: ERIC.
MEZIROW, J. (1997). TRANSFORMATIVE LEARNING: THEORY TO PRACTICE. *NEW DIRECTIONS FOR ADULT CONTINUING EDUCATION, 1997*(74), 5-12.
MEZIROW, J. (1999). *TRANSFORMATION THEORY - POSTMODERN ISSUES.* PAPER PRESENTED AT THE ANNUAL ADULT EDUCATION RESEARCH CONFERENCE PROCEEDINGS, NORTHERN ILLINOIS UNIV., DE KALB.
MICHAELSEN, L. K., & SWEET, M. (2008). THE ESSENTIAL ELEMENTS OF TEAM-BASED LEARNING. *NEW DIRECTIONS FOR TEACHING LEARNING AND INSTRUCTION, 2008*(116), 7-27.
MIIKKULAINEN, R., LIANG, J., MEYERSON, E., RAWAL, A., FINK, D., FRANCON, O., . . . DUFFY, N. (2019). EVOLVING DEEP NEURAL NETWORKS. IN *ARTIFICIAL INTELLIGENCE IN THE AGE OF NEURAL NETWORKS AND BRAIN COMPUTING* (PP. 293-312): ELSEVIER.
MILLER, G. A. (1956). THE MAGICAL NUMBER SEVEN, PLUS OR MINUS TWO: SOME LIMITS ON OUR CAPACITY FOR PROCESSING INFORMATION. *PSYCHOLOGICAL REVIEW, 63*(2), 81.
MILLER, G. A. (2003). THE COGNITIVE REVOLUTION: A HISTORICAL PERSPECTIVE. *TRENDS IN COGNITIVE SCIENCES, 7*(3), 141-144.
MORENO, R., & MAYER, R. E. (1999). COGNITIVE PRINCIPLES OF MULTIMEDIA LEARNING: THE ROLE OF MODALITY AND CONTIGUITY. *JOURNAL OF EDUCATIONAL PSYCHOLOGY, 91*(2), 358.
MURDOCH-EATON, D., & WHITTLE, S. (2012). GENERIC SKILLS IN MEDICAL EDUCATION: DEVELOPING THE TOOLS FOR SUCCESSFUL LIFELONG LEARNING. *MEDICAL EDUCATION, 46*(1), 120-128.
NEUFELD, V. R., & BARROWS, H. S. (1974). THE 'MCMASTER PHILOSOPHY': AN APPROACH TO MEDICAL EDUCATION. *JOURNAL OF MEDICAL EDUCATION, 49*, 1040-1050.
NEUFELD, V. R., & SPAULDING, W. (1973). USE OF LEARNING RESOURCES AT MCMASTER UNIVERSITY. *BRITISH MEDICAL JOURNAL, 3*, 101-103.
NORMAN, D. A. (1988). *THE DESIGN OF EVERYDAY THINGS*. NEW YORK: BASIC BOOKS.
NORMAN, G. R., & SCHMIDT, H. G. (1992). THE PSYCHOLOGICAL BASIS OF PROBLEM-BASED LEARNING: A REVIEW OF THE EVIDENCE. *ACADEMIC MEDICINE, 67*(9), 557-565.
NORMAN, G. R., & SCHMIDT, H. G. (2000). EFFECTIVENESS OF PROBLEM-BASED LEARNING CURRICULA: THEORY, PRACTICE AND PAPER DARTS. *MEDICAL EDUCATION, 34*, 721-728.
OATES, R. K., & GOULSTON, K. J. (2011). THE HIDDEN COST OF MEDICAL STUDENT EDUCATION: AN EXPLORATORY STUDY. *AUSTRALIAN HEALTH REVIEW, 37*, 185-188. DOI:HTTP://DX.DOI.ORG/10.1071/AH12151
OBLINGER, D. G., & OBLINGER, J. L. (2005). *EDUCATING THE NET GENERATION* (D. G. OBLINGER & J. L. OBLINGER EDS.): EDUCAUSE.
OLIVER, M. (2011). TECHNOLOGICAL DETERMINISM IN EDUCATIONAL TECHNOLOGY RESEARCH: SOME ALTERNATIVE WAYS OF THINKING ABOUT THE RELATIONSHIP BETWEEN LEARNING AND TECHNOLOGY. *JOURNAL OF COMPUTER ASSISTED LEARNING, 27*, 373-384. DOI:DOI: 10.1111/J.1365-2729.2011.00406.X
OVIEDO-TRESPALACIOS, O., HAQUE, M. M., KING, M., & WASHINGTON, S. (2016). UNDERSTANDING THE IMPACTS OF MOBILE PHONE DISTRACTION ON DRIVING PERFORMANCE: A SYSTEMATIC REVIEW. *TRANSPORTATION RESEARCH PART C: EMERGING TECHNOLOGIES, 72*, 360-380.
PAAS, F. G., TUOVINEN, J. E., TABBERS, H., & VAN GERVEN, P. W. (2003). COGNITIVE LOAD MEASUREMENT AS A MEANS TO ADVANCE COGNITIVE LOAD THEORY. *EDUCATIONAL PSYCHOLOGIST, 38*(1), 63-71.
PAAS, F. G., & VAN MERRIËNBOER, J. J. (1994). INSTRUCTIONAL CONTROL OF COGNITIVE LOAD IN THE TRAINING OF COMPLEX COGNITIVE TASKS. *EDUCATIONAL PSYCHOLOGY REVIEW, 6*(4), 351-371.
PAPERT, S. (1980). *MINDSTORMS CHILDREN, COMPUTERS AND POWERFUL IDEAS.* NEW YORK: BASIC BOOKS INC.
PAPINCZAK, T. (2009). ARE DEEP STRATEGIC LEARNERS BETTER SUITED TO PBL? A PRELIMINARY STUDY. *ADVANCES IN HEALTH SCIENCE EDUCATION, 14*(3), 337-353. DOI:10.1007/S10459-008-9115-5
PAPINCZAK, T., TUNNY, T., & YOUNG, L. (2009). CONDUCTING THE SYMPHONY: A QUALITATIVE STUDY OF FACILITATION IN PROBLEM-BASED LEARNING TUTORIALS. *MEDICAL EDUCATION, 43*, 377-383. DOI:DOI:10.1111/J.1365-2923.2009.03293.X
PAPINCZAK, T., YOUNG, L., GROVES, M., & HAYNES, M. (2008). EFFECTS OF A METACOGNITIVE INTERVENTION ON STUDENTS' APPROACHES TO LEARNING AND SELF-EFFICACY IN A FIRST YEAR MEDICAL COURSE. *ADVANCES IN HEALTH SCIENCES EDUCATION, 13*(2), 213-232.
PARADIS, E., & SUTKIN, G. (2017). BEYOND A GOOD STORY: FROM HAWTHORNE EFFECT TO REACTIVITY IN HEALTH PROFESSIONS EDUCATION RESEARCH. *MEDICAL EDUCATION, 51*(1), 31-39.
PASKINS, Z., MCHUGH, G., & HASSELL, A. B. (2014). GETTING UNDER THE SKIN OF THE PRIMARY CARE CONSULTATION USING VIDEO STIMULATED RECALL: A SYSTEMATIC REVIEW. *BMC MEDICAL RESEARCH METHODOLOGY, 14*(1), 1.
PASSEY, D., SHONFELD, M., APPLEBY, L., JUDGE, M., SAITO, T., & SMITS, A. (2018). DIGITAL AGENCY: EMPOWERING EQUITY IN AND THROUGH EDUCATION. *TECHNOLOGY, KNOWLEDGE, LEARNING AND INSTRUCTION, 23*(3), 425-439.
PATEL, K. K., & PATEL, S. M. (2016). INTERNET OF THINGS-IOT: DEFINITION, CHARACTERISTICS, ARCHITECTURE, ENABLING TECHNOLOGIES, APPLICATION & FUTURE CHALLENGES. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCE COMPUTING, 6*(5).
PATTANAPHANCHAI, J., O'HARA, K., & HALL, W. (2013). *TRUSTWORTHINESS CRITERIA FOR SUPPORTING USERS TO ASSESS THE CREDIBILITY OF WEB INFORMATION.* PAPER PRESENTED AT THE PROCEEDINGS OF THE 22ND INTERNATIONAL CONFERENCE ON WORLD WIDE WEB COMPANION.
PEUTE, L. W., DE KEIZER, N. F., & JASPERS, M. W. (2015). THE VALUE OF RETROSPECTIVE AND CONCURRENT THINK ALOUD IN FORMATIVE USABILITY TESTING OF A PHYSICIAN DATA QUERY TOOL. *JOURNAL OF BIOMEDICAL INFORMATICS, 55*, 1-10.

PHYE, G. D. (2004). LEARNING. IN C. SPIELBERGER (ED.), *ENCYCLOPEDIA OF APPLIED PSYCHOLOGY* (VOL. 2, PP. 519-526): ACADEMIC PRESS.
PIAGET, J. (1976). PIAGET'S THEORY. IN *PIAGET AND HIS SCHOOL* (PP. 11-23): SPRINGER.
PILLING-CORMICK, J., & GARRISON, D. R. (2007). SELF-DIRECTED AND SELF-REGULATED LEARNING: CONCEPTUAL LINKS. *CANADIAN JOURNAL OF UNIVERSITY CONTINUING EDUCATION, 33*(2).
PINTRICH, P. R. (2002). THE ROLE OF METACOGNITIVE KNOWLEDGE IN LEARNING, TEACHING, AND ASSESSING. *THEORY INTO PRACTICE, 41*(4), 219-225.
PINTRICH, P. R., & DE GROOT, E. V. (1990). MOTIVATIONAL AND SELF-REGULATED LEARNING COMPONENTS OF CLASSROOM ACADEMIC PERFORMANCE. *JOURNAL OF EDUCATIONAL PSYCHOLOGY, 82*(1), 33-40.
POLLARD, M. A., & COURAGE, M. L. (2017). WORKING MEMORY CAPACITY PREDICTS EFFECTIVE MULTITASKING. *COMPUTERS IN HUMAN BEHAVIOR, 76*, 450-462.
PRENSKY, M. (2001A). DIGITAL NATIVES, DIGITAL IMMIGRANTS PART 1. *ON THE HORIZON, 9*(5), 1-6.
PRENSKY, M. (2001B). DIGITAL NATIVES, DIGITAL IMMIGRANTS, PART 2. *ON THE HORIZON, 9*(6).
PRINCE, M. (2004). DOES ACTIVE LEARNING WORK? A REVIEW OF THE RESEARCH. *JOURNAL ENGINEERING EDUCATION, 93*(3), 223-231.
. PROBLEM. (2021). IN O. U. PRESS (ED.), OXFORD ADVANCED LEARNERS DICITIONARY: OXFORD UNIVERSITY. RETRIEVED FROM HTTPS://WWW.OXFORDLEARNERSDICTIONARIES.COM/DEFINITION/ENGLISH/PROBLEM_1?Q=PROBLEM.
. QUESTION. (2021). IN O. U. PRESS (ED.), OXFORD ADVANCED LEARNERS DICTIONARY: OXFORD UNIVERSITY. RETRIEVED FROM HTTPS://WWW.OXFORDLEARNERSDICTIONARIES.COM/DEFINITION/ENGLISH/QUESTION_1?Q=QUESTION.
RAMBE, P. (2012). CRITICAL DISCOURSE ANALYSIS OF COLLABORATIVE ENGAGEMENT IN FACEBOOK POSTINGS. *AUSTRALASIAN JOURNAL OF EDUCATIONAL TECHNOLOGY., 28*(2), 295-314.
RANGEL, J. C., CARTMILL, C., MARTIMIANAKIS, M. A., KUPER, A., & WHITEHEAD, C. R. (2017). IN SEARCH OF EDUCATIONAL EFFICIENCY: 30 YEARS OF MEDICAL EDUCATION'S TOP-CITED ARTICLES. *MEDICAL EDUCATION, 51*(9), 918-934.
RASHID, T., & ASGHAR, H. M. (2016). TECHNOLOGY USE, SELF-DIRECTED LEARNING, STUDENT ENGAGEMENT AND ACADEMIC PERFORMANCE: EXAMINING THE INTERRELATIONS. *COMPUTERS IN HUMAN BEHAVIOR, 63*, 604-612.
RIENTIES, B., & TEMPELAAR, D. (2018). TURNING GROUPS INSIDE OUT: A SOCIAL NETWORK PERSPECTIVE. *JOURNAL OF THE LEARNING SCIENCES, 27*(4), 550-579.
RINATO, B. (2014). *THE INFLUENCE OF MUSIC TEMPO AND LYRICS ON DECISION MAKING.* (DOCTORATE), THE OHIO STATE UNIVERSITY,
RISKO, E. F., & DUNN, T. L. (2015). STORING INFORMATION IN-THE-WORLD: METACOGNITION AND COGNITIVE OFFLOADING IN A SHORT-TERM MEMORY TASK. *CONSCIOUSNESS AND COGNITION, 36*, 61-74.
RISKO, E. F., FERGUSON, A. M., & MCLEAN, D. (2016). ON RETRIEVING INFORMATION FROM EXTERNAL KNOWLEDGE STORES: FEELING-OF-FINDABILITY, FEELING-OF-KNOWING AND INTERNET SEARCH. *COMPUTERS IN HUMAN BEHAVIOR, 65*, 534-543.
RISKO, E. F., & GILBERT, S. (2016). COGNITIVE OFFLOADING. *TRENDS IN COGNITIVE SCIENCES, 20*(9), 676-688.
ROSCHELLE, J. (1992). LEARNING BY COLLABORATING: CONVERGENT CONCEPTUAL CHANGE. *THE JOURNAL OF THE LEARNING SCIENCES, 2*(3), 235-276.
ROSE, E. (2011). THE PHENOMENOLOGY OF ON-SCREEN READING: UNIVERSITY STUDENTS' LIVED EXPERIENCE OF DIGITISED TEXT. *BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY, 42*(3), 515-526. DOI:DOI: 10.1111/J.1467-8535.2009.01043.X
ROSEN, L. D., CARRIER, L. M., & CHEEVER, N. A. (2013). FACEBOOK AND TEXTING MADE ME DO IT: MEDIA-INDUCED TASK-SWITCHING WHILE STUDYING. *COMPUTERS IN HUMAN BEHAVIOR, 29*(3), 948-958.
ROTGANS, J., & SCHMIDT, H. G. (2011). SITUATIONAL INTEREST AND ACADEMIC ACHIEVEMENT IN THE ACTIVE-LEARNING CLASSROOM. *LEARNING AND INSTRUCTION, 21*, 58-67.
RUFFLE, J. K., FARMER, A. D., & AZIZ, Q. (2019). ARTIFICIAL INTELLIGENCE-ASSISTED GASTROENTEROLOGY—PROMISES AND PITFALLS. *AMERICAN JOURNAL OF GASTROENTEROLOGY, 114*(3), 422-428.
RUSSO, J. E., JOHNSON, E. J., & STEPHENS, D. L. (1989). THE VALIDITY OF VERBAL PROTOCOLS. *MEMORY & COGNITION, 17*(6), 759-769.
RUSSO, L., & RUSSO, S. (2020). SEARCH ENGINES, COGNITIVE BIASES AND THE MAN-COMPUTER INTERACTION: A THEORETICAL FRAMEWORK FOR EMPIRICAL RESEARCHES ABOUT COGNITIVE BIASES IN ONLINE SEARCH ON HEALTH-RELATED TOPICS. *MED HEALTH CARE PHILOS, 23*(2), 237-246. DOI:10.1007/S11019-020-09940-9
RYAN, R. M., & DECI, E. L. (2000). SELF-DETERMINATION THEORY AND THE FACILITATION OF INTRINSIC MOTIVATION, SOCIAL DEVELOPMENT, AND WELL-BEING *AMERICAN PSYCHOLOGIST, 55*(1), 68-78. DOI:10.1037110003-066X.55.1.68
SAFARINA, N., & HALIMAH, L. (2019). *SELF-CONTROL AND ONLINE GAME ADDICTION IN EARLY ADULT GAMERS.* PAPER PRESENTED AT THE JOURNAL OF PHYSICS: CONFERENCE SERIES.
SALVUCCI, D. D., & TAATGEN, N. A. (2008). THREADED COGNITION: AN INTEGRATED THEORY OF CONCURRENT MULTITASKING. *PSYCHOLOGICAL REVIEW, 115*(1), 101.
SAMUEL, A., KONOPASKY, A., SCHUWIRTH, L. W., KING, S. M., & DURNING, S. J. (2020). FIVE PRINCIPLES FOR USING EDUCATIONAL THEORY: STRATEGIES FOR ADVANCING HEALTH PROFESSIONS EDUCATION RESEARCH. *ACADEMIC MEDICINE, 95*(4), 518-522.
SANA, F., WESTON, T., & CEPEDA, N. J. (2013). LAPTOP MULTITASKING HINDERS CLASSROOM LEARNING FOR BOTH USERS AND NEARBY PEERS. *COMPUTERS & EDUCATION, 62*, 24-31.
SAVERY, J. R., & DUFFY, T. M. (1995). PROBLEM BASED LEARNING: AN INSTRUCTIONAL MODEL AND ITS CONSTRUCTIVIST FRAMEWORK. *EDUCATIONAL TECHNOLOGY RESEARCH, 35*(5), 31-38.
SCARDAMALIA, M., & BEREITER, C. (2006). *KNOWLEDGE BUILDING: THEORY, PEDAGOGY AND TECHNOLOGY*. NEW YORK: CAMBRIDGE UNIVERSITY PRESS.

SCHAEFER, S. M., DOMINGUEZ, M., & MOELLER, J. J. (2018). *THE FUTURE OF THE LECTURE IN NEUROLOGY EDUCATION.* PAPER PRESENTED AT THE SEMINARS IN NEUROLOGY.
SCHMIDHUBER, J. (2015). DEEP LEARNING IN NEURAL NETWORKS: AN OVERVIEW. *NEURAL NETWORKS, 61*, 85-117.
SCHMIDT, H. G. (1983). PROBLEM-BASED LEARNING: RATIONALE AND DESCRIPTION. *MEDICAL EDUCATION, 17*(1), 11-16. DOI:10.1111/J.1365-2923.1983.TB01086.X
SCHMIDT, H. G. (1994). RESOLVING INCONSISTENCIES IN TUTOR EXPERTISE RESEARCH: DOES LACK OF STRUCTURE CAUSE STUDENTS TO SEEK TUTOR GUIDANCE? *ACADEMIC MEDICINE, 69*, 656.
SCHMIDT, H. G., ROTGANS, J., & YEW, E. H. (2011). THE PROCESS OF PROBLEM-BASED LEARNING: WHAT WORKS AND WHY. *MEDICAL EDUCATION, 45*.
SCHUNK, D. H. (2012). *LEARNING THEORIES AN EDUCATIONAL PERSPECTIVE* (6 ED.). BOSTON: PEARSON.
SELWYN, N. (2009). THE DIGITAL NATIVE – MYTH AND REALITY. *ASLIB PROCEEDINGS, 61*(4), 364-379. DOI:10.1108/00012530910973776
SHABANI, K., KHATIB, M., & EBADI, S. (2010). VYGOTSKY'S ZONE OF PROXIMAL DEVELOPMENT: INSTRUCTIONAL IMPLICATIONS AND TEACHERS' PROFESSIONAL DEVELOPMENT. *ENGLISH LANGUAGE TEACHING, 3*(4), 237-248.
SHI, Y.-R., & SHIH, J.-L. (2015). GAME FACTORS AND GAME-BASED LEARNING DESIGN MODEL. *INTERNATIONAL JOURNAL OF COMPUTER GAMES TECHNOLOGY, 2015*.
SHIFFRIN, R., & ATKINSON, R. (1969). STORAGE AND RETRIEVAL PROCESSES IN LONG-TERM MEMORY. *PSYCHOLOGICAL REVIEW, 76*(2), 179-193.
SHIRKY, C. (2010). *COGNITIVE SURPLUS: CREATIVITY AND GENEROSITY IN A CONNECTED AGE*: PENGUIN UK.
SHUELL, T. J. (1990). PHASES OF MEANINGFUL LEARNING. *REVIEW OF EDUCATIONAL RESEARCH, 60*(4), 531-547.
SINGAL, H., & KOHLI, S. (2016). TRUST NECESSITATED THROUGH METRICS: ESTIMATING THE TRUSTWORTHINESS OF WEBSITES. *PROCEDIA COMPUTER SCIENCE, 85*, 133-140.
SINGH, K., BHARATHA, A., SA, B., ADAMS, O. P., & MAJUMDER, A. A. (2019). TEACHING ANATOMY USING AN ACTIVE AND ENGAGING LEARNING STRATEGY. *BMC MEDICAL EDUCATION, 19*(1), 1-8.
SKINNER, B. (1963). OPERANT BEHAVIOR. *AMERICAN PSYCHOLOGIST, 18*(8), 503-515. DOI:10.1037/H0045185
SLAVICH, G. M., & ZIMBARDO, P. G. (2012). TRANSFORMATIONAL TEACHING: THEORETICAL UNDERPINNINGS, BASIC PRINCIPLES, AND CORE METHODS. *EDUCATIONAL PSYCHOLOGICAL REVIEWS, 24*, 569-608.
SLAVIN, R. E. (1983). WHEN DOES COOPERATIVE LEARNING INCREASE STUDENT ACHIEVEMENT? *PSYCHOLOGICAL BULLETIN, 94*(3), 429-445.
SLEEMAN, J., LANG, C., & DAKICH, E. (2020). SOCIAL MEDIA, LEARNING AND CONNECTIONS FOR INTERNATIONAL STUDENTS: THE DISCONNECT BETWEEN WHAT STUDENTS USE AND THE TOOLS LEARNING MANAGEMENT SYSTEMS OFFER. *AUSTRALASIAN JOURNAL OF EDUCATIONAL TECHNOLOGY, 36*(4), 44-56.
SMAGORINSKY, P. (1998). THINKING AND SPEECH AND PROTOCOL ANALYSIS. *MIND, CULTURE, AND ACTIVITY, 5*(3), 157-177.
SOARES, J. S., & STORM, B. C. (2018). FORGET IN A FLASH: A FURTHER INVESTIGATION OF THE PHOTO-TAKING-IMPAIRMENT EFFECT. *JOURNAL OF APPLIED RESEARCH IN MEMORY COGNITION, 7*(1), 154-160.
SOCKALINGHAM, N., ROTGANS, J., & SCHMIDT, H. G. (2011). THE RELATIONSHIPS BETWEEN PROBLEM CHARACTERISTICS, ACHIEVEMENT-RELATED BEHAVIOURS, AND ACADEMIC ACHIEVEMENT IN PROBLEM-BASED LEARNING. *ADVANCES IN HEALTH SCIENCE EDUCATION, 16*, 481.
ŠORGO, A., BARTOL, T., DOLNIČAR, D., & BOH PODGORNIK, B. (2017). ATTRIBUTES OF DIGITAL NATIVES AS PREDICTORS OF INFORMATION LITERACY IN HIGHER EDUCATION. *BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY, 48*(3), 749-767.
SPARROW, B., & CHATMAN, L. (2013). PSYCHOLOGICAL INQUIRY: AN INTERNATIONAL JOURNAL FOR THE ADVANCEMENT OF PSYCHOLOGICAL THEORY. *PSYCHOLOGICAL INQUIRY, 24*, 273-292. DOI:HTTP://DX.DOI.ORG/10.1080/1047840X.2013.827079
SPARROW, B., LIU, J., & WEGNER, D. M. (2011). GOOGLE EFFECTS ON MEMORY: COGNITIVE CONSEQUENCES OF HAVING INFORMATION AT OUR FINGERTIPS. *SCIENCE, 333*, 776-778. DOI:10.1126/SCIENCE.1207745
STÅHL, T. (2017). HOW ICT SAVVY ARE DIGITAL NATIVES ACTUALLY? *J NORDIC JOURNAL OF DIGITAL LITERACY, 12*(03), 89-108.
STEGERS-JAGER, K. M., COHEN-SCHOTANUS, J., & THEMMEN, A. P. (2012). MOTIVATION, LEARNING STRATEGIES, PARTICIPATION AND MEDICAL SCHOOL PERFORMANCE. *MEDICAL EDUCATION, 46*, 678-688.
STORM, B. C., STONE, S. M., & BENJAMIN, A. S. (2017). USING THE INTERNET TO ACCESS INFORMATION INFLATES FUTURE USE OF THE INTERNET TO ACCESS OTHER INFORMATION. *MEMORY, 25*(6), 717-723.
SWELLER, J. (1988). COGNITIVE LOAD DURING PROBLEM SOLVING: EFFECTS ON LEARNING. *COGNITIVE SCIENCE, 12*, 257-285.
SWELLER, J. (2010). ELEMENT INTERACTIVITY AND INTRINSIC, EXTRANEOUS, AND GERMANE COGNITIVE LOAD. *EDUCATIONAL PSYCHOLOGICAL REVIEW, 22*(123-138).
SWELLER, J., KIRSCHNER, P. A., & CLARK, R. E. (2007). WHY MINIMALLY GUIDED TEACHING TECHNIQUES DO NOT WORK: A REPLY TO COMMENTARIES. *EDUCATIONAL PSYCHOLOGIST, 42*(2), 115-121.
SWELLER, J., VAN MERRIËNBOER, J. J., & PAAS, F. (2019). COGNITIVE ARCHITECTURE AND INSTRUCTIONAL DESIGN: 20 YEARS LATER. *EDUCATIONAL PSYCHOLOGY REVIEW*, 1-32.
SWELLER, J., VAN MERRIËNBOER, J. J., & PAAS, F. G. (1998). COGNITIVE ARCHITECTURE AND INSTRUCTIONAL DESIGN. *EDUCATIONAL PSYCHOLOGY REVIEW, 10*(3), 251-296.
TAATGEN, N. A., KATIDIOTI, I., BORST, J., VAN VUGT, M., & MEHLHORN, K. (2015). *A MODEL OF DISTRACTION USING NEW ARCHITECTURAL MECHANISMS TO MANAGE MULTIPLE GOALS.* PAPER PRESENTED AT THE ICCM CONFERENCE.
TAPSCOTT, D. (1999). EDUCATING THE NET GENERATION. *EDUCATIONAL LEADERSHIP, 56*(5), 6-11.
TAPSCOTT, D. (2008). *GROWN UP DIGITAL*: MCGRAW-HILL EDUCATION BOSTON.
TESS, P. A. (2013). THE ROLE OF SOCIAL MEDIA IN HIGHER EDUCATION CLASSES (REAL AND VIRTUAL) – A LITERATURE REVIEW. *COMPUTERS IN HUMAN BEHAVIOR, 29*(5), A60-A68. DOI:10.1016/J.CHB.2012.12.032

THISTLETHWAITE, J. E., DAVIES, D., EKEOCHA, S., KIDD, J. M., MACDOUGALL, C., MATTHEWS, P., . . . CLAY, D. (2012). THE EFFECTIVENESS OF CASE-BASED LEARNING IN HEALTH PROFESSIONAL EDUCATION. A BEME SYSTEMATIC REVIEW: BEME GUIDE NO. 23. *MEDICAL TEACHER, 34*(6), E421-E444.
TIEN, N. H., VAN DAT, N., & CHI, D. T. (2019). PRODUCT POLICY IN INTERNATIONAL MARKETING COMPARATIVE ANALYSIS BETWEEN SAMSUNG AND APPLE. *INTERNATIONAL JOURNAL OF RESEARCH IN MARKETING MANAGEMENT AND SALES, 1*(2), 129-133.
TSOPRA, R., COURTINE, M., SEDKI, K., EAP, D., CABAL, M., COHEN, S., . . . LAMY, J.-B. (2020). ANTIBIOGAME®: A SERIOUS GAME FOR TEACHING MEDICAL STUDENTS ABOUT ANTIBIOTIC USE. *INTERNATIONAL JOURNAL OF MEDICAL INFORMATICS, 136*, 104074.
TUCKMAN, B. W., & JENSEN, M.-A. C. (1977). STAGES OF SMALL-GROUP DEVELOPMENT REVISITED. *GROUP AND ORGANISATION STUDIES, 2*(4), 419-427.
TUDGE, J., RH, & WINTERHOFF, P., A. (1993). VYGOTSKY, PIAGET, AND BANDURA: PERSPECTIVES ON THE RELATIONS BETWEEN THE SOCIAL WORLD AND COGNITIVE DEVELOPMENT. *HUMAN DEVELOPMENT, 36*.
TURVEY, M. T. (1992). AFFORDANCES AND PROSPECTIVE CONTROL: AN OUTLINE OF THE ONTOLOGY. *ECOLOGICAL PSYCHOLOGY, 4*(3), 173-187.
ULLMAN, S. (2019). USING NEUROSCIENCE TO DEVELOP ARTIFICIAL INTELLIGENCE. *SCIENCE, 363*(6428), 692-693.
. UNKNOWN. (2021). IN O. U. PRESS (ED.), OXFORD ADVANCED LEARNERS DICTIONARY: OXFORD UNIVERSITY. RETRIEVED FROM HTTPS://WWW.OXFORDLEARNERSDICTIONARIES.COM/DEFINITION/ENGLISH/UNKNOWN_1?Q=UNKNOWN.
VAN BLANKENSTEIN, F. M., DOLMANS, D. H., VAN DER VLEUTEN, C., & SCHMIDT, H. (2013). ELABORATION DURING PROBLEM-BASED GROUP DISCUSSION: EFFECTS ON RECALL FOR HIGH AND LOW ABILITY STUDENTS. *ADVANCES HEALTH SCIENCE EDUCATION: THEORY PRACTICE, 18*(4), 659-672. DOI:10.1007/S10459-012-9406-8
VAN BLANKENSTEIN, F. M., DOLMANS, D. H., VAN DER VLEUTEN, C. P., & SCHMIDT, H. G. (2011). WHICH COGNITIVE PROCESSES SUPPORT LEARNING DURING SMALL-GROUP DISCUSSION? THE ROLE OF PROVIDING EXPLANATIONS AND LISTENING TO OTHERS. *INSTRUCTIONAL SCIENCE, 39*, 189-204.
VAN DE POL, J., DE BRUIN, A. B., VAN LOON, M. H., & VAN GOG, T. (2019). STUDENTS' AND TEACHERS' MONITORING AND REGULATION OF STUDENTS' TEXT COMPREHENSION: EFFECTS OF COMPREHENSION CUE AVAILABILITY. *CONTEMPORARY EDUCATIONAL PSYCHOLOGY, 56*, 236-249.
VAN DEN BOSSCHE, P., GIJSELAERS, W. H., SEGERS, M., & KIRSCHNER, P. A. (2006). SOCIAL AND COGNITIVE FACTORS DRIVING TEAMWORK IN COLLABORATIVE LEARNING ENVIRONMENTS TEAM LEARNING BELIEFS AND BEHAVIORS. *SMALL GROUP RESEARCH, 37*(5), 490-521.
VAN DEN HURK, M. M., WOLFHAGEN, I. H., DOLMANS, D. H., & VAN DER VLEUTEN, C. P. (1999). THE IMPACT OF STUDENT-GENERATED LEARNING ISSUES ON INDIVIDUAL STUDY TIME AND ACADEMIC ACHIEVEMENT. *MEDICAL EDUCATION, 33*(11), 808-814.
VAN DOORN, J., & VAN DOORN, J. (2014). THE QUEST FOR KNOWLEDGE TRANSFER EFFICACY: BLENDED TEACHING, ONLINE AND IN-CLASS, WITH CONSIDERATION OF LEARNING TYPOLOGIES FOR NON-TRADITIONAL AND TRADITIONAL STUDENTS. *FRONTIERS IN PSYCHOLOGY, 5*, 324. DOI:10.3389/FPSYG.2014.00324
VAN GOG, T., KESTER, L., NIEVELSTEIN, F., GIESBERS, B., & PAAS, F. (2009). UNCOVERING COGNITIVE PROCESSES: DIFFERENT TECHNIQUES THAT CAN CONTRIBUTE TO COGNITIVE LOAD RESEARCH AND INSTRUCTION. *COMPUTERS IN HUMAN BEHAVIOR, 25*(2), 325-331.
VAN GOG, T., PASS, F., & SWELLER, J. (2010). COGNITIVE LOAD THEORY: ADVANCES IN RESEARCH ON WORKED EXAMPLES, ANIMATIONS, AND COGNITIVE LOAD MEASUREMENT. *EDUCATIONAL PSYCHOLOGICAL REVIEW, 22*(375-378).
VAN LOON, M. H., DE BRUIN, A. B., VAN GOG, T., VAN MERRIËNBOER, J. J., & DUNLOSKY, J. (2014). CAN STUDENTS EVALUATE THEIR UNDERSTANDING OF CAUSE-AND-EFFECT RELATIONS? THE EFFECTS OF DIAGRAM COMPLETION ON MONITORING ACCURACY. *ACTA PSYCHOLOGICA, 151*, 143-154.
VAN MERRIENBOER, J. J., & AYRES, P. (2005). RESEARCH ON COGNITIVE LOAD THEORY AND ITS DESIGN IMPLICATIONS FOR E-LEARNING. *EDUCATIONAL TECHNOLOGY RESEARCH DEVELOPMENTAL REVIEW, 53*(3), 5-13.
VAN MERRIËNBOER, J. J., & KIRSCHNER, P. A. (2017). *TEN STEPS TO COMPLEX LEARNING: A SYSTEMATIC APPROACH TO FOUR-COMPONENT INSTRUCTIONAL DESIGN*: ROUTLEDGE.
VAN MERRIËNBOER, J. J., KIRSCHNER, P. A., & KESTER, L. (2003). TAKING THE LOAD OFF A LEARNER'S MIND: INSTRUCTIONAL DESIGN FOR COMPLEX LEARNING. *EDUCATIONAL PSYCHOLOGIST, 38*(1), 5-13.
VAN MERRIENBOER, J. J., & SWELLER, J. (2005). COGNITIVE LOAD THEORY AND COMPLEX LEARNING: RECENT DEVELOPMENTS AND FUTURE DIRECTIONS. *EDUCATIONAL PSYCHOLOGY REVIEW, 17*(2), 147-177.
VAN MERRIËNBOER, J. J., & SWELLER, J. (2010). COGNITIVE LOAD THEORY IN HEALTH PROFESSIONAL EDUCATION: DESIGN PRINCIPLES AND STRATEGIES. *MEDICAL EDUCATION, 44*, 85-93. DOI:DOI:10.1111/J.1365-2923.2009.03498.X
VANDEWAETERE, M., MANHAEVE, D., AERTGEERTS, B., CLAREBOUT, G., VAN MERRIËNBOER, J. J., & ROEX, A. (2015). 4C/ID IN MEDICAL EDUCATION: HOW TO DESIGN AN EDUCATIONAL PROGRAM BASED ON WHOLE-TASK LEARNING: AMEE GUIDE NO. 93. *MEDICAL TEACHER, 37*(1), 4-20.
VANDEYAR, T. (2020). THE ACADEMIC TURN: SOCIAL MEDIA IN HIGHER EDUCATION. *EDUCATION INFORMATION TECHNOLOGIES*, 1.
VERKOEIJEN, P. P., RIKERS, R. M., & SCHMIDT, H. G. (2005). THE EFFECTS OF PRIOR KNOWLEDGE ON STUDY-TIME ALLOCATION AND FREE RECALL: INVESTIGATING THE DISCREPANCY REDUCTION MODEL. *THE JOURNAL OF PSYCHOLOGY, 139*(1), 67-79.
VISSCHERS-PLEIJERS, A. J. (2006). *TUTORIAL GROUP DISCUSSION IN PROBLEM-BASED LEARNING: STUDIES ON THE MEARSUREMENT AND NATURE OF LEARNING-ORIENTATED STUDENT INTERACTIONS.* (PHD), UNIVERSITY OF MAASTRICHT, ICO DISSERTATION SERIES.

VISSCHERS-PLEIJERS, A. J. (2007). *TUTORIAL GROUP DISCUSSION IN PROBLEM-BASED LEARNING: STUDIES ON THE MEASUREMENT AND NATURE OF LEARNING-ORIENTED STUDENT INTERACTIONS.* MAASTRICHT UNIVERSITY,

VISSCHERS-PLEIJERS, A. J., DOLMANS, D. H., DE GRAVE, W. S., & WOLFHAGEN, I. H. (2006). STUDENT PERSEPTIONS ABOUT THE CHARACTERISTICS OF AN EFFECTIVE DISCUSSION DURING THE REPORTING PHASE IN PROBLEM-BASED LEARNING. *MEDICAL EDUCATION, 40*, 924-931.

VYGOTSKY, L. S. (1930). *MIND AND SOCIETY* (A. A. S. BLUNDEN, NATE, TRANS.): HARVARD UNIVERSITY PRESS.

VYGOTSKY, L. S. (1980). *MIND IN SOCIETY: THE DEVELOPMENT OF HIGHER PSYCHOLOGICAL PROCESSES*: HARVARD UNIVERSITY PRESS.

WANG, Z., IRWIN, M., COOPER, C., & SRIVASTAVA, J. (2015). MULTIDIMENSIONS OF MEDIA MULTITASKING AND ADAPTIVE MEDIA SELECTION. *HUMAN COMMUNICATION RESEARCH, 41*(1), 102-127.

WARD, A. F. (2013A). *ONE WITH THE CLOUD: WHY PEOPLE MISTAKE THE INTERNET'S KNOWLEDGE FOR THEIR OWN.* (DOCTOR OF PHILOSOPHY), HARVARD UNIVERSITY, HTTP://NRS.HARVARD.EDU/URN-3:HUL.INSTREPOS:11004901.

WARD, A. F. (2013B). SUPERNORMAL: HOW THE INTERNET IS CHANGING OUR MEMORIES AND OUR MINDS. *PSYCHOLOGICAL INQUIRY, 24*(4), 341-348.

WARREN, W. H. (1984). PERCEIVING AFFORDANCES: VISUAL GUIDANCE OF STAIR CLIMBING. *JOURNAL OF EXPERIMENTAL PSYCHOLOGY: HUMAN PERCEPTION AND PERFORMANCE, 10*(5), 683.

WEGNER, D. M. (1987). TRANSACTIVE MEMORY: A CONTEMPORARY ANALYSIS OF THE GROUP MIND. IN *THEORIES OF GROUP BEHAVIOR* (PP. 185-208): SPRINGER.

WEGNER, D. M., GIULIANO, T., & HERTEL, P. (1985). COGNITIVE INTERDEPENDENCE IN CLOSE RELATIONSHIPS. IN *COMPATIBLE AND INCOMPATIBLE RELATIONSHIPS* (PP. 253-276): SPRINGER.

WEGNER, D. M., & WARD, A. F. (2013). PSYCHOLOGY HOW GOOGLE IS CHANGING YOUR BRAIN. *SCIENTIFIC AMERICAN, 309*(6), 58-61.

WESTERMAN, D., SPENCE, P. R., & VAN DER HEIDE, B. (2014). SOCIAL MEDIA AS INFORMATION SOURCE: RECENCY OF UPDATES AND CREDIBILITY OF INFORMATION. *JOURNAL OF COMPUTER-MEDIATED COMMUNICATION, 19*(2), 171-183. DOI:10.1111/JCC4.12041

WETZELS, S. A., KESTER, L., & VAN MERRIENBOER, J. J. (2011). ADAPTING PRIOR KNOWLEDGE ACTIVATION: MOBILISATION, PERSPECTIVE TAKING, AND LEARNERS' PRIOR KNOWLEDGE. *COMPUTERS IN HUMAN BEHAVIOR, 27*(1), 16-21.

WIETH, M. B., & BURNS, B. D. (2014). REWARDING MULTITASKING: NEGATIVE EFFECTS OF AN INCENTIVE ON PROBLEM SOLVING UNDER DIVIDED ATTENTION. *THE JOURNAL OF PROBLEM SOLVING, 7*(1), 7.

WOLTERING, V., HERRIER, A., SPITZER, K., & SPRECKELSEN, C. (2009). BLENDED LEARNING POSITIVELY AFFECTS STUDENTS' SATISFACTION AND THE ROLE OF THE TUTOR IN THE PROBLEM-BASED LEARNING PROCESS: RESULTS OF A MIXED-METHOD EVALUATION. *ADVANCES IN HEALTH SCIENCE EDUCATION, 14*, 725-738.

WONG, A., LEAHY, W., MARCUS, N., & SWELLER, J. (2012). COGNITIVE LOAD THEORY, THE TRANSIENT INFORMATION EFFECT AND E-LEARNING. *LEARNING AND INSTRUCTION, 22*, 449-457.

WOOD, D. F. (2003). PROBLEM BASED LEARNING. *BRITISH MEDICAL JOURNAL, 326*(7384), 328.

WOPEREIS, I. G., & VAN MERRIËNBOER, J. J. (2011). EVALUATING TEXT-BASED INFORMATION ON THE WORLD WIDE WEB. *LEARNING AND INSTRUCTION, 21*, 232-237. DOI:10.1016/J.LEARNINSTRUC.2010.02.003

YASAKA, K., & ABE, O. (2018). DEEP LEARNING AND ARTIFICIAL INTELLIGENCE IN RADIOLOGY: CURRENT APPLICATIONS AND FUTURE DIRECTIONS. *PLOS MED, 15*(11), E1002707. DOI:10.1371/JOURNAL.PMED.1002707

YEW, E. H., & SCHMIDT, H. G. (2009). EVIDENCE FOR CONSTRUCTIVE, SELF-REGULATORY, AND COLLABORATIVE PROCESSES IN PROBLEM-BASED LEARNING. *ADVANCES IN HEALTH SCIENCES EDUCATION, 14*(2), 251-273.

ZHANG, S., & CABAGE, N. (2017). SEARCH ENGINE OPTIMIZATION: COMPARISON OF LINK BUILDING AND SOCIAL SHARING. *JOURNAL OF COMPUTER INFORMATION SYSTEMS, 57*(2), 148-159.

ZHONG, B. (2013). FROM SMARTPHONES TO IPAD: POWER USERS' DISPOSITION TOWARD MOBILE MEDIA DEVICES. *COMPUTERS IN HUMAN BEHAVIOR, 29*(4), 1742-1748.

ZIMMERMAN, B. J. (1989). A SOCIAL COGNITIVE VIEW OF SELF-REGULATED ACADEMIC LEARNING. *JOURNAL OF EDUCATIONAL PSYCHOLOGY, 81*(3), 329-339.

ZIMMERMAN, B. J. (1990). SELF-REGULATED LEARNING AND ACADEMIC ACHIEVEMENT: AN OVERVIEW. *EDUCATIONAL PSYCHOLOGIST, 25*(1), 3-17.

ZIMMERMAN, B. J. (2000). SELF-EFFICACY: AN ESSENTIAL MOTIVE TO LEARN. *CONTEMPORARY EDUCATIONAL PSYCHOLOGY, 25*(1), 82-91. DOI:10.1006/CEPS.1999.1016

ZIMMERMAN, B. J., & SCHUNK, D. H. (2009). *SELF-REGULATED LEARNING AND ACADEMIC ACHIEVEMENT - THEORETICAL PERSPECTIVES* (B. J. ZIMMERMAN & D. H. SCHUNK EDS. 2 ED.). NEW YORK: ROUTLEDGE.

ZULL, J. E. (2011). *FROM BRAIN TO MIND:USING NEUROSCIENCE TO GUIDE CHANGE IN EDUCATION.* (1ST ED.). STRELING, VIRGINIA: STYLUS PUBLISHING LLC.