Title: *Insights from a case study in building STEM Education for Vietnam Education.*

Long Nguyen — Master of Leadership in Education

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Contents

Abstract

To become a new place for high-tech manufacturing, Vietnam needs to quickly increase the availability of Vietnam's skilled workers in STEM fields. Therefore, the Vietnam Ministry of Education and Training (MOET) introduced a new education curriculum to promote interdisciplinary education integrating STEM education in 2018. Integrating STEM education is still a massive challenge for Vietnam. There is a lack of consensus in definitions or approaches related to STEM education, a lack of quality teacher teams, and differences in teachers' beliefs about STEM education. Under the pressure of educational reform, Vietnamese education may be able to replicate practices to improve education quality. The integrated STEM education model from the Australian Science and Mathematics School (ASMS) has the potential for some insights after 20 years of maintaining STEM interdisciplinary learning.

The ASMS had solutions to difficulties to overcome in implementing interdisciplinary, such as the need for a well-prepared curriculum, consensus in instructional practices, and a desire for shared/distributed leadership.

The literature highlighted many challenges in implementing educational reforms in Vietnam, especially the need for instructional leadership and suitable teachers' professional development. Therefore, in the challenging context of integrating STEM education in Vietnam, the ASMS is a potential place to look at and discuss to evaluate what can be learnt and perhaps replicated. Therefore, aiming to bring insights for Vietnam education in integrating STEM education, the study sought to capture what can be learnt from the process of developing ASMS from its start, 20 years ago. The study seeks to bring an understandable version of building an interdisciplinary learning environment at ASMS to Vietnamese school leaders and teachers.

Considering the above missions, the study was designed as a case study using portraiture as the method.

The data was collected from interviewing the founding principal, extracting and distilling information from press releases related to the ASMS, and observing public events at the ASMS. The study's key finding is encapsulated by a unique topography portrait and narratives capturing the early years of ASMS. While the portrait was built using the collage technique with various images and news about ASMS, the narratives were written using a combination of interpretation, preoccupation, and autobiography. The findings helped detail the formation of ASMS, providing an accessible picture of building an interdisciplinary learning environment. In addition, the findings helped to consolidate recommendations for implementing interdisciplinary learning.

Potential insights for the Vietnam context were pointed out, including applying theme-based learning for the interdisciplinary curriculum; focusing on co-teaching, project/problem-based learning, and student-centred approaches in improving the professional development of Vietnamese teachers; bringing other professions to the classroom as teachers; and building partnerships with universities. In addition, ideas for Vietnam's educational leadership in integrating STEM education are provided, including encouragement in adopting and tailoring a localised leadership model, paying attention to improving instructional leadership, and carefully enhancing school authority.

Declaration

To the best of my knowledge and belief, I certify that this work does not include any previously published or written material by another person without due acknowledgement by way of reference.

Long Nguyen

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Glossary

ASMS:	Australian Sciences & Mathematics School
BUILD-IT:	Building University-Industry Learning and Development through Innovation and Technology
GDP:	Gross Domestic Product
GERM:	Global Education Reform Movement
IDC:	Interdisciplinary Curriculum
ILE:	Innovative Learning Environment
MOET:	Ministry Of Education and Training
SES:	School of Environmental Studies
STEM:	Science, Technology, Engineering, and Math

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INTRODUCTION

1.1 Introduction to the Inquiry

The demand for interdisciplinary capabilities in Science, Technology, Engineering, and Mathematics (STEM) in Vietnam is growing based on the fourth industry revolution, called Industry 4.0 or Smart Industry, referring to the technological evolution from embedded systems to cyber-physical systems (Idin, 2018; Li, 2020). STEM is becoming a priority in education (Li, 2020), especially in developing countries such as Vietnam (Hafni et al., 2020; Kamsi et al., 2019), which is the context for this study.

An influx of global manufacturers has sharply increased the demand for high-quality human resources in STEM disciplines in Vietnam (Hoang, 2020). Vietnam is trying to become a new place for high-tech manufacturing in response to the need to reduce trade import reliance on China (Hoang, 2020; Swanson & Smialek, 2023). However, the availability of Vietnam's skilled workers is insufficient to respond to the STEM demand (Bodewig et al., 2014; Demombynes & Testaverde, 2018; Hoang, 2020; Nguyen et al., 2021). Aware of the need to improve the quality of human resources for STEM as a product of the education system, the Vietnamese Ministry of Education and Training (MOET) has introduced a new education curriculum to promote interdisciplinary education since 2018 (MOET, 2018). The new curriculum focuses on improving the quality of education related to the STEM disciplines to prepare the future workforce (Pham et al., 2023).

1.2 STEM and STEM education

STEM education is the notion of purposefully integrating the four disciplines of science, technology, engineering and mathematics to solve real-world problems (Blackley & Howell, 2015;

Breiner et al., 2012). STEM education is considered to have started in the 1990s in the USA to improve sciences and mathematics education toward enhancing scientific literacy (Breiner et al., 2012). This special attention to STEM was a response to the poor performance of US students in mathematics and science, leading to failures in preparing the future workforce (Breiner et al., 2012). Many stakeholders, including government, teachers, businesses, and students, became interested in STEM, leading to different perspectives on STEM, such as future workforce investment or replacement of traditional educational practices (Breiner et al., 2012). For governments globally, investing in STEM disciplines has become a strategy to increase both the quantity and quality of engineers and scientists in an era of growing globalisation (Blackley & Howell, 2015). For this reason, STEM education was seen as part of a Global Education Reform Movement (GERM) attempting to ensure a country's globally competitive future (Carter, 2018).

STEM development policies and strategies vary across countries. For example, Blackley and Howell (2015) described the development of STEM education in Australia from initially being enacted as S.T.E.M. to acknowledge the four distinct disciplines to being enacted as *STEM education* as an extension program in Australian schools. A growing appreciation of how four disciplines interplay in the real world led to STEM education being seen to be based on two or more subjects with the possibility of non-STEM subjects in the integration (Blackley & Howell, 2015). An example is the STEM PE program at Seaview High School, Adelaide, South Australia, where students learn and utilise the science behind physical performance.

Some high-performing education Asian countries, such as China, South Korea, Japan, Taiwan, and Singapore, which share a post-Confucian heritage, approached STEM education with long-term plans focusing on comprehensive reform of the whole schooling system for STEM education in schools (Blackley & Howell, 2015). The reforms involved a direction towards a more

student-centred, inquiry-based, and problem-solving learning movement and emphasised creativity (Marginson et al., 2013).

Teaching STEM

Teaching STEM often positions all four disciplines together, uses the integration as a cohesive entity to show how these disciplines are inter-connected, and teach them through a problem-solving methodology (Breiner et al., 2012). Moore and Smith (2014) described two ways to integrate STEM education, including contextual integration and content integration. Contextual integration refers to integrating engineering design process, a structured approach used to create solutions for problems, as a motivator to teach science and mathematics content. Meanwhile, content integration refers to integrating engineering thinking as a part of the learning objectives besides the science and mathematics content.

1.3 A theoretical conceptualisation of STEM integration

Cheng and So (2020) noticed that it is problematic to implement integrated STEM learning without a theoretical conceptualisation of its nature so that its complicated relationship with learning processes and outcomes can be understood. Therefore, they introduced the integration model in STEM learning (See Figure 1.1), extending from content integration to content separation and from pedagogical integration to pedagogical separation. Cheng's typology also indicates that integration in STEM learning involves three basic categories: content integration, pedagogical integration and learner integration. The model from Cheng and So (2020) offered a comprehensive framework for organising and conceptualising different kinds of STEM education in the school curriculum to reduce the vagueness of integrated STEM learning.

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Figure 1.1. Models of integration in STEM learning (Cheng & So, 2020)

Cheng and So (2020) emphasised that regardless of the model used to explain the conceptualisation of STEM, an integrated and cross-discipline program approach may be necessary to maximise learning opportunities for students' development in multiple thinking, innovative competencies, creative attitudes, broad-based knowledge, and particularly STEM integrative perspectives. An integrated and cross-discipline approach means using theme-based modules or projects (e.g., air pollution, water engineering, energy sustainability) to encourage integrated learning across STEM disciplines or even with some non-STEM disciplines. Integrated STEM education can be implemented through the formal interdisciplinary curriculum (e.g., the interconnected components within key learning areas including Mathematics, Science, and

Technology Education), informal curriculum (e.g., General Studies under the strand Science and Technology in everyday life), cross-disciplinary learning (e.g., Generic Skills including technology skills, numeracy skills, and problems solving skills), and learning outside of the classroom or school (e.g. Science Projects events) (So et al., 2018).

Interdisciplinary learning

Vasquez et al. (2013) introduced a comprehensive perspective on STEM integration. Their perspective strengthened the emphasis on subject discipline boundary crossing, a primary feature of integrated STEM perspectives (Li, 2014). English (2016) later emphasised that the different interpretations of STEM education and STEM integration, from disciplinary to transdisciplinary approaches, caused problems for researchers and curriculum developers, mainly the limited focus on connecting core content knowledge and processes across disciplines. Therefore, English (2016) called for a stronger emphasis on STEM integration with more equitable representation of the four disciplines to enhance STEM education.

Table 1.1. *Increasing levels of integration (adapted from Vasquez et al., 2013, as cited in English, 2016)*

From of integration	Features
Disciplinary	Concepts and skills are learned separately in each discipline.
Multidisciplinary	Concepts and skills are learned separately in each discipline but within a common theme.
Interdisciplinary	Closely linked concepts and skills are learned from two or more disciplines to deepen knowledge and skills.
Transdisciplinary	Knowledge and skills learned from two or more disciplines are applied to real-world problems and projects, thus helping to shape the learning experience.

There is a recommendation in the literature to use an interdisciplinary approach to STEM education (Cheng & So, 2020; English, 2016). The concept of interdisciplinarity in education is not novel or unique to STEM. It is related to integrated learning, an educational strategy that aims to assist students in creating the meaning of information by focusing on synthesising disciplines (Ashby & Exter, 2019). It is expressed that students participating in interdisciplinary education can better gain the knowledge and skills to see the world from a variety of angles, combine disciplines to understand better the phenomena they study, recognise the connections between various subjects or topics, and comprehend the larger systems in which multiple disciplines are found better than when content is siloed into discrete disciplines (subjects) (Cotantino et al., 2010). In addition, students can better learn higher-order metacognitive skills, including critical thinking, the capacity to evaluate problems from several disciplinary perspectives, teamwork and devising innovative solutions (Ashby & Exter, 2019; Holley, 2017; Spelt et al., 2009).

Although research on interdisciplinary approaches to STEM education has grown, many obstacles still exist to understanding and validating tenets of interdisciplinary approaches (Hubber et al., 2022). For example, teaching STEM interdisciplinarity requires teachers' willingness, curriculum and content knowledge, and pedagogical and content confidence to connect different STEM disciplines (Hubber et al., 2022). Globally, conflicting philosophical stances, current restrictions in the traditional (discipline-based) higher education system, or a lack of educational frameworks for interdisciplinary approaches provide difficulties for teachers and developers in applying interdisciplinary approaches for integrated STEM education (Baker & Däumer, 2015; Hubber et al., 2022; Klein, 2005). Blackley and Howell (2015) also cautioned about a possibly significant financial investment and work commitment for retraining teachers to prepare for the implementation of integrated STEM education. In addition, interdisciplinary STEM curriculum

design must consider higher-level cognitive processes, including critical thinking, problem-solving, and interdisciplinary integration (Ashby & Exter, 2019).

1.4 Context of the Inquiry

Context of Vietnam (overview)

Vietnam is in Southeast Asia, sharing borders with Laos, Cambodia, and China. Vietnam has a long coastline running along the country with many beautiful beaches. Vietnam has a population of about 100 million people with an average GDP per capita of about $ 3700 USD in 2021 (The World Bank Group, 2023). Vietnam is one of the countries with the fastest economic growth in the world in 2020 (Hoang, 2020), and this trend continues despite being affected by the COVID-19 pandemic. GDP growth reached 8% in 2022 (The World Bank Group, 2023).

Vietnam has gone through many periods of colonisation and war, starting with over 1,000 years of domination by the Han Dynasty of China. Japan, France, England, and the American army successively colonised Vietnam. Although the Democratic Republic of Vietnam was established in 1945 after the victory in the Indochina War under the leadership of President Ho Chi Minh, Vietnam was still divided into two different territories, the Communist Party supported by the Soviet Union and China in the North and the anti-Communist supported by the United States in the South. In 1975, Vietnam was officially completely liberated and unified into the Socialist Republic of Vietnam.

Hallinger et al. (2015) described the Vietnamese social context as the infusion of global values of the Soviet era, which are rooted in Confucianism. This infusion has shaped the hierarchical relationship in Vietnamese education, especially the school environment (Dao & Hayden, 2010; Hallinger & Truong, 2016). In addition, Vietnam is a power-concentrated culture

with collectivist values, replicative rather than generative approaches, and a focus on community relationship-building (Dimmock & Walker, 2005).

STEM Education in Vietnam

STEM education emerged in Vietnam in the early 2010s through extracurricular learning in some private institutions (Chen et al., 2021a). However, STEM education has been taking place firmly in Vietnam since 2015 after the MOET provided a guide for implementing integrated STEM education (T. T. K. Nguyen et al., 2020). Support from foreign organisations, such as *The British Council STEM Education Program in Vietnam* for secondary schools and the *Building University-Industry Learning and Development through Innovation and Technology (BUILD-IT)* project from USAID, became an inspiration for a new high school curriculum (Luong & Dam, 2021; Nguyen, 2017; T. T. K. Nguyen et al., 2020). In 2018, a completely new general education curriculum was introduced. The MOET focused on STEM by mandating comprehensive teaching and learning, supporting student interaction with STEM themes, and assisting in developing students' interdisciplinary knowledge, problem-solving skills, and mindset (Pham et al., 2023; Vietnam National University, 2019).

STEM education activities are attracting attention throughout Vietnam with various organisations and educational models (Chen et al., 2021b). Professional organisations, such as the Vietnam STEM ALLIANCE, under the leadership of domestic STEM field education experts, continuously lead training activities and promote STEM education nationwide (Oanh, 2023). STEM education support models, such as Fablab or Maker Innovation Space, are continuously invested in schools and universities nationwide. These spaces are increasingly attracting the participation of students (Linh, 2022). The STEM festival, held yearly since 2015, is one example of the Vietnamese government's efforts and commitment to promoting STEM education (An,

2021; Chen et al., 2021b). Recently, the STEAM (the A standing for Art) for Vietnam organisation, which aims to bring FREE world-class STEAM education to Vietnamese children (STEAM FOR VIETNAM), has also brought certain successes in STEM education to Vietnam through robotics competitions (Huong, 2023).

The new MOET curriculum is an educational change in Vietnam, resulting from participating in regional and international academic activities (Huong & Fry, 2004; Le, 2020; Pham et al., 2023). Although the complex social context of Vietnam has heavily influenced Vietnamese education, and some suggest turned it into "a patchwork of foreign ideas" (Le, 2020, p. 457), it continuously borrows ideas from all over the world through the belief that Vietnam can adopt "best education practices" (Le, 2020, p. 456). However, this also risks becoming the era of fast policy, such as relying on contested evidence, finding politically expedient magic bullets, or narrowing the understanding of legitimate educational best practices (Le, 2020).

1.5 Problem underlying the study.

STEM education was implemented for the Vietnamese secondary school level in 2020 and the primary school level in 2023. However, the formal teaching of STEM in Vietnamese schools has many challenges, such as the inflexibility of the current educational curriculum, the lack of STEM materials and STEM labs (T. T. K. Nguyen et al., 2020), the inadequacy in teacher preparation, and teachers' beliefs about STEM education (Le et al., 2021). Significantly, Vietnam has not had an official STEM curriculum yet (Pham et al., 2023). Therefore, teachers must modify the current curriculum and arrange suitable school timetables for STEM education (T. T. K. Nguyen et al., 2020). Meanwhile, Nguyen et al. (2019) cautioned that Vietnamese teachers did not know how to develop and implement STEM topics regularly and effectively. Therefore, most Vietnamese schools lack a team of teachers with qualified STEM education competencies,

including cognitive competency of STEM education, competency to design STEM teaching plans, competency to implement STEM teaching plans, and competency to evaluate and adjust the STEM teaching plan to carry out the STEM task in the new curriculum (Pham et al., 2023). Pham et al. (2023) pointed out that final-year students at Vietnamese pedagogical universities have only average STEM education competency, many even below average with some competencies, including the ability to design STEM teaching plans and evaluate and adjust STEM teaching plans.

STEM education training for Vietnamese teachers has received support from various organisations (Chen et al., 2021b). For example, Vin University, a private university with Cornell University and Vingroup - Vietnam's largest property developer from 2018, collaborated with experts from Vietnam STEM Alliance to train high school teachers on various areas of STEM education (VinUniversity, 2020). They tried to build a team called 'STEM Master Trainers', which I am a member of, to support high school STEM education nationwide (VinUniversity, 2021). However, I observed unofficial training activities from self-proclaimed STEM experts nationwide targeting preschool and elementary school teachers in areas with lower awareness. In the latest sharing about the current status of STEM education in Vietnam, one of the pioneers in promoting STEM education in Vietnam disappointedly pointed out many misconceptions, such as STEM fields, STEM subjects, STEM experts, STEM education, STEM approach, or interdisciplinary learning (Dang, 2023). He admitted that even domestic STEM education trainers are still confused about those definitions. In addition, there are inconsistencies in the policies issued by MOET (Dang, 2023).

Le et al. (2021) found that a notable challenge for STEM education in Vietnam high school is teachers' belief about STEM education caused by the tension between the importance of STEM education in developing students' abilities and the short-term goals of education in their local

contexts. This tension significantly influences teachers' motivation, involvement, and initiatives in applying STEM teaching. In a heavily test-oriented education system (Nguyen, 2019), Vietnamese teachers still think their students must gain high scores or obtain prizes in various academic competitions (Le et al., 2021). Therefore, teachers' professional development should be given more attention (Le et al., 2021; T. T. K. Nguyen et al., 2020).

In the plan to renovate the general education program, Vietnam MOET increased the authority for school leaders to lead the change (MOET, 2018, 2020). However, Nguyen (2023) cautioned that the Vietnamese school leaders' interpretation of new policies varied based on their knowledge, experiences, values and beliefs, which made their implementation deviate from the original policy's intents. In addition, as the policy changed frequently, it made school leaders tend to respond in urgent mode, and "they took on a burdensome responsibility for interpreting policy initiatives, not only for themselves, but also for their teachers, staff, students, and parents" (Nguyen, 2023, p. 421).

It is apparent that the current school and curriculum situation requires Vietnam MOET to carefully consider STEM initiatives if they fully realise the potential of developing STEM education, for example taking a more comprehensive review of their current approach to implement STEM models in Vietnam schools.

1.6 Rationale for this study.

Marginson et al. (2013) showed that the global context offers various STEM paradigms and implementation results that can be attained. Under the pressure of educational change/reform, Vietnamese education replicates practices. Vietnam is unlikely to move from replicative to generative because borrowing proven educational practices can quickly improve Vietnamese education quality (Le, 2020). For example, recently, Vietnamese education borrowed a multigrade

school model directly from Escuela Nueva – Colombia, in 2015 (Le, 2020). However, there were some criticisms about that project, such as why it was not from Western countries and its effectiveness (Le, 2020). The Vietnamese education system has always been influenced from the outside (Le, 2020).

When the new general education program was issued, it brought many challenges to Vietnam's education in building an interdisciplinary learning environment, particularly integrated STEM education. Therefore, it is not strange that in developing STEM education, many models from abroad will be quickly brought to Vietnam. For example, although there are no accurate statistics, the Makerspace model is booming in Vietnam at all educational levels.

The model of STEM education I consider in this study is interdisciplinary STEM education at the Australian Science and Mathematics School (ASMS). Initially established in 2003 in Adelaide, South Australia, it responded to the "declining enrolments in senior secondary mathematics and science, students' negative attitudes, a shortage of qualified science, technology, engineering, and mathematics (STEM) teachers, and a curriculum that lacked relevance to contemporary life" (Bissaker, 2014, p. 1). After nearly 20 years of operation, ASMS maintains its interdisciplinary educational characteristics, aiming to develop robust interdisciplinary activities.

1.7 Positioning myself as the Researcher.

After graduating as a mechatronic engineer, I transferred to work as a STEM teacher and an after-school program manager at Fablab Danang, Vietnam. I have assisted other teachers who are purely science teachers with my experience of engineering skills.

Fablab Danang (FD) is a small social enterprise formed by a group of people who wish to contribute to developing interdisciplinary education in Da Nang from 2015. Fablab works directly with educational advisors, school leaders, teachers, and students to promote the design,

development, and delivery of interdisciplinary academic programs into the school environment. We aim to bring the Maker movement/Maker Culture and 21st-century skills to Vietnam and train the innovative Problem Solvers of tomorrow.

While our traditional teaching, which includes some characteristics such as heavy in theory, teacher-centred, or exam orientation, is being questioned with some limitations (Le et al., 2022), the reliance on external education is increasing (Marino, 2018; V. H. Nguyen et al., 2020; Shadoian-Gersing, 2015). Fablab tried to develop and deliver new extracurriculars to some schools in Vietnam to support educational change. Although we have received much positive feedback from the students and school leaders, some things bother us. For example, although school leaders want to adopt the new curriculum quickly and actively support building new physical learning environments, such as Maker Innovation Spaces, they do not pay enough attention to the teachers' difficulties and apply appropriate leadership. As a result, teachers are gradually avoiding the programs.

Five years at Fablab allowed me to experience and challenge myself in a new role to find educational difficulties and challenges in Vietnam. More specifically, it is also the foundation for my scholarship to pursue a master's program in education to find creative solutions for Vietnamese education. Therefore, through this research, I hope to find insights for the implementation of STEM education in Vietnam, especially in supporting school leaders and teachers.

1.8 Significance and Aim of the Study

The aim of my research is to:

A) Examine the process of building an interdisciplinary learning environment, including designing curriculum and learning material and building pedagogical approaches and teacher support.

B) Examine the experience of one school leader in creating an interdisciplinary STEM focused secondary school.

C) Explore the potential insights from the two aims above into the context of Vietnam education at the school level.

These aims have been explored through a case study that examined the beginning of building an interdisciplinary school and how pioneers created the foundation to maintain this new learning environment. However, in learning from abroad, explicitly borrowing policies based on best practices to shorten the time, educators need to consider the influence of culture on educational practices. Therefore, this study also carefully considers the impact of cultural differences in assessing the potential of insights gained during the research. I anticipate that the research will be beneficial and valuable for Vietnamese schools and educational systems to understand better the actual requirements of school leaders and teachers in developing a new learning environment that promotes interdisciplinary learning and the processes they use to undertake these developments.

1.9 Research Questions

To accomplish the research aims, during the process of doing the dissertation, I focused on searching for answers to the following key research question, which was divided into four sub-questions to guide the study:

What do Vietnamese school leaders need to know about the beginning of building an interdisciplinary learning environment, and what may prove beneficial for implementation in the context of their own school?

1. *How were the learning materials, including the physical environment, curriculum, and pedagogy, built from the beginning for interdisciplinary learning at ASMS?*

2. *How were ASMS's initial human resources established, including its founding principal, pioneer teachers, and staff?*
3. *How did the founding school leaders build supportive strategies during the beginning of the new interdisciplinary school?*
4. *What are the critical aspects in building the foundation for an interdisciplinary learning environment from ASMS that new education institutions like Vietnam should carefully consider replicating?*

1.10 Conclusion

This chapter outlines the study's context, rationale, and aims. The study aimed to investigate how ASMS's leaders developed their school from the early years to capture a vivid portrait of the building of an interdisciplinary learning environment. In addition, through the ASMS case, the study wants to suggest some insights for supporting STEM integration in Vietnam. Additionally, its methodology, significance, constraints, and boundaries are discussed, assisting in a smooth transition to the following chapters.

LITERATURE REVIEW

2.1 Introduction

In Chapter 1, I introduced the idea that interdisciplinary education helps students gain the knowledge and skills to see the world from various perspectives, better understand the phenomena, connect various subjects or topics, and comprehend the more extensive system (Cotantino et al., 2010). However, as the school context includes the interconnected interactions between three subsystems, students, teachers, and school leaders (Crick et al., 2017), interdisciplinary education requires a comprehensive design process encompassing the three subsystems for an entire organisation, bringing different pressures to these subsystems. It is therefore recommended that school leaders and teachers must build STEM pedagogical practice together (Grice, 2019).

In Chapter 1, I suggest that teachers, curriculum designers, and students are often unprepared to design and experiment with the interdisciplinary curriculum (Baker & Däumer, 2015; Reynolds, 2012), and school leaders do not do well in leading this organisational change (Hubber et al., 2022; Thibaut et al., 2018). Historically, a lack of administrative encouragement and support prevented the adoption of an interdisciplinary approach to STEM (Asghar et al., 2012; Ertmer et al., 2003; Ertmer et al., 2009). Finding ways to assist school leaders in leading organisational change toward creating an interdisciplinary learning environment for STEM is essential.

To best support school leaders in the context of Vietnam, it is necessary to understand the current state of education and the changing process in education in Vietnam, particularly understanding Vietnam's educational processes and educational leadership. In other words, this inquiry needs to consider the relationship between Vietnamese culture, leadership, and implementation. As my study looks explicitly at STEM at the ASMS, cultural differences between

Vietnam and Australia may affect the potential for the knowledge gained from the ASMS case to be viable in different cultural contexts. Therefore, in this section, I will briefly review educational change in Vietnam, leadership in Vietnam education, roles and challenges of leadership during Vietnam's education reform, and challenges of interdisciplinary learning before appraising the existing research on the ASMS.

2.2 Education in Vietnam

In Chapter 1, I reference Le's use of the metaphor "a patchwork of foreign ideas" (Le, 2020, p. 457) to describe Vietnamese education. This is because of Vietnam's relatively complicated development process and the effect on its education. The Education Strategic Development Plan 2011-2020 officially opened the country toward international collaboration as a critical initiative for the advancement of Vietnamese education, including three tasks:

(1) increase the number of teaching staff and students trained overseas;

(2) expand cooperation with foreign institutions to enhance Vietnamese institutions' capacity in both management and education, including research and professional development; and

(3) attract international organisations, groups, individuals and overseas Vietnamese to invest in and support education, participate in teaching, research and technology transfer and contribute to education reforms (Le, 2020, p. 458).

The Education Strategic Development Plan seems somewhat at odds with Vietnamese education's traditional positioning as supporting the State's ideological duty under the absolute control of the Communist Party. However, Le (2020) suggested the pride in *Vietnamisation*, the idea that the Vietnamese constantly can adapt outside ideas to the unique context inspired by the story of Ho Chi Minh, can become a solid anchor/foundation for international collaboration. To

this end, Western-trained individuals, such as the former Minister of Education, have been considered to serve as *the merchant of ideas* facilitating the transfer of information and knowledge from abroad back to their country (Lewis & Mosse, 2006 as cited in Le, 2020).

So far, I have established that as a postcolonial developing country, Vietnam is engaged in the global phenomenon of policy lending or borrowing (Le, 2020). In Chapter 1, I introduced the idea that under high pressure to learn from abroad, looking for the best practices seems to be the easiest way to make policy, which has led Vietnamese education to the era of fast policy (Le, 2020), meaning a certain policy can be quickly adopted or put in place but also easily be resisted, revised and rejected by the group that the policy is aimed at (Takayama et al., 2017).

2.3 Leadership in Vietnam Education

Hallinger and Truong (2016) used the proverb *Above must be above, and below must be below* to describe a critical socio-cultural norm in defining relationships in Vietnamese society. By this, they highlighted the hierarchical nature of relationships when looking into successful leadership in Vietnamese society, including school leadership (Hallinger & Truong, 2016). When reporting to superiors, Vietnamese principals are subject to two distinct political and bureaucratic power systems (Hallinger & Thang, 2014). The MOET and local DOET represent the bureaucratic line responsible for the national curriculum and personnel administration. Meanwhile, Communist party cells at the central, regional, local, and school levels function parallel in exercising political power (London, 2011). Although separate, the power of the Communist party is greatly exercised and largely shapes school practices, such as the direction of the national curriculum or school developments (London, 2011).

The education context of Vietnam consists of "progressively broader sources of overlapping influence, moving from the institutional (e.g., MOET), to the political (e.g., the

Communist Party) and socio-cultural (e.g., Confucian cultural values) spheres of society"(Hallinger & Truong, 2016, p. 679). Hallinger and Troung (2016) suggested that successful school leadership "must meet the operative normative expectations, formal requirements, and resource constraints in a given school context" (p.679). Thus, in Vietnam, successful leadership must meet three requirements: (1) preserve harmony among staff (i.e., avoiding conflicts or enhancing internal unity), (2) sustain legitimacy in the eyes of bureaucratic and political superiors, and (3) increase the prestige of their schools (i.e., the credibility of individuals and the entire school community) (Hallinger & Truong, 2016). In addition, under the dual authority structure of Vietnamese schools, know-who and know-how become key relational competencies for school leaders. These relational competencies allow school leaders to allocate time outside the school to maintain strong connections to the education and political systems as a taken-for-granted duty as they "hold the political destiny of others in their hands" (Hallinger & Truong, 2016, p. 684). Although school success is assessed on criteria valued by the central authorities, such as graduation rates, academic awards, and teacher merit titles, staff harmony and strong relationships are essential to the prestige of schools in Vietnam (Truong et al., 2017).

Power distance, referring to the differences in status and power in society, is always maintained at Vietnamese schools, and principals are advised to keep a certain distance from teachers (Hallinger & Truong, 2016). For example, equality can exist between colleagues but should not be in the leader–teacher relationship, regardless of age (Hallinger & Truong, 2016). The collective benefits of the school are essential, so group orientation is natural, plus the focus on compromise and negotiation when conflicts arise (Hallinger & Truong, 2016; Truong & Hallinger, 2017; Truong et al., 2017). Due to the characteristics of consideration and tolerance at work, an individual's expression of negative emotions or objections rarely occurs at joint meetings

or classrooms in Vietnam (Hallinger & Kantamara, 2003; Truong & Hallinger, 2017). School leaders prioritise "stability and routines and look for written rules and regulations as guidance for their actions, providing solid ground and justification for decisions" (Hallinger & Kantamara, 2003, p. 9). Vietnamese principals are the key decision-makers for their schools (Truong et al., 2017). Thus, their support can be a critical factor for innovation (Hallinger & Kantamara, 2003).

However, Vietnamese school leaders have been perceived as lacking the flexibility to adjust practices to meet the needs of the local context because of the centralised political system (Walker & Hallinger, 2015). Although certain forms of instructional leadership appear appropriate for improving specific areas of Vietnamese education, they have not been recognised as normative roles of Vietnamese school leaders (Nguyen et al., 2023). The roles of Vietnamese principals are attached to the responsibility of government officers and political representatives rather than the professional instructional leadership role (Dimmock et al., 2021; Nguyen et al., 2023).

Although both Vietnamese school leaders and teachers recognise the importance of teacher professional development (Hallinger et al., 2023; Nguyen et al., 2023; Tran et al., 2020), Vietnamese school leaders have been shown to believe that professional development is a teacher's compulsory task and they have the right to dictate professional learning (Nguyen et al., 2023; Truong & Hallinger, 2017). However, there are also certain pressures for teachers to participate in professional development, such as fear of failure or losing face (Hallinger et al., 2023; Nguyen et al., 2023).

Schools' internal enablers (i.e., school leadership, internal professional development, or school culture) are shaped by external enablers (i.e., external policy guidance, external professional development) during reform. Internal enablers have a significant role in local adaptation reform process (Dimmock et al., 2021). Therefore, greater emphasis on the importance

of the school and its resources, especially the quality of teachers, principals and within-school professional development, is needed to implement system reform successfully (Dimmock et al., 2021, p. 27). This discussion is summarised in Table 2.1.

Table 2.1. *Summary of Vietnam's education characteristics and educational leadership.*

Vietnam Education	
Educational change	**Educational leadership**
A patchwork of foreign ideas - Postcolonial developing country (Confucian, French, US) - Merchant of ideas from overseas (Soviet Union, then Western)	**Main characters:** - Hierarchical nature of the relationship - Political and bureaucratic powers - Relational process - Instructional leadership is not normative roles
Lending/Borrowing policy - Fast policy problems - Best practice replicating - "Vietnamisation" pride	**Model of successful leadership:** - Preserve harmony among staff - Sustain legitimacy in the eyes of bureaucratic and political superiors - Increase the prestige of their schools
Primary strategies for developing: - Increasing staffs - Expanding cooperation with foreign institutions - Attracting international agencies	**Power-concentrated culture with collectivist values:** - key decision-makers - power distance is always maintained at school - Leaders keep their distance to remain the harmony - group-oriented is natural and focuses on compromise and negotiation when conflicts arise.
New general curriculum from 2018: - Promoting integrating STEM education but lacking the official STEM curriculum. - Lack of quality teacher teams for STEM. - Lack of consistency in perception about STEM education.	**Focus on relationship-building in local communities:** - maintain their political relationships as their duty - out-of-school support for school leaders is natural
Enhancing the school's authority to develop curriculum by characteristics of students and local conditions.	**Replicative rather than generative approaches:** - avoid uncertain and ambiguous situations - replicating, borrowing, or adopting ideas.
Giving schools flexibility to work with external organisations.	**Professional development:** - Lacking principal development. - Lacking the flexibility to adjust practices. - Can dictate teachers' professional learning.

2.4 School leadership and challenges for implementing education reform.

Several recent systematic reviews indicated the importance of school leaders for education reform (McLure & Aldridge, 2022, 2023; Walker & Hallinger, 2015). Historically, Leithwood et al. (2004) described that school leaders are the bridge between reform and its success in school based on leaders' motivation and skills. Recently, Pont (2020) described that the role of school leaders "has evolved in response to changing governance trends, from management, through accountability and now into professionalism" (p. 165). To clarify the role of school leadership, Aldridge and McLure (2023) discussed some factors that facilitate or prevent the reforms, including 1) the school climate (or pre-condition), 2) planning for change, 3) preparing for change, and 4) capacity building. First, the school climate can sufficiently support reform implementation through four aspects: a shared vision, high expectations, a positive relationship with a high level of trust, and a collaborative environment. Aldridge and McLure (2023) found numerous research that emphasised the importance of building a collaborative environment characterised by "high levels of trust, shared values and decision-making, working effectively as a team, and commitment to co-developing teaching practices" (p. 12). Second, a comprehensive school plan and the analysis and reflection of planning will be required in planning for change. Third, to implement the reform, the school structure needs to be adapted along with the clear communication of the goals. They recommended preparation before implementation with a necessary structural feature such as routines or scheduling. Finally, school leaders must ensure that their personnel understand the reform's criteria and develop their ability to serve as role models and mentors for others (Aldridge & McLure, 2023).

Aldridge and McLure (2023) suggested that school leaders must lead (not only manage) the change through a wide range of interpersonal skills such as collaborative skills, promoting

relationship building, developing social trust, or resolving conflicts. In building school leadership capacity to manage and lead the reforms, shared or distributed leadership is essential for more significant school change and sustaining the change (Aldridge & McLure, 2023; Leithwood, 2016). For example, distributed leadership combined with clear guidelines and teacher support can balance top-down and bottom-up principles (Aldridge & McLure, 2023). As distributed leadership is interactive, co-experienced, and collective, it fosters teacher leadership to maximise the benefits of student outcomes (Grice, 2019). However, distributed leadership my present a challenge in the Vietnamese context if leaders viewed themselves as being above other members.

Many researchers mentioned the importance of leading the professional development of school leaders for educational change (Grice, 2019; Leithwood et al., 2020; McLure & Aldridge, 2023; Walker & Hallinger, 2015) in order for principals to be able to provide teachers with the support with pedagogical change during the reform they need as the enactors of the curriculum (Grice, 2019).

2.5 Challenges for interdisciplinary learning (in secondary school).

Systematic reviews from White and Delaney (2021) and Hubert (2021) found some challenges and barriers to implementing interdisciplinary learning, including STEM education, in school, such as time-consuming preparation (Hubert, 2021), well-planned curriculum requirements (Self et al., 2019; White & Delaney, 2021), or the lack of consensus about instructional practices in integrated STEM (Thibaut et al., 2018). From the student perspective, a lack of required skills, such as collaborative skills or working in groups, can be difficult in the early stage of adopting interdisciplinary learning and hinder them from finding the connection between disciplines (Hubert, 2021). Co-teaching is a popular form used in applying interdisciplinary education; however, besides the benefits like increasing and enhancing the

teacher time for students, it also poses some challenges (Hubert, 2021; Self et al., 2019; Thibaut et al., 2018). For example, Self et al. (2019) described that "instruction was provided by faculty from different disciplines… at different times, resulting in a juxtaposition of disciplinary views and ideas" (p. 6).

Gao et al. (2020) found that in interdisciplinary constructs, most assessments still focused on assessing monodisciplinary learning (i.e., the assessment targets individual disciplines) and transdisciplinary affective domains (i.e., self-efficacy and willingness to major in STEM-related disciplines in college, or attitude towards STEM career) rather than interdisciplinary knowledge, practices, and affective domains. This may be anticipated, as it is argued that assessing interdisciplinary knowledge or practices is very time-consuming (Gao et al., 2020). Therefore, Gao et al. (2020) suggested developing practical assessment tools and guidance for teachers to assess STEM learning.

A framework for integrated Stem in secondary schools

Thibaut et al. (2018) introduced a framework for instructional practices in integrated STEM in secondary education that contained five fundamental principles: integration of STEM content, problem-centred learning, inquiry-based learning, design-based learning, and cooperative learning. Concerning problem-centred learning, White and Delaney (2021) also found that project/problem-based learning and community collaboration and involvement significantly contributed to the success of implementing interdisciplinary learning in a school. In addition, Self et al. (2019) called for using the actual application of learning as a critical driver for interdisciplinary approaches to design education alongside considering cultural context and social norms.

2.6 ASMS as a model for integrating STEM education.

The foundation of the ASMS

In 2002, the idea of the ASMS resulted from the partnership between the South Australian Department of Education and Flinders University in Adelaide, Australia, responding to the requirement of a total transformation of existing models of senior science and mathematics education (Bissaker et al., 2011). The combination of curricula lacking relevance to contemporary life, negative student attitudes and a shortage of qualified science and mathematics teachers created a significant decline in student interest and participation in secondary and tertiary mathematics and sciences (Bissaker et al., 2011). Therefore, ASMS's mission was re-engaging senior secondary school students in science and mathematics through innovative and authentic curriculum, promoting inquiry pedagogies, and self-directed learning and capacities to engage with and contribute to the 21st-century world (Bissaker et al., 2011). The ASMS was established due to "the need to explore new ways of teaching and learning in science" (Davies, 2006, p. 56). In rethinking schooling at the ASMS, students, educators, and leaders were all new learners and the centre of the process (Davies, 2006). To ensure the school's core beliefs were actioned (Appendix A), ASMS's leaders adapted learning organisation models and action research to create the ASMS Cycle of Re-thinking (Davies, 2006).

Figure removed due to copyright restriction.

Figure 1.1. ASMS Cycle of Re-thinking (Davies, 2006)

The ASMS school leaders tried to liberate science teaching from rigid preoccupations about what/how/when to learn by developing an interdisciplinary curriculum (IDC) combined with student-directed learning (Davies, 2006). Student-directed learning refers specifically to pedagogy whereby students are empowered to regulate their learning process in various ways, such as goal-setting, time-management, learning strategies, self-evaluation, or self-motivational beliefs (Lunenberg & Korthagen, 2005). The reason for developing the IDC was that phenomena in the real world are not confined to separate disciplines; life is interdisciplinary, and how people think is naturally interdisciplinary (Davies and Heath (2004). The ASMS IDC was designed to enable students to be knowledgeable in the disciplines of Mathematics and Sciences, make connections

in their learning, see multiple perspectives and appreciate diversity, problem solve and develop a viewpoint on various issues, and repackage knowledge to create new understandings to meet the complexities of the modern world (Davies & Heath, 2004). Through rethinking the Year 10 to 12 curriculum (the ASMS is a senior secondary school, meaning it encompasses only the last three years of secondary schooling: Year 10 to 12), the leadership of the ASMS wanted the curriculum to speak to students' interests through the leading-edge technologies leading the economy at the time, such as mobile phones, quantum computers, and smart appliances.

Learning for Years 10 and 11 in ASMS was structured in Central Studies (Figure 2.2) around key themes such as Nanotechnology, Earth and Cosmos, or Sustainable Futures (Davies, 2006). The Central Studies allowed students and staff to weave scientific understanding into other perspectives, such as culture, society, or ethics, to generate meaningful and connected understanding of real-world experiences. In addition, there was the development of University Modules in which Flinders University academics worked alongside ASMS's teachers to develop an enrichment and extension curriculum with leading-edge sciences taught at the university.

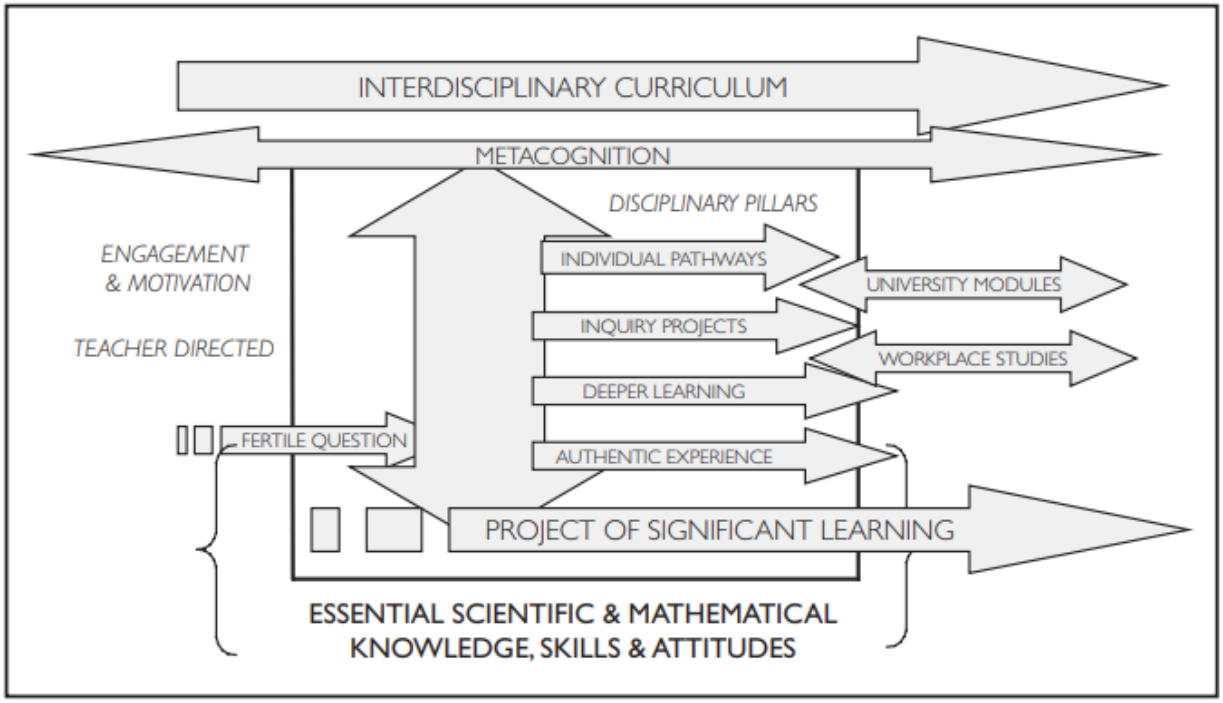

Figure 2.2. ASMS Central Study Framework

ASMS built its unique teaching practice and the interdisciplinary team model (Figure 2.3) involving teachers from different disciplines and university academic staff (Davies & Heath, 2004). The school schedules were designed to have weekly meetings between teachers' teams and the university academic staff to create rich dialogue and solve many challenges related to teaching practices, such as interacting or arguing other points while co-teaching (Bissaker et al., 2011). Davies and Heath (2004) pointed out that the highly public (apparent to students) and collaborative nature of teacher's work at the ASMS was the key driver of pedagogical reform.

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Figure 2.3. The ASMS interdisciplinary team model (Bissaker et al., 2011)

The interdisciplinary curriculum framework applied collaborative, inquiry-based, student-centred, and constructivist teaching practices in ASMS (Figure 2.4) to help students gain a deep understanding of science concepts (Davies & Heath, 2004). ASMS teachers were especially encouraged to view their students as professional partners to create opportunities for teachers to reflect on their teaching practices and their students' reflections on learning (Bissaker et al., 2011).

PEDAGOGICAL SHIFTS	
Teacher-directed →	**Student-directed**
Teacher	Teacher
• Knows. • Tells. • Examines.	• Facilitiates learning. • Coaches. • Challenges. • Verifies learning.
Student	Student
• Boundaries to learning defined for student. • Learning quantified by others.	• No boundaries to learning. • Demonstrates learning — verified by others.

Figure 2.4. ASMS Pedagogical shifts

Assessment emphasised real-life problems and ideas that deserved real audiences. Students demonstrate understanding and building on individual learning, sharing learning, and demonstrating learning in various ways (Davies & Heath, 2004). ASMS student attainments were guided by rubrics that intended to create opportunities to shape the depth of learning by helping set learning goals and individual learning plans for tracking and monitoring (Davies & Heath, 2004).

The desire for a collaborative learning community was the driver for the design of the ASMS learning space (Davies & Heath, 2004). The ASMS leadership wanted to create flexibility and adaptability in using space in which teachers worked alongside students as learning coaches or mentors (Davies, 2006). To redefine the relationship between teacher and student from teacher-directed to student-directed, there were and continue to be no traditional classrooms at the ASMS, and the teachers' workspaces were designed as open-to-learning common areas where the students gather. This design was thought to enhance collaborative and interactive teacher-student

engagement throughout the school day, as teaching always occurred around the teachers' workspaces, even when it was their nonteaching time. A unique physical space for teaching was thus merged with e-learning provision (Davies & Heath, 2004). This unique space is quite a significant issue in consideration of the impact of building design on the implementation of STEM within the context of more traditional schools. There are fundamental principles that should not be bounded by physical space and yet physical space can act as an enabler or barrier to effective STEM education.

Davies (2006) explained that for authenticity, the provision of a particular learning culture for ASMS students needed to be derived from the learning culture of ASMS staff, so ASMS leadership had to re-think the processes for professional development whereby learning becomes an integral part of a teacher's work (Davies & Heath, 2004). The ASMS, therefore, structured its timetable to include teachers' professional development, de-privatising teaching and creating an environment of interaction with university scientists and educationalists to bring 'real learning' to ASMS students. Therefore, being on the same precinct as Flinders University was an essential component of the school innovation, allowing teachers and the university scientists to work together in the school in developing curriculum, teaching practices, or bringing leading-edge sciences to the education of ASMS students (Bissaker, 2014). Partnerships between ASMS teachers and academics have been a critical professional learning strategy for transforming STEM education at the ASMS and developing an IDC (Bissaker, 2014).

The success of ASMS

The ASMS was awarded the South Australian 'SA Great' Education Award in 2008. In 2011, the OECD's Innovative Learning Environments (ILE) project recognised the ASMS by including it in a select group of 30 most innovative schools from 26 countries (Roberts & Owens,

2012). The ILE project emphasised that ASMS's achievements were expressed in many ways, such as a very high rate of student graduation, high levels of student satisfaction with teaching, and the recognition of the Australian Academy of Science about the school's curriculum as a leading example of an engaged curriculum.

From its opening in 2003, the ASMS had almost 20,000 visitors "from all corners of the globe" in its first decade (Oliver & Fisher, 2015, p. 60). People were particularly interested in its four critical platforms for teaching and learning about science and mathematics more engagingly: (1) a learning environment with its unique architecture and design; (2) learning programs with interdisciplinary science programs; (3) student learning with its high levels of student engagement; and (4) professional learning with its teacher's adaptation and development (Oliver & Fisher, 2015).

More recently, Bills and Howard (2019) conducted research with seven school leaders of the ASMS. This research revealed a relational essence of learning togetherness at the ASMS. The ASMS learning design prioritised the relational necessity for all school members to work closely with "greater coherence of purpose, deeper understandings and appreciation of each other's teaching and learning strengths" (Bills & Howard, 2019, p. 6). This learning design created a learning culture that embraced a willingness to innovate. Bills and Howard (2019) suggested the existence of learning togetherness in three embedded structures of the ASMS: (1) interdisciplinary learning, (2) an open learning environment, and (3) contributive leadership. The leaders of the ASMS introduced and continued to advocate the concept of 'contributive leadership' (Appendix B). This concept views all staff as contributing learners and "denotes the innovative willingness of staff and students collectively and creatively to dream big in learning." (Bills & Howard, 2019, p. 10). Contributive leadership drives the school's approach, pushing the edges to all. Bills and

Howard (2019) suggested that the success of the ASMS is based on the togetherness of all students and staff for the IDC and "the student inquiry-based learning teams that form naturally to make sense of the big ideas underpin the curriculum" (p. 14).

2.7 Summary of the literature review

The ASMS had solutions to face difficulties in implementing interdisciplinary curriculum and teaching as noted by systematic reviews, such as the need for a well-prepared curriculum, the consensus in instructional practices, or time consumption. The ASMS leadership also developed its unique leadership to drive the school successfully. The contributive leadership concept is not opposed to or distinct from the concept of distributed leadership, recommended by systematic review for interdisciplinary learning, contributing to the success of the ASMS right from its formative years (Bills & Howard, 2019). Therefore, I argue that the formation and development process of the ASMS may be a quality resource for a better understanding of working towards the sustainable construction of an interdisciplinary educational environment, specifically for STEM education. Although it would be important to acknowledge the unique features of being located on a university campus and in a purpose designed school as difficult to replicate, however, this doesn't detract from potential to replication other principles such as the professional learning model, contributive leadership etc.

2.8 Conclusion

I earlier suggested that the literature showed the importance of leadership roles during educational reforms and called for improved instructional leadership in Vietnamese schools (Dimmock et al., 2021; Nguyen et al., 2023). However, I noted many challenges for Vietnamese school leaders during education reform. In addition, implementing interdisciplinary learning, including integrating STEM education, has many challenges and barriers (Hubert, 2021; Self et

al., 2019; Thibaut et al., 2018; White & Delaney, 2021). Therefore, I argued that Vietnamese school leaders and teachers need to cooperate closely in the current process of integrating STEM education.

In Chapter 1, I described many current misunderstandings and challenges in integrating STEM education in Vietnam. Facing challenges, Vietnamese education can aim to borrow STEM education practices from abroad to implement the educational reform process quickly. Therefore, I aim to bring insights from a successful model integrating STEM education like ASMS to broad Vietnamese school leaders and teachers' communities. However, bringing ASMS's successes through academic papers to these audiences would still be difficult. Therefore, I may need more vivid, straightforward information and a closer approach. In addition, with the difference in culture and context, aspects of the curriculum design and implementation at ASMS need to be clarified and discussed more carefully before considering any replication in Vietnam.

With the considerations I have presented, I focused on closely and authentically documenting the early years of ASMS's development, aiming to provide both Vietnamese school leaders and teachers with a framework for integrating STEM education in Vietnam.

METHODOLOGY

3.1 Introduction

In this chapter, I outline the research design, methodology, research methods, and the epistemological perspective underpinning the methodology. This chapter also provides the instruments and the process of analysing the data. It presents the parameters of the study and my ethical duties while conducting it. This chapter explains my adoption of the naturalistic paradigm (Owens, 1982). Naturalistic inquiry has numerous qualities that make it appealing to my research. Based on naturalistic inquiry, I crafted my research as a case study using portraiture to examine the experience of one of the founding school principals of the ASMS during the school's beginning period to address the research questions (Chapter 1).

3.2 Research Design

Research epistemology

The epistemological foundation underpinning this research is social constructionism. Crotty (1998) described social constructionism as the view that "all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of the interaction between human beings and their world and developed and transmitted within *an essentially social context*" (p. 53). Social constructionism is interested in what happens between social actors in the social space that contributes to the construction of knowledge between them (Gergen, 2015). The nature of social construction is creating meaning/reality (Crotty, 1998; Gergen & Wortham, 2001). Social constructionism is fit for this study as the study aims to understand the process of building an interdisciplinary learning environment, which is a socially constructed reality developed from a collective generation of meaning (Crotty, 1998) through a process of coordinating actions among persons (Gergen & Wortham, 2001). In this case, I argued

in Chapter 2 that the ASMS has characteristics that make it successful in a particular context, such as the contributed leadership model out of the broad recommendation of distributed leadership. Therefore, it is necessary to use the social constructionism perspective to gain insights from how people at ASMS co-constructed during its early years.

Theoretical perspective: An appreciative perspective

Cooperrider and Whitney (2011) argued that dialogue and stories focused on strengths and elements of success will yield meaningful knowledge. Therefore, I went into this study believing that through dialogue and stories about the good things within the beginning of the ASMS with the founding principal, meaningful knowledge and insights about building and sustaining an interdisciplinary learning environment will be constructed. From a social constructionism perspective, I understand meanings and social realities to be actively co-constructed between participants (Gergen, 2015), and this included my personal experiences working within the areas close to what ASMS is doing. I therefore set out to actively co-construct the meaning with the participant.

3.3 Research methodology

This study was a case study. A case study is an empirical method that investigates a contemporary phenomenon in depth and within its real-world context (Yin, 2018). I used the ASMS as the case of this study. This research drew on samples within this case by interviewing the founding principal and collecting specific documents, including public records and briefing documents, to gather the data. The selected public documents focus on the period of ASMS development from 2003 to 2010. Considering the sustainability of interdisciplinary educational development at ASMS, undertaking a case study helped me focus on agreements and constructing knowledge about organising interdisciplinary learning (Merriam, 1998; Yin, 2018).

Research method: Portraiture as research method

Sara Lawrence-Lightfoot (1997) introduced the portraiture research method, which seeks to record and interpret the perspectives and experiences of the people they are studying, documenting their voices and visions – their authority, knowledge, and wisdom. Portraiture is a method framed by the traditions and values of the phenomenological paradigm, sharing many of ethnography's techniques, standards, and goals. However, it pushes against the constraints of those traditions and practices in its explicit effort to combine empirical and aesthetic description, in its focus on the convergence of narrative and analysis, and in its goal of speaking to broader audiences beyond the academy (Lawrence-Lightfoot & Davis, 1997, pp. 13-14). Therefore, portraiture was suitable for this research as I sought to highlight successes and present findings in user-friendly ways to enhance understanding of the experience and the process of building an interdisciplinary learning school in this case (Hackmann, 2002; Lawrence-Lightfoot, 2005).

Portraiture employs qualitative data collection methods, including observations, interviews, and reviews of public and private documents, to generate trustworthiness (Hackmann, 2002; Lawrence-Lightfoot & Davis, 1997; Travis, 2020). As this study focused on the beginning of ASMS 20 years ago, the observations were limited.

Purposeful Sampling

Purposeful sampling was used, and a participant was specifically chosen as he could provide insight into the investigation (Creswell, 2012). The sample size for a qualitative study can also be small, even just one, when the study aims for depth in the data collected from the source and breadth is not necessarily needed (Creswell, 2012). Therefore, I planned to interview the founding principal to collect data around the beginning period of ASMS. The person was the

school principal for seven years, from 2003 to 2010. In this study, I use FP to represent him with his permission.

After gaining ethics approval from the Flinders University Social and Behavioural Research Ethics Committee (Appendix C), I contacted the FP via an invitation email (Appendix D). I received his happy agreement to assist me in this project. Our first in-person meeting was on August 19th, 2023, the 20th anniversary of the ASMS, where we looked at artifacts about the school and decided on how to conduct the interviews together.

3.4 Data collection procedures

Observations

Observations were employed to give me a better understanding of ASMS, including the physical space, strong artifacts, and the school's atmosphere. I was aware that the school has changed compared to 20 years ago. However, some characteristics have not changed too much, such as the structure of physical space. I chose two public events to observe, including 1) the Open Night, which was used as a chance for junior secondary students and their families to explore and experiment with the school and 2) the 20th anniversary of ASMS.

The first observation was conducted during a public *Open night* event on August 2nd, 2023. I participated as a parent to learn about the school, and some of the highlights were noted, such as placing the teacher's corner in the middle of the learning space or student agency, which was a buzzword when talking with current students.

The second observation was conducted during the public 20th anniversary of the ASMS event on August 19th, 2023, in which I had a chance to listen to sharing about ASMS's success as well as the feelings of some students.

Reviewing public documents

Reviewing public documents, including press releases, helped me gather different perspectives on forming ASMS to create rigour in the data collection (Hackmann, 2002; Lawrence-Lightfoot & Davis, 1997). In addition, collecting press releases provided critical materials for recalling stories during the interview process.

The review of public documents was conducted in the ASMS's library, located within the Sturt Library of Flinders University. The librarian helped to provide the collection of press releases from the beginning of ASMS and ASMS's yearbooks. I focused on the press releases from 2003 to 2010, the founding principal working period. Several stories that I felt related to the research questions were selected as suggestions for recalling stories. Images were also extracted to provide relevant artifacts about the school.

Interview process

In portraiture, interviews bridge the subject and the researcher, facilitating the production of rich, complex, and emotionally resonant images (Gerstenblatt, 2013), and allow the interviewer to probe and expand the interviewee's response to obtain in-depth information and have more flexibility (Alshenqeeti, 2014). Aiming to understand the process of building the learning environment back to 20 years ago, the interview questions were designed as open-ended to allow the interviewee flexibility to recall what information they remember and also elicit the most elaborate response (Powell & Guadagno, 2008; Weller et al., 2018). Lawrence-Lightfoot (2005) cautioned that "the identity, character, and history of the researcher are critical to how he or she listens, selects, interprets, and composes the story" (p. 11). Therefore, I had to clarify my personal experiences and views on interdisciplinary education/STEM education during my work in Vietnam with the interviewee to support our process of co-constructing the data.

The participant and I agreed to divide the content we needed to discuss into three parts through three interviews. The first interview focused on better understanding what this research hopes to bring, understanding the issues surrounding the formation of the school, and sharing our perspectives. The participant also shared some documents related to the ASMS formation process. For example, a presentation the participant used when introducing how they created the school or the participant's note about how the School of Environmental Studies greatly inspired ASMS. After consulting with my supervisor, the initial interview questions for the subsequent two sessions were adjusted (Appendix F). The interview questions and clues extracted from reviewing public releases were sent to the participant one to two days before the second and third interviews to help him recall memories from 20 years ago.

Before conducting interviews, the participant signed the consent form (Appendix E) after its content was carefully explained. All the interviews were conducted in a quiet, private space and took an average of 90 minutes in length. All interviews were audio recorded and taken notes.

3.5 Data analysis

In analysing the data, portraitists try to draw out and construct emergent themes to create individual portraits of critical features of the phenomenon (Ahrens, 2019). I followed five modes of synthesis, convergence, and contrast from Lawrence-Lightfoot and Davis (1997), including 1) listening for repetitive refrains, 2) listening for resonant metaphors and poetic and symbolic expression, 3) listening for the themes expressed through cultural and institutional rituals, 4) using the triangulation to weave the threads of data converging, and 5) creating the portrait of critical features of the phenomenon (as cited in Ahrens, 2019). In addition, embedding the researcher's voice within the text (the narratives) enables readers to achieve deeper understanding and empathy (Hackmann, 2002). Therefore, I also identified my voice when conducting the portraits.

I first transcribed the recorded interviews into verbatim transcriptions. Then, these transcriptions were emailed to the participant to check, add, or adjust some specific words. After receiving confirmation, I first looked for repetitive refrains, resonant metaphors, and symbolic expressions to create the first list of codes. I then grouped similar codes and removed the redundant codes. I also combined listening to the audio recordings to capture the voices and feelings of the participants when recalling the memories. Each code group had notes about the participant's voices and reminiscent colours to use later in painting the portrait. I re-read and re-listened to the interview transcriptions to check whether I correctly identified any emerging codes and highlighted specific quotes and stories.

Lawrence-Lightfoot and Davis (2002) mentioned that the portraitist comes to analyse the data with an intellectual framework and set of guiding questions resulting from reviewing the literature, experiencing the similarities, and having general knowledge of the field of inquiry. Therefore, I used the recommendation from the success of ASMS (Figure 1.1) in the literature review as the framework for reducing the code and creating the basic themes. In addition, some new themes emerged from the collected data. Finally, all themes were woven into each other in creating the portrait and narratives. The narratives explained the whole picture of the formation of ASMS into small pieces.

Drawing the portrait

In capturing what is, in essence, a case study of the beginnings of ASMS, I used the collage technique, in which I extracted pieces of information and images from press releases, combined with the topographic mapping approach to hold the threads together. Looking for a metaphor while using portraiture to analyse the data (Ahrens, 2019) led me to use topographic mapping to draw the portrait of the school. When seeing the actual school from a panoramic view combined with

information about the school's mission and connecting the goal of providing a more accessible document to the target audience, school leaders and teachers in Vietnam, I tried to generate a unique portrait that is close to the summer schools in Vietnamese culture. The detail of the Metaphorical images (Table 4.1) and their metaphorical colour code (Table 4.2) are explained in the next chapter.

Writing the Narratives

Lawrence-Lightfoot and Davis (2002) mentioned that portraitists must clearly define their voice when writing the narratives, including witness, interpretation, preoccupation, autobiography, other voices, and dialogue. They explained that voice is the individualistic impression of the researcher on the portrait. Therefore, it cannot be isolated from the product – the portrait with the narratives - and from the collecting and analysing process to create the portrait. With my working experiences in promoting STEM education, my basic knowledge of interdisciplinary learning, my personal perspectives on education, my philosophical stance, and my emerging impressions about this school, three different voices of mine will appear in narratives. First, as I listened for stories, I would listen and guide the narratives through my carefully prepared questions and the emerging responses based on the keywords I picked up from the listening process. Second, as I am interested in the school building, my preoccupation would happen throughout the narratives, such as the interdisciplinary learning or the leadership. Third, most of the narratives would be in the voice of *autobiography,* as I used my knowledge and experience as resources for understanding, connecting, and interacting with the participant. Using these voices gave me flexibility in using direct quotes or participant's stories to bring truthful information.

3.6 The quality of the study

The rigour of this qualitative study will be addressed through trustworthiness, credibility checking, member checking, fittingness, and audibility.

Generating trustworthiness

Using multiple sources of information in using portraiture in analysing the data, the study has already generated trustworthiness, such as data from interviews and related public documents (Golsteijn & Wright, 2013; Lawrence-Lightfoot, 2005). In addition to public documentation, I also used information samples from press releases about activities, highlights, reviews, and materials suggested by the participants.

Credibility checking

I enhanced the credibility of the findings by discussing them frequently with supervisors. This enabled different views or perspectives and the practice of reflexivity in developing the findings. I tried to manage my biases on the research outcomes by making bias visible through sharing, seeking feedback, and ongoing dialoguing with my supervisor (Hosking & Pluut, 2010) to make visible my sources of subjectivity, such as the cultural lens I bring to the study.

Member checking

First, the transcripts of audio records were carefully checked with the participant to ensure accuracy before coding. Then, the portrait narratives and findings were also reviewed with the participant to ensure the interpretation of the data in the participant's manner (Krefting, 1991; Lincoln & Guba, 1985). I was aware of carefully managing "the tension between personal predisposition and rigorous scepticism" (Lawrence-Lightfoot, 2005, p. 11). Therefore, member checking of the portrait narratives and findings was essential in forming the rigour of this narrative portraiture research.

Fittingness

As I used the case study method, it was also essential to provide documents related to the context and the case of the study through the years to ensure the relevance and applicability of the findings, including the public records or briefing papers relating to the establishment of ASMS and the context of interdisciplinary learning in South Australia at that time. In addition, I position myself within the context of Vietnamese education, particularly STEM education, so that my interpretation can fit into the study's aims.

Auditability

Guba and Lincoln (1994) describe the auditability of research as another researcher's capacity to follow the decisions at every stage of the analysis. To increase the audibility of the study, detailed information was provided, including the process of collecting and analysing the data and the process of writing up the portraits.

3.7 Parameters of the study

There is no perfect research, so this study also has certain limitations due to circumstances outside the researcher's control and delimitations.

Limitations

Generalisability and replicability are not goals inherent in this qualitative research. Therefore, using a qualitative case study as the research method brings limitations in generalising and replicating the study results. Specifically, the uniqueness of ASMS may mean that my conclusions may not be transferable to other school contexts. The study involved only one participant and asked to recall the stories from 20 years ago, which may affect the study's reliability. Using a portraiture narrative to analyse data, which involves the researcher's interpretation, opens space for researcher bias; my personal experience in STEM education in

Vietnam was especially used in how I co-constructed the data collection process (Lawrence-Lightfoot, 2005).

Delimitations

With ASMS's distinct elements, it succeeds in promoting interdisciplinary learning and gradually becomes a good practice. However, due to time constraints, the research only focused on the beginning of ASMS to help researchers understand the process of building an interdisciplinary learning environment to support the promotion of interdisciplinary education in Vietnam. However, the ASMS is 20 years old and has changed significantly since its early days. There will be many lessons worth considering in the school's development process. Therefore, future research can focus on examining the transformation of the school's portrait through each intermediate stage to outline the school's change process.

3.8 Ethical considerations

This research obtained unconditional ethics approval from the Flinders University ethics committee and the South Australia Department for Education, application number 6252. In applying this ethics approval, I carefully reviewed the ethical considerations in the research design, review, and implementation, especially the burden placed on the participant (National Health Medical Research Council, 2007).

The study recruited the founding principal as the primary participant through an email (see Appendix D). There are no recruitment risks or privacy issues for the participants. Since there was no link between the researcher and the target participant, there was no coercion or influence on the participant's existing relationship. The interviews were guided by the participant freely retelling good stories or memorable moments without the pressure of documenting the entire construction of the ASMS.

Considering the benefits for the participant, the focus was on trying to make the most of the information the participant provided, thereby indirectly benefiting the participant, specifically in documenting the participant's contribution to education. By respecting the participant as a human being, the researcher wanted to show the highest recognition of his intrinsic values (National Health Medical Research Council, 2007).

Some possible risks and the burdens placed on the participant during the data collection process were also carefully considered. First, there was no conflict of interest as the primary participant no longer works at ASMS. Second, aiming to have in-depth interviews, the researcher separated the discussion into different sessions. Finally, the participant was assured that their withdrawal would not put the project at risk as the research could be completed by document analysis and other data sources, thus avoiding any unnecessary sense of obligation.

3.9 Conclusion

This chapter outlined the research design and process. In addition, it specifically described the tools the researcher used to collect and analyse data. It also includes information about the quality of the research, ethical concerns, and the research parameters the researcher is concerned about. In Chapter 4, the researcher will provide the result of the study, including the portrait and its narratives.

FINDINGS

4.1 Introduction

The findings are presented as a portrait combining images and narratives (Lawrence-Lightfoot & Davis, 1997) about the early years of ASMS's development, aiming to provide both Vietnamese school leaders and teachers with a framework for integrating STEM education. All personal names have been provided pseudonyms to maintain confidentiality, prevent the participant's identification, and respect the participant's privacy.

4.2 Overview of the participant

In 1999, FP worked as a principal in South Australia. The South Australian government approached him with a proposal to work with a professor at Flinders University to solve the significant decline in the number of students interested in science subjects in Year 12 and entering the university. FP and the professor collaborated and reported the key suggestion of building a lab school to try out new ideas. After receiving South Australian government approval in 2002, the idea of the ASMS began to take shape. FP continued to join a group of experts in finding ideas for building ASMS. After the school officially opened in 2003, FP worked as principal until 2010.

Throughout his years working at ASMS, FP's primary duties were leading research and development of cutting-edge science and math curricula and pedagogy; ensuring that ASMS provided excellent senior secondary education with a focus on Science and Mathematics; creating and implementing professional development programs for educators in South Australia, across the country, and around the world, with a focus on innovative Science and Mathematics curriculum and pedagogy; and building cooperative alliances and cooperative projects with industry-based research and technology groups, Flinders University, and several government bodies.

4.3 The portrait

The portrait that follows (Figure 4.1) recreates the early years of this unique school through information collected about it from 2004 to 2007. In this findings chapter, I will explore each section and its associated meaning in more detail.

Figure 4.1. Portrait of the ASMS's formation

In Vietnam, summer schools are organised by temples and often located at the top of a hill, entirely separate from the surrounding world. The ASMS is also situated on a hill in Adelaide, South Australia. To build that school on the top of a hill, we need a good foundation, usually built from pieces of stone. Therefore, I can use the collages to represent the stones I call the school's foundation (brown sections in Figure 4.1). In addition, I also used other metaphorical images to represent different aspects related to the foundation of ASMS's building process.

Table 4.1. Metaphorical images

Metaphor	Description	It represents	Inspiration
Partnership bridge	yellow part connecting the yellow corner with the orange area	A unique partnership between ASMS and Flinders	A unique bridge and buses directly connect ASMS with the university's main campus.
The demonstration stadium	An image of a stadium in the blue area	ASMS's culture of 'Expo Day' and Science Fair	ASMS organises Expo Day at the end of the semester in which student can invite everyone to come and show them their learning product
The international runway	An image of an airport runway in the blue area	Opportunity to connect with international partners	After the first Science Fair hosted in Adelaide, ASMS's students had many chances to fly worldwide to share their learning.
School bus	An image of a bus in the orange area	The pedagogical approach of ASMS	ASMS teachers work as mentors and help students find what they need by driving them to the suitable areas.

Each section of this metaphorical topographic mapping used the colour emerging from creating codes.

Table 4.2. Metaphorical colour code for ASMS's portrait

Colour	The metaphorical represent	Reason
Brown	Foundation of ASMS's formation	Dissecting the mountain to reveal the instabilities within and fortifying it with sturdy stones.
Yellow	Partnership with Flinders University	Flinders University's signature colour and Colour of positive light ray
Green	Students come to ASMS	Symbolising the development, freshness, and fertility.
Pink	Teachers come to ASMS	Symbolising positive change.
Blue	Culture of demonstration of learning	The colour of the sky expands our horizons or boundaries.
Orange	Learning culture of ASMS	The tone of enthusiasm, determination, and brightness.

In the next section, I describe each part of this portrait to you, in turn, through stories formed from my conversations with FP, one of the school's founding leaders.

4.4 The narratives

From the response to a new direction

Even though it was more than 20 years ago, FP, who accompanied the project of building this school from the early stages, reminisced with a smile. The mood of excitement, he exuded pride. I started to think that maybe this project was very special for everyone.

First inquiries…

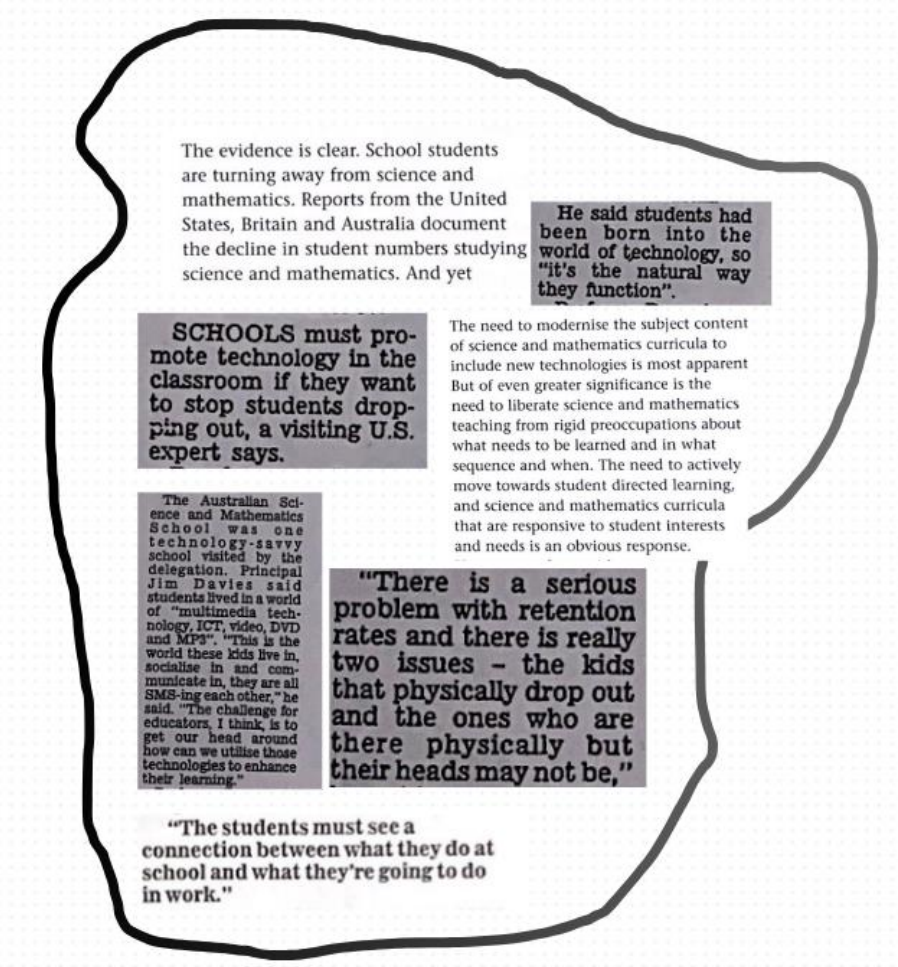

Figure 4.2. The reason behind this.

At that time, Professor J from Flinders University noticed a decline in the number of students entering university in the broad sciences and, indeed, participation of students in year 12 in Physics, Chemistry, Biology, and Geography sort of subjects. I understood that year 12 students were not interested in choosing these subjects for the South Australian Certificate of Education (SACE) program, similar to high school graduation in Vietnam. Professor J approached the Minister of Education in South Australia, and after some discussions, they thought, "*Why don't we try and do something together?*". FP was asked to join a group of members to dig deeper into the

causes of this situation. What had led students to turn away from science and mathematics, and what could they do? Even students became aware of the importance of new technologies and the role of science and mathematics in understanding these technologies. Sadly, how they were taught failed to keep up with technologies reshaping modern life. Moreover, from there, they fail to attract students' attention. FP explained,

> Students have been born into the world of technology, so it's the natural way they function. Schools must promote technology in the classroom to stop students from dropping out… Students must see a connection between what they do at school and what they do at work.

They then questioned some science curricula from the South Australian Secondary Assessment Board.

> Do those curricula speak to the interests and general life experiences of the young people in our schools? …Clearly, no… people don't see physics playing itself out necessarily.

At the end of those inquiries, Professor J came up with the idea that they needed a laboratory school to implement and *play with these ideas about how we can do this better*.

The inspiration…

A group of experts, including FP and Professor J, participated in an international study tour worldwide. They found the most impactful model of the development of ASMS to be the *Zoo School*. The school's official name is The School of Environmental Studies (SES). It is a partnership of Independent School District 196, the Minnesota Zoological Gardens, and the City of Apple Valley in Minnesota. The school's vision is to be a community of leaders learning to enhance the relationship between people and their environment. The school opened in 1995 for 400 eleventh and twelfth-grade students in a facility built on the site of the Minnesota Zoological Gardens. SES was chosen by students interested in interdisciplinary instruction, studying about the environment, and doing hands-on work. Also, students are attracted to independent learning

experiences with the opportunity for real-world applications and the potential to prepare themselves for a future career and college.

Figure 4.3. Inspiration from Zoo School

FP was fascinated by what was happening there, and it became the founding team's fundamental belief in building ASMS, the *demonstration of learning*. Some ideas emerged when FP observed the Zoo school, especially the collaborative learning model (Appendix G – Story 1).

The action…

So, the decision was made to tackle the problem with a $14 million project to develop a purpose-built school with funds provided for teachers and leaders to contribute to curriculum design in collaboration with university staff before the school opened. The school was opened in 2003 as a public school under the management of the South Australia Department of Education. Meanwhile, the partnership with Flinders University remained strong as the university contributed to the project, not with money, but the school was built on the university's swimming pool, right in the middle of the university's campus.

Figure 4.4. The first building of ASMS

To the new direction…

FP always says ASMS's biggest goal is to find a new way to teach and learn science. ASMS would challenge several traditional views about learning, especially in science and mathematics, ranging from the design of learning environments, curriculum, pedagogy, and the structure of the school day. Its activities were shaped by the interaction between teachers, university staff, and industry partners that guaranteed continued professional development. It is responsive to student interests and student-directed learning. It has credibility and depth endorsed by practising scientists and educators focusing on the new sciences and philosophy of science education. It liberated science and mathematics from being a set of narrow technicalities.

Rethinking to stretch the boundaries: The physical environment

On their study tour to Zoo school, the key architect questioned: “FP, tell me where the students will be. What will the students be doing?”. And that was the way they formed the design of the building.

> All spaces are linked by an internal street or common space, providing informal learning, display, social interaction, and circulation. All other spaces are linked to this street, which exposes staff and students to the life and activity of the school as they move through it.

Figure 4.5. ASMS’s central spine

Stuffy classrooms and rows of desks have been replaced with an open-plan setting. No classroom, no walls separating the learning domains, no offices for teachers to hide in, or a ubiquitous ICT-rich environment are words used to describe the physical space of ASMS. Under those descriptions were the beliefs that contributed to the design of the learning space at ASMS,

including collaboration and community. ASMS wants to *remove traditional classroom barriers that isolate groups of students and teachers*.

Figure 4.6. The learning common.

So, what does ASMS have? Learning commons are always the busiest space, providing the students with their workstations and where the learning happens. They have all the necessary teaching equipment, from whiteboards and projectors to stations with learning tools. These places can take place every possible activity, from group study and tutoring to conventional teaching practices for 50-60 students at the same time. Significantly, there are times when you can see different classes going on simultaneously without walls between them. These activities take place without any physical barriers.

Studios, which provide specialist services and equipment to give students practical work and experimentation opportunities, are located adjacent to the common study area. The students' ability to access them while doing their inquiry projects makes Studios different from regular schools' labs, where students only go there for certain lessons (Appendix G – Story 2).

Adjacent to the learning commons and studios, the teacher corners are where the group of teachers have their tables. It is also easy for teachers to observe the activities inside the common spaces and for students to approach teachers easily. There are no offices for teachers to hide in.

At the time of opening, ASMS was also equipped with much technology, such as a wireless environment and desktop computers throughout the learning commons. They strived towards minimal use of textbooks when teaching and learning materials were available on the shared network. ASMS learning space is trying to de-privatise educational practices.

The interdisciplinary curriculum…to stretch the boundaries of student learning

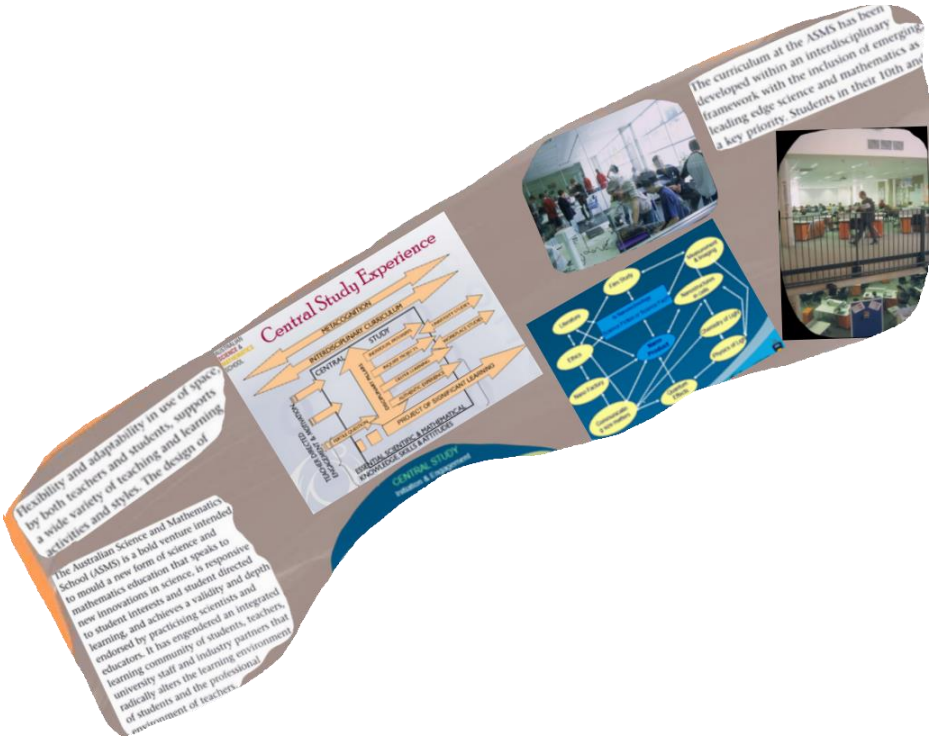

Figure 4.7. The interdisciplinary curriculum.

When Professor J noticed the decline trend in the early days, they wondered if something was going wrong. S*tudents all do science and mathematics up to year 10 in school, but out of year 12, there is a significant drop-off*. They found that at that time, what was happening in schools was still heavily teacher-directed and out-of-date knowledge.

> Teachers tell them what they will learn and examine. The boundaries to the learning were defined for them… and you're still teaching year 12 students a traditional physics course that I did in 1962.

They, of course, encountered counterarguments such as the foundations of science found in physics and chemistry, or before letting students have a go at nanotechnology, make sure they have done physics in year 12. However, it also came back with the mission of ASMS to look at the curriculum and ways of teaching to capture the knowledge of the real-world experience for young people.

One time, when they had an interview with the Minister of Education with a group of 6 or 7 students, the minister asked: "*V, you tell me why you're at this school*". Very quickly, she said: "*Because there are no boundaries to my learning*." It was a very insightful answer from a 16-year-old student to show understanding of her learning. FP stated that:

> When you get into this interdisciplinary curriculum, you open the doors for students to investigate things, inquiry-based learning, and so on. What you actually do is to generate opportunities for students to escape those boundaries, not be confined to them…

However, things were difficult, and they encountered challenging times. First, as ASMS is still a public school, it must follow the state's formal education act regulatory environment. This problem stuck with them for a long time until a special committee was formed with the cooperation of many stakeholders, including universities, parents, school boards, and governing councils. FP describes with excitement that:

> It gave us a vehicle to bring scientists and new sciences into the disciplinary curriculum and …gave us the vehicle to make these innovations with consent.

Secondly, they had to deal with the SACE certification and examination, which is the vehicle for student's success in the future, especially the university pathway. FP had to make the most difficult decision to use a unique program for year 10 and 11 students, and students will return to the study of individual topics as per the SACE model rather in year 12 rather than the interdisciplinary approach.

From the central study… to the self-inquiries and authentic performances

The centre of the interdisciplinary curriculum framework is the 'Central Studies', which allows students to connect their learning with learning from other disciplines. Those Central Studies, such as Towards Nanotechnology, Earth and Cosmos or Sustainable Futures, provide students and ASMS staff with the chance to weave scientific and mathematical logic with cultural, social, historical, legal and ethical perspectives, generating meaningful and connected understanding of real-world experiences.

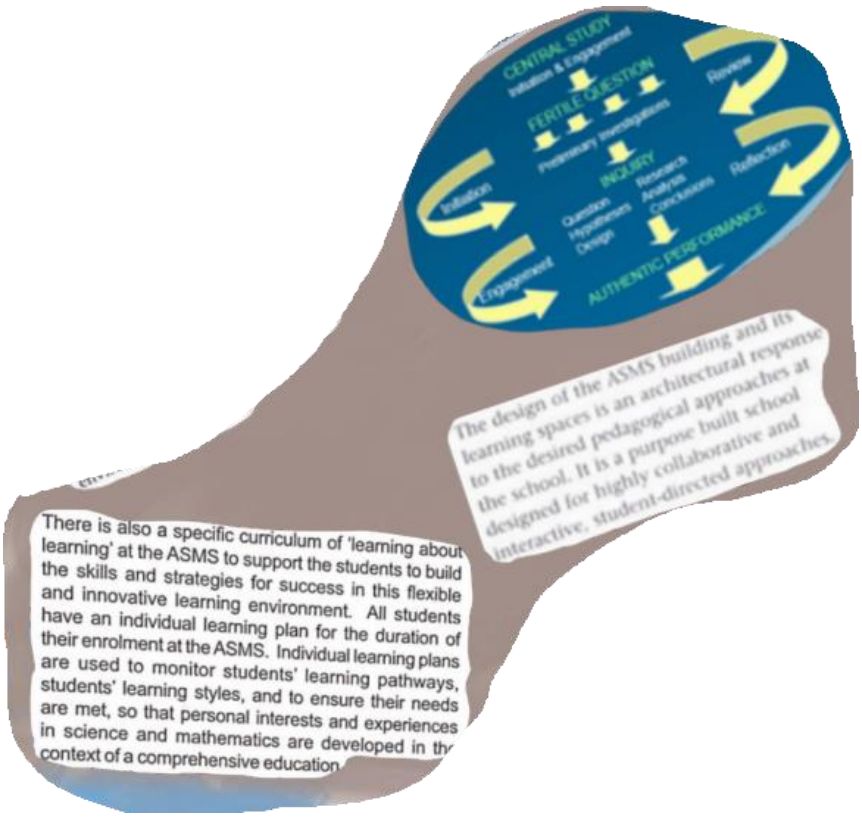

Figure 4.8. Enhancing authentic performance within ASMS's pedagogy.

Every Central Studies starts with some fundamental content that students need to know. Then it comes to the *fertile question*, which opens lots of opportunities, different answers, or avenues of investigation. For instance, under a fertile question like "science fact or science fiction?" within the nanotechnology theme, an English teacher would work with students on the science fiction side by asking them to read and interpret certain topics. At the end of the exercise, students would develop *Preliminary Investigations* based on their interests. They can get some recommendations about research avenues from teachers working alongside mentoring, helping them through the investigations, bringing them back as a class group or keeping reporting about what they are doing. Students can come to the next step in which they develop their inquiries through developing questions or research hypotheses. Then, they can design and analyse research, which will lead to their authentic performance, such as a new nano product. This task challenges

students to get out there and think about the application of nanoscience. It creates and motivates students to perform their authenticity. Ultimately, they will have a demonstration day inviting everyone to come, show them their products, and get feedback (Appendix G – Story 3).

Personalised learning with inquiry-based approaches

Within Central Studies, ASMS lets students go beyond the boundaries and play with their inquiries. This also shapes the daily activities seen at ASMS (Appendix G – Story 4). Significantly, the students are in the driving seat, and the teacher is very much in support.

> Oh, you have learned that. Oh, have you thought about this? What else can you do? You know, that sort of mentoring, driving it, driving it forward.

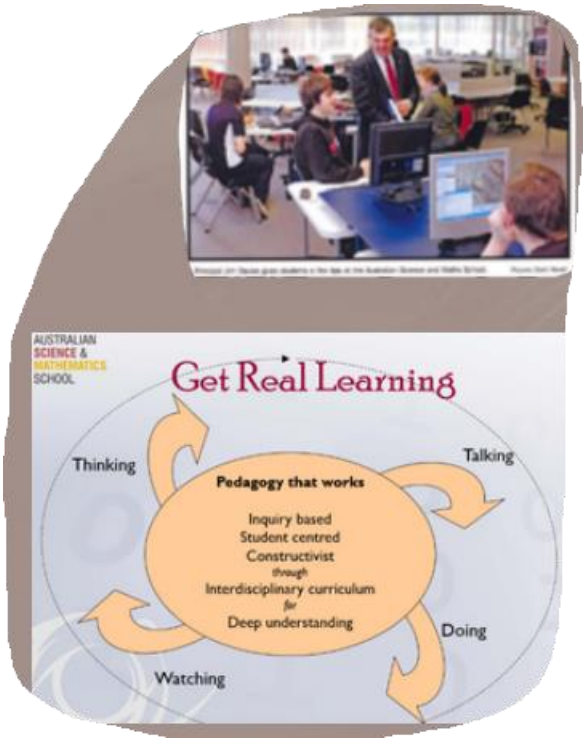

Figure 4.9. Inquiry-based at the top of pedagogy.

For FP, *teaching is not telling, and teachers are clinicians, not technicians*. He explained that clinicians develop a deep understanding of what is happening and how it can be developed. If you want to be a learner, you must understand all the contributing bits to the knowledge you are

trying to learn. This idea reminded us of the story about ‘no textbook’. The story started when a student, who was doing some calculus, came to FP and complained about where the maths textbooks were. Moreover, FP’s answer was, “No, you don’t need one; you’re going to do it this way.” The student will write their own textbook based on everybody’s research, and the teacher will contribute to the background (Appendix G – Story 5).

Right from the start, they had a big idea about building learning models in which students work together in thinking, talking, and building knowledge. FP always wants to tell his students, "*You think your learning is really important to you, but your learning's far more important to share with the person next to you*.” For him, if you own the learning, sharing that learning is just like you own anything else.

Moreover, FP and his team were trying to increase student agency about what/when/how they learned and, importantly, how students knew about the quality and the extent of what they learned. He said that *“if we think about the interdisciplinary, it does not need to all be in the school. Some of it could be in the partner university or the library; some could be after school or at home”*. They want to create pedagogical things, including highly collaborative, highly interactive, and inquiry-driven. FP calmly asked himself, "*Who owns the learning? Who should decide what kids learn in school?*”. Students should have the opportunity to decide what they learn in school.

The ASMS’s drivers

In the beginning period, 85 per cent of the school budget was for human resources. Although it is a public school within the state system, it still had much autonomy in building its structure. They had a principal, a deputy principal, and two assistant principals. The start-up group of teachers included some experienced teachers from other schools in the state and two graduated teachers. They also included some heads of department coordinators in Biology, Mathematics,

English, and Physical sciences. They also had other support positions, including IT media manager, laboratory manager, studio manager, personal assistant for the principal and deputy principal, business manager who managed all the school finances, and some administrative officers for various activities.

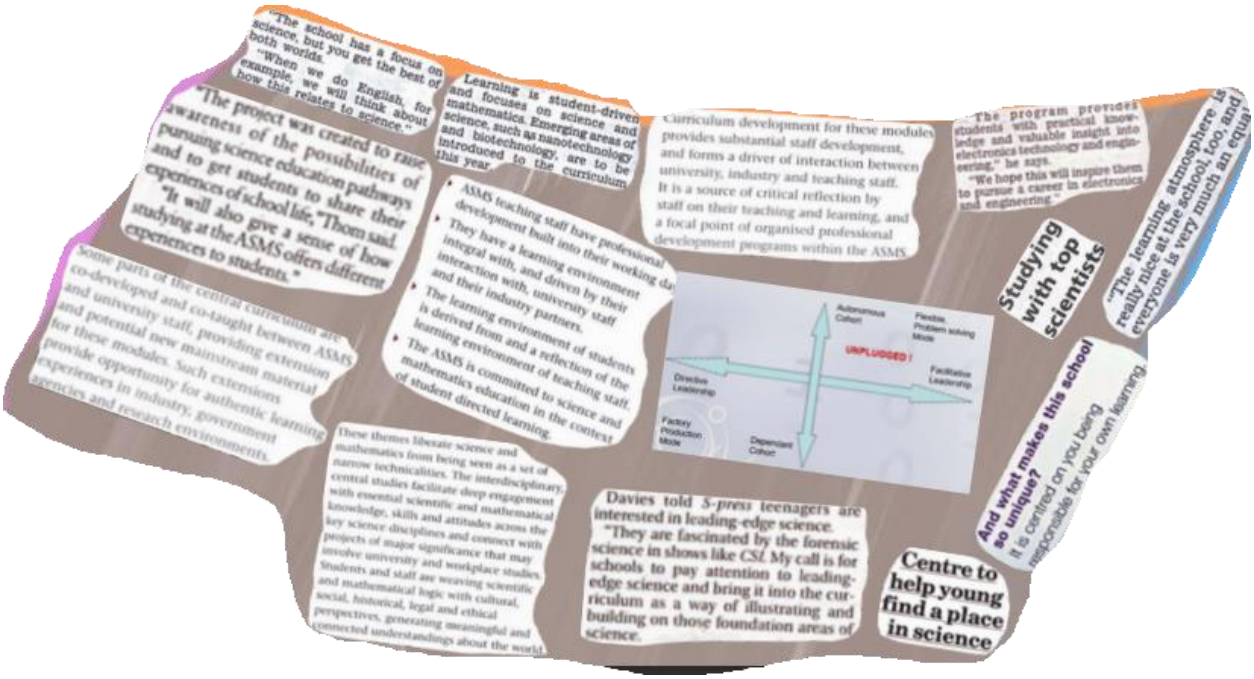

Figure 4.10. The ASMS's drivers.

Each of them has a mission with this creative school, so they must work with big ideas. For example, the deputy principal developed the school's profile nationally and internationally. He started identifying and contacting science schools elsewhere and decided to run a science fair with international students, making it one of the ASMS's signatures and cultures. Meanwhile, one of the assistant principals would oversee the professional development of the teachers to adapt the new curriculum and learning approach.

This leads to the question, how can teachers implement an interdisciplinary curriculum through Central Studies?

FP slowly recalled that the process of developing the Central Studies informed who ought to be there and how to structure a team of teachers. Moreover, once established, the team could stay the same for a long time as the school had a two-year cycle for the Central Studies. The heads of departments would manage and settle the teacher teams in various ways.

A teacher team could work with 60 to 100 students in Central Studies, and the day-to-day activities became the responsibility of that team. It opened the opportunity for a teaching team to self-manage and develop. In addition, students could have more valuable time with not only the same teacher (Appendix G – story 6).

This team-teaching method opens many opportunities to de-privatise educational practices. It can remove many boundaries from the teachers' capacity as they work collaboratively to support each other.

Partnership to stretch boundaries: University partnership

The school was built within Flinders University's campus, and fundamentally, the building put the young people into this, in a sense, a lifelong learning environment where they can keep engaging with the broader world through the school, through the university into the wider world.

The founding team made a critical decision that the school building would not contain the library. They believed it would enable ASMS students to interact with older university students in a shared university library. So, it takes only 3 minutes for ASMS students to walk from ASMS to the closest 2-floor university library, which includes common study areas for ASMS students. The school also has few vending machines, so students do not have many choices for their food and drink sources. They must go next door to the university cafeteria, a mature university learning environment, to explore.

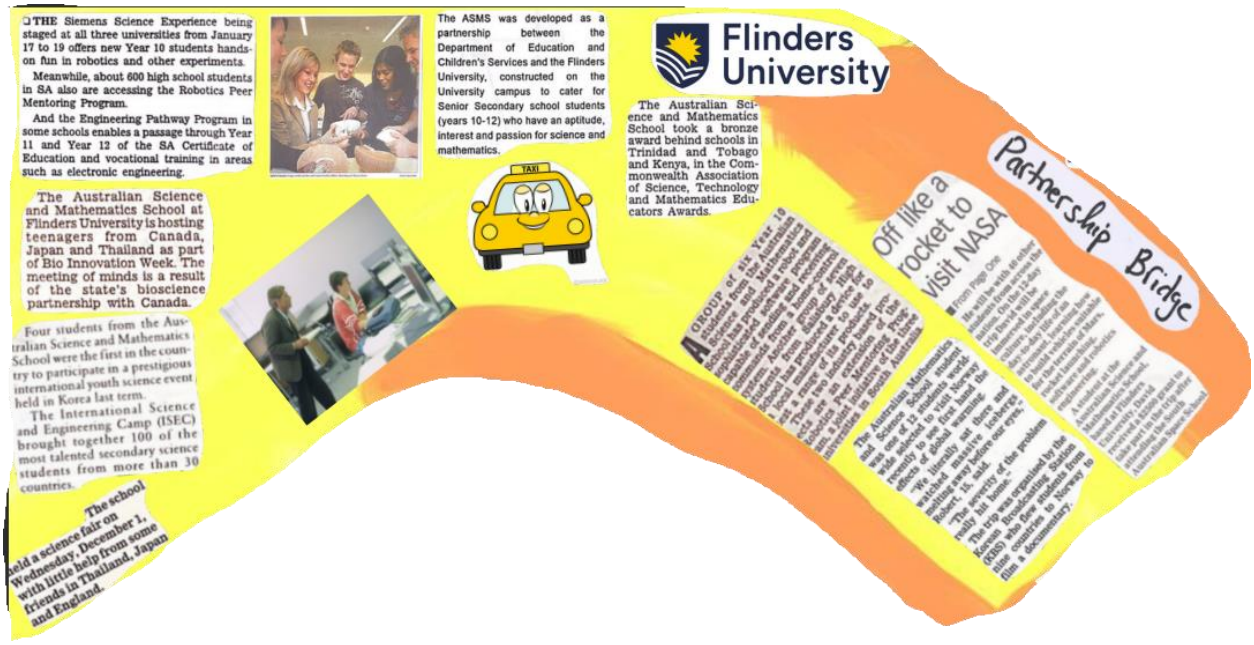

Figure 4.11. The ASMS's partnerships.

Leading edge science curriculum

From the early days, Professor J and his team shared much interest in advancing particular sciences, not only in knowledge but also in creating the totality of human resources. So, FP would take on feedback from Professor J from the perspective of the sciences and mathematics to combine with his views regarding the development of the pedagogical processes and curriculum.

As a state public school, ASMS's staff are regular teachers. Therefore, Professor J had to work with various scientists to find time away from their research and teaching to engage with the school. Moreover, it is a considerable effort in terms of time and money as the school cannot pay for the university staff. So, when the idea of Central Studies evolved, and they evolved with leading-edge science, such as biotechnology, many university staff joined the curriculum development activities. The University Modules were primarily found with short-term stuff within

the Central Studies in which the Scientists would come down, do some things with students in the school, and even encourage students to come to their lab for further research.

Other high schools in the state

ASMS's curriculum revolves around leading-edge technology or science, raising questions for school leaders about what they would miss out on. FP remembered the early days when he could not have music lessons in school. They created a unique program called the "*taxi program*". They worked with other nearby schools to send off ASMS students there. For example, when music was being taught at Blackwood High School, they could take three or four students in a taxi to do their music and return.

A Welcome to new learners

For students…

At ASMS, FP had to be strong about the mission of this school, looking for better ways to teach science and mathematics to better engage kids in science and mathematics.

> This is for students who are interested in or have a broad interest in science and or mathematics. They don't have to be the best-gifted students...they have to be interested in the sciences.

One time, in an information night, FP simplified what they wanted to do here:

> What this school is about is *stretching your ability*…you'll come to us as a year ten student, and what we want you to leave is as *a year 13 learner, you know, a lifelong learner*… if you've got a C grade or better in year ten science and mathematics, *you'll cope with the curriculum here. We'll find an avenue for you to learn*.

The school was not elitist; they wanted to remove fears about academic abilities and generate the idea that you are all learners.

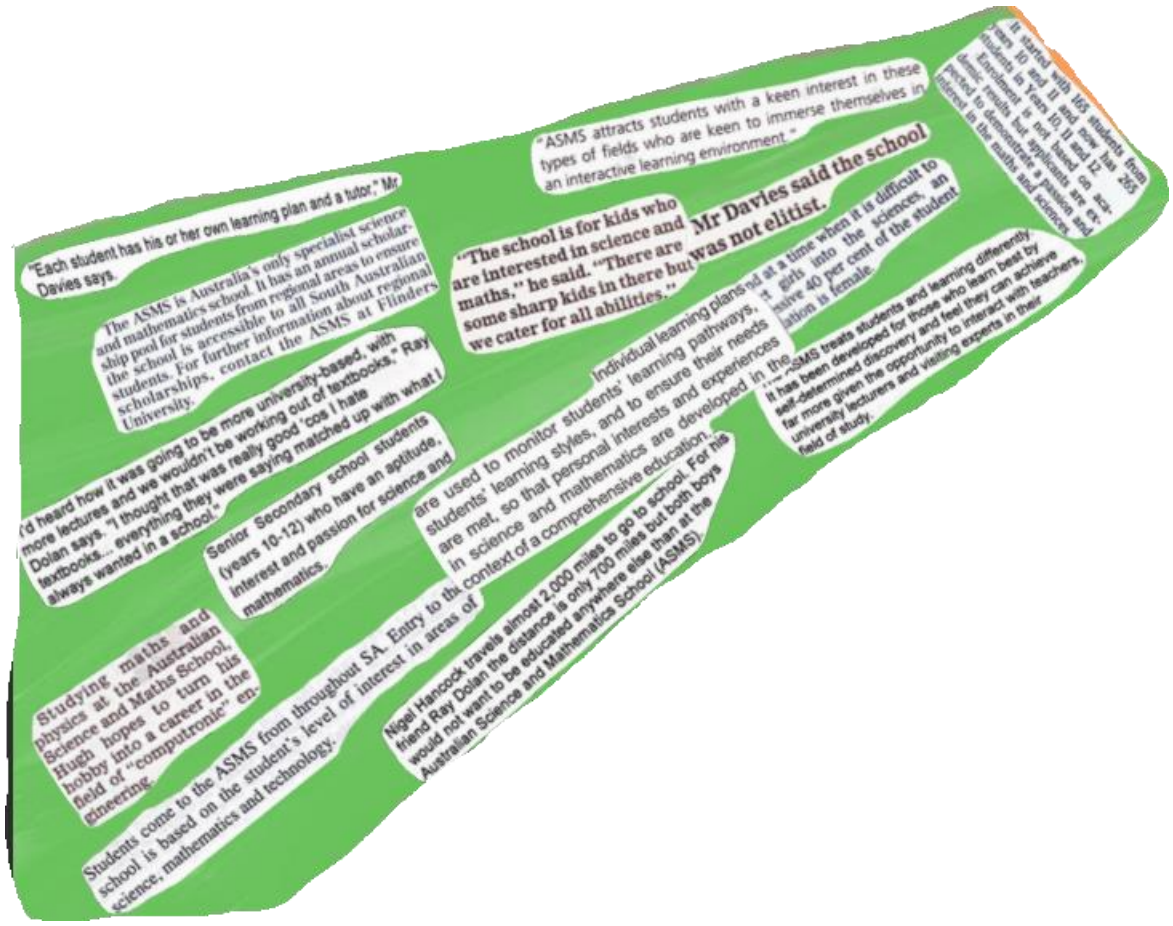

Figure 4.12. ASMS's students

In his leadership role, FP always tried to welcome all students who wanted to come to ASMS, as he understood that they may have to leave many things behind to go to ASMS. In South Australia, at that time, secondary school started in year eight, while ASMS only had years 10, 11, and 12. This meant that students were studying years 8 and 9 somewhere with their friends and then had to leave them behind to come to ASMS. So, there was always a sense of trying to build a strong sense of community in and around the school.

For teachers…

ASMS has also become a special place for traditional teachers with countless challenges and new things. As a public school, the teacher recruitment stages must still meet the criteria of the Education Act. Therefore, the leader team had to advertise the vacancies for the categories in the public education system. For example, they could employ biology and then include the proposed job description about particular areas of science that they were interested in trying to develop and enhance with the university staff.

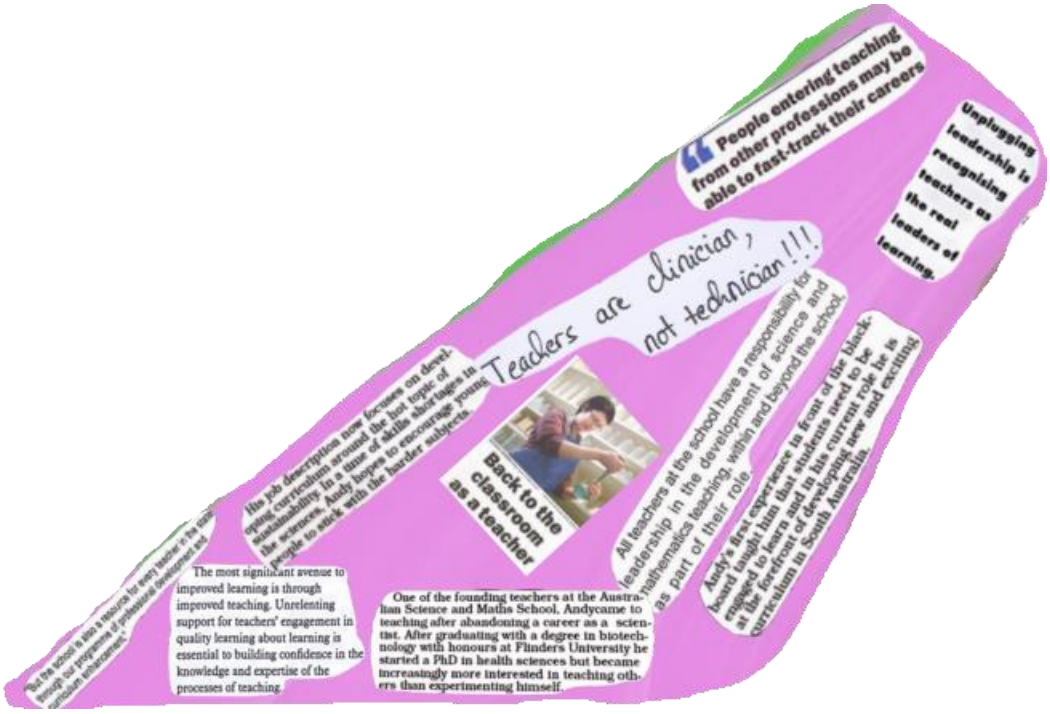

Figure 4.13. ASMS's teachers.

Geared towards student-directed and collaborative learning, ASMS's pedagogy brought much trouble for traditional teachers who had heavy instructional methodology. However, ASMS also attracted special teachers. The recruitment team once had to consider a strong case from a very experienced teacher under a physics vacancy who came for an interview by introducing the

teaching materials carefully stored in two thick folders, from lesson plans and presentation materials to examination. Immediately, FP thought:

> This guy will not cope in this school… in terms of the flexibility, the pedagogical practice, and the open…

FP wondered why an exemplary and high-performing teacher like him would like to come to ASMS.

> I just want to become a better teacher.

That answer made FP willing to give the job to that teacher because FP understood that he came to ASMS "*as a learner … improve his practice and accept the challenge of working in a new school*." And his journey paid off when he became one of the beloved teachers at ASMS.

From the beginning, FP and Professor J were aware of the challenges for teachers, and Professor J had the notion that 'the school ought to be a place where the learning environment of the teachers influences the learning environment of the students.' Therefore, they must see teachers as learners so that students can see them as learners, developers, workers, etc. A collaborative learning model's whole tone and culture emerged from that process. They know ASMS is "a learning school, an innovation; we are here to find new ways. So, we have all got to engage in that."

Weaving the learners

FP and the leader's team try their best to weave everyone's learning together to bring a sense of building a school community with its own unique identity.

Young learners – students with students

They want students to self-regulate and manage their affairs and behaviours to create a school's unique identity. The sense of community and collaboration between ASMS students is clearly shown through daily activities at ASMS (Appendix G – story 7). One of the assistant

principals had developed the unique rules for the school, which were '*look after yourself, look after colleagues, and look after the building*'. Whenever a problem happens, they would go back to those three things and ask themselves did you look after yourself here? Did you appear like an idiot, or did you yell at somebody… And that sort of conversation helped the student learn how to adjust their human behaviour to live in the school community.

FP would often say to his students, "Yes, your learning is really important to you, but it's also really important to those around you. So, share your learning; don't hold it to yourself; share your learning because it builds community. I learn from you, you learn from me, we all learn together, yeah, all that stuff." The textbook story is a clear example of the collaboration in learning between those young learners.

Adult learners – teachers with teachers

Seeing teachers as learners, school leaders had to weave them together, and they also understood the importance of professional development for teacher-learners. Therefore, they created a particular weekly 'class' for this kind of learner and, of course, enhanced collaboration (Appendix G – story 8). ASMS's teachers remain in their learning environment to contribute to students' learning environment. In the sense of the role model for students, FP found another story about teachers' collaboration extremely interesting.

> A teacher of English, a man with an intense, powerful voice… And I was in my office, and I heard him basically yell…I walked out and saw two or three other teachers go to him and say, "That's not what we do here. We're in this big learning community; it's an open space; we've got to work together, and we don't need to yell".

Weaving teachers together is essential for using an interdisciplinary curriculum. They need to weave together to stretch the learning boundaries.

Young learners with adult learners

Collaborative learning offers ASMS students a lot of chances to approach their teachers. Students were also woven to academic staff to stretch their abilities. Many staff from the university were ready to give students one-on-one mentoring support, and it is not surprising that some students did intensive research at the university's lab for their independent study component.

The leadership of learning

FP came to this unique school without any particular ideas about leadership. He went into the job with a sense of confidence in his leadership capacity, expertise, and so on. FP emphasised that "just like everybody else at the Science and Maths School, I was engaged in this whole sense of learning as well, and part of that was learning about leadership." From the beginning of the school, he and the leader team tried to build a collaborative leadership model that mirrors the collaborative classroom, which is their way of finding new ways of teaching and learning.

> We've put a lot of weight on collaboration, community, interaction, and so on. And I was conscious of bringing that into the leadership frame. So, there was a lot of cooperation with the senior leaders in the school, a lot of collaboration with the university and so on.

They would have heads of department meetings, or they would have the principal, deputy, and two assistant principals as the senior leadership team. However, he would bring the business manager into that team out of the administrative staff so that there was a sense of her leadership of the administration of the schools, which was equally crucial as their leadership of the pedagogy and the curriculum.

As a public school, FP remembers that the ways they structured, in a sense, look like distributed leadership. However, once, after he finished the job, a principal assistant rang him and told him that it was contributive leadership. FP recalled his idea about the DAC leadership model: direction, alignment, and commitment (Appendix G – story 9).

FP believes that if he had identified some development or evolution of his leadership throughout the years at ASMS, "*it would have been essentially about working with the collective as a whole.*"

School leaders with partner's leaders

Partnership with the university has existed since the school's first days and has always been a part of the school. Besides, other partners, such as other high school leaders, constantly appear and contribute to what the school is doing. So, for FP or any school leader, weaving these partners together and with themselves is always important.

> There was, certainly I talked with J about this a lot because he talked to me a lot about trying to understand the culture of education, public education. And I said, "J, I'm trying to understand the culture of the university".

The community as a whole

They are all the learners coming to this new school, so having a sense of belonging is essential. Moreover, with collaboration as the school's core theme, they are building their community as a collective responsibility.

There is a fabulous story about the school culture, the 5:30 ritual. So, the school finished at 3:30, but some students would stay to work together or access teachers. However, sometimes, FP had to go and say to students, "No, you can't stay any later than 5:30. We've got to shut the doors." When time moved on, they started to have some past students return at that ritual time and offer support to current students.

Figure 4.14. ASMS's community.

Another way of weaving this community is their lunchtime sports program, which was run by students and staff, and it came from the idea of a studio manager who was a former athlete (Appendix G – story 10). For FP, it was vital to the school leadership as other teachers could confidently take themselves in the leadership role.

FP passionately emphasised his belief in "*Dignify the learners*". FP believed that every bit of learning is valuable, and it is valuable for the individual.

> If it's learning about some obtuse idea that's not found in the physics or chemistry syllabus and so on, it's still learning. So, don't make any negative judgments about it, that whole dignify the learner seems so important to me.

Weaving the learners with sciences

The founding group knew that "*the points of engagement with science, in general, are not at the theoretical stuff*." In trying to keep young people at opportunities at the cutting edge of science, the theories were not enough for a deep understanding. FP emphasised that "*science is not just about research; here are the applications. What is it here that you have developed, and what's your deep understanding of the science and technology behind it*." This idea became an essential part of the learning process at ASMS to weave students with sciences (Appendix G – story 11).

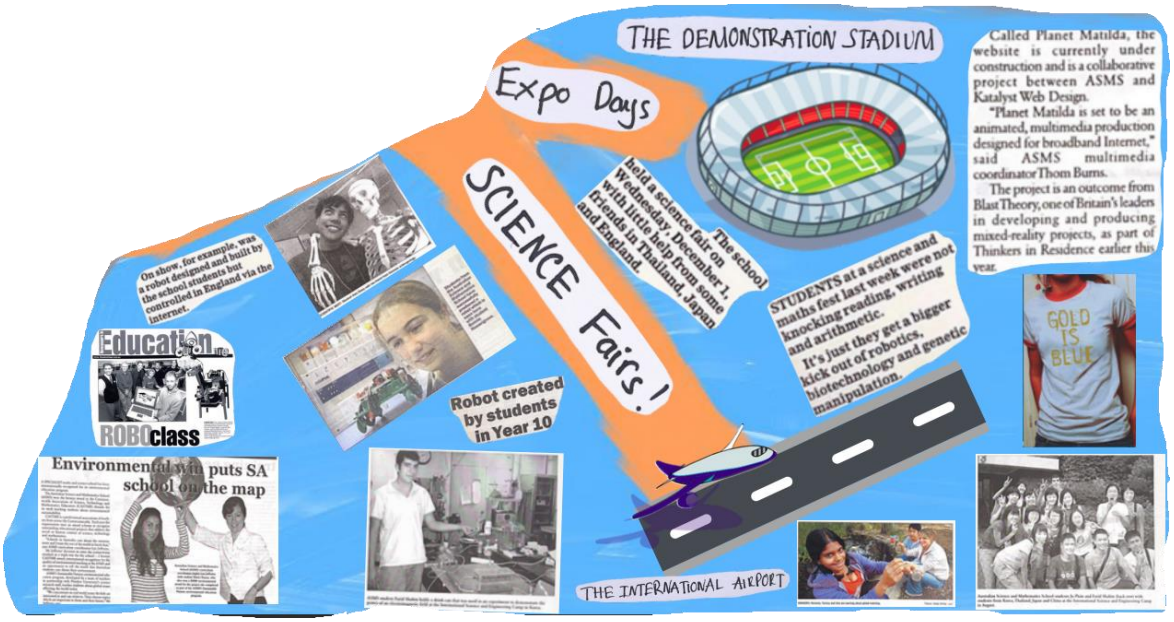

Figure 4.15. How ASMS weaves its students with sciences.

FP was trying to replicate the whole sense of the scientific community in the school's culture. Demonstration of learning became part of the school culture as a new way of assessment. Instead of written exams or school-based examinations, they had other opportunities to assess the depth of their student's understanding of these scientific areas.

FP said that *if you have learned something, you have a responsibility to demonstrate the quality and extent of your learning to others*. Therefore, it did not stop at the school's internal expo

days; they came up with the idea of hosting an International Science Fair with other special schools worldwide.

> … we would set up these interactive processes where students would go and look at each other's research and so on… the science fairs became an essential part of the culture of the school because it was a rich learning experience.

Their student developed international connections from the science fair experience and looked forward to visiting overseas.

Weaving the learners with the world

Students at ASMS could do their interdisciplinary curriculum in years 10 and 11, but from year 12, they had to return to the SACE program. So, it is a challenge for school leaders to present the holistic development of their students when they are going to the world.

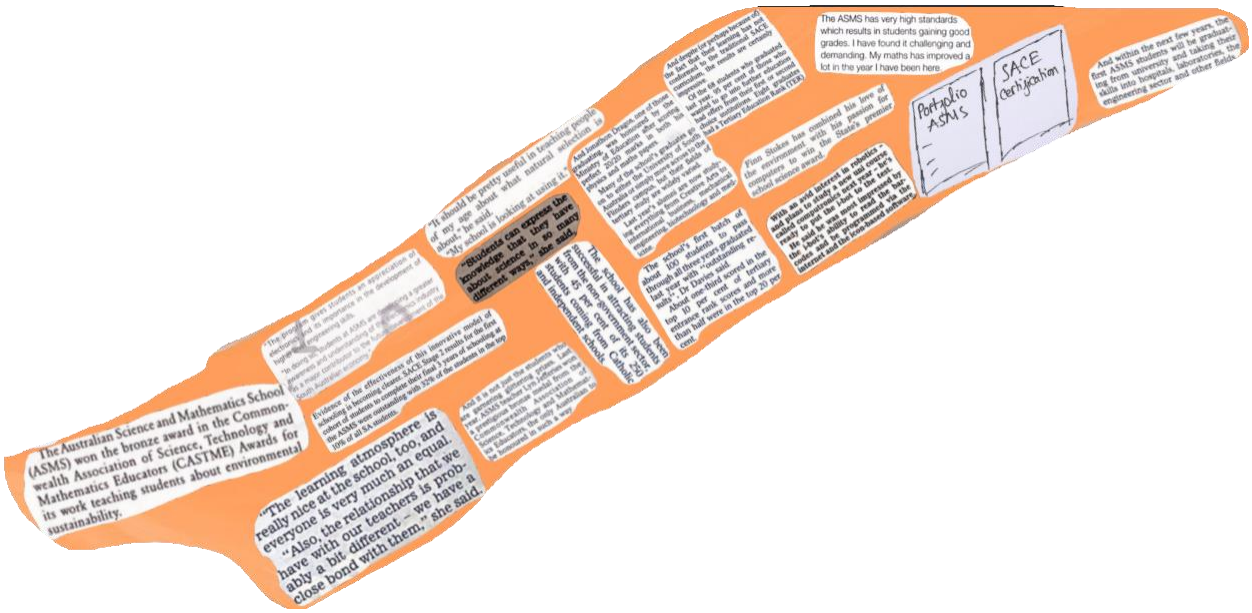

Figure 4.16. How ASMS weaves its students with the world.

Once, an outstanding student delivered his presentation for the SACE board at the end of his independent study in year 12. Even Professor J confidently mentioned that a graduate Bachelor

of Science student did not understand the mathematics that this young man was doing; he only got a B grade. Moreover, what they were saying was, well, his presentation skills were not that good.

> And I thought to myself, that's not the point. The point is, what's the learning that's going on here?

One of the assistant principals did a lot of work trying to connect with the personal learning plans where student developed their inquiry projects and turned them into a learning portfolio when they exited the school. Through the personal learning plan and the interaction with the mentor teacher, there was a significant process regarding the graduate's qualities and ability to work collaboratively. Students would come out of school with a portfolio that described these graduate qualities and more holistic things, weaving with their results from the SACE exams.

4.5 It is all about building relationships.

From the day we first became aware of the trend, we saw that the school's mission was to find a new way to build students' relationships with science. Traditional content or traditional teaching methods do not seem to create a strong relationship between students and science. A sustainable multi-dimensional relationship is formed if we can promote students' inquiries and create opportunities for them to learn more deeply.

More broadly, when looking at what they did at ASMS, FP acknowledged that it revolved around relationships: the relationship between students and teachers with the physical learning space, the relationship between students and teachers, the relationship between teachers and students, the relationship between teachers and students, the relationship with the science world, and so on.

Moreover, when we think about a learning ‘community’, the real essence is building relationships among the components within that community.

DISCUSSION OF FINDINGS

The findings (Chapter 4) are consistent with the literature review's recommendations for interdisciplinary learning (Ashby & Exter, 2019; Cheng & So, 2020; English, 2016). Consolidating the findings, I will summarise some recommendations for integrating STEM education. Looking back to the current STEM education in Vietnam, some potential insights will be discussed to reduce the challenges. More importantly, some gaps in Vietnamese educational leadership must be addressed for successful reform.

5.1 Consolidate recommendations from literature reviews.

How were the learning materials, including the physical environment, curriculum, and pedagogy, built from the beginning for interdisciplinary learning at the ASMS?

The brown parts of the portrait (Figure 4.1) present information about the foundation of the ASMS collected from public releases and documents shared by the founding principal. This section captures a consistency in how the ASMS developed interdisciplinary learning from the beginning with the literature reviews encapsulated in the ASMS Cycle of Re-thinking (Davies, 2006). Significantly, this section identified that the ASMS started with a strong influence on the demonstration of learning from The School of Environmental Studies (SES). Some of the SES's beliefs became the beliefs of the ASMS. The brown parts also clarified how the ASMS uniquely established learning materials and activities. For instance, co-teaching for interdisciplinary learning (Hubert, 2021; Self et al., 2019), the ASMS teacher teams taught together for the same group of students. This strategy not only creates rigour in the working process of teacher teams but also gives them flexibility and authority in organising teaching activities, preventing co-teaching challenges, such as juxtaposing disciplinary views and ideas (Self et al., 2019).

The brown parts also show how the ASMS gave more student agency toward stretching students' learning and enhancing the authenticity of learning. The ASMS especially managed their student agency within a collaborative learning culture, consistent with the literature's recommendations (e.g., Pont (2020)). The ASMS's collaborative learning culture was captured in the orange part of the portrait (Figure 4.1), including outstanding characteristics such as no boundaries for students' learning, sharing your learning, dignifying the learner, or self-regulating.

Meanwhile, the blue part (Figure 4.1) captures the ASMS's signature activities, including the expo days and science fairs, to assess learning through demonstrating understanding. These activities helped to speak their interests to the world, get feedback from the broader community, and thereby gain more objective assessments of learning, which is consistent with the recommendations in literature (e.g., Gao et al. (2020)) about using the final product cannot fully assess student's learning.

How were ASMS's initial human resources established, including its founding principal, pioneer teachers, and staff?

The pink part of the portrait (Figure 4.1) identifies how the ASMS created human resources under the barriers as a state public school, especially by bringing people from other professions, particularly STEM-related areas, back to the classroom as teachers. The ASMS had to provide careful professional development plans consistent with the literature encapsulated in the ASMS Cycle of Re-thinking (Davies (2006). In the narratives (Chapter 4), the founding principal emphasised that they could negotiate much autonomy for the school's structure and decided to spend around 85% of the school budget on human resources. This information closely complements Aldridge and McLure (2023)'s suggestion (Chapter 2) that the school structure needs to be adapted and a comprehensive school-changing plan is required to facilitate the reforms.

How did the founding school leaders build supportive strategies during the beginning of the new interdisciplinary school?

In the narratives (Chapter 4), the founding principal recalled that he came to the school without any intention of adopting any particular leadership ideas. Like others, he came there as a new learner and tried to enhance the collaborative culture under the distributed leadership structure. They worked with the collective as a whole, not hierarchy. Together, the leaders and teachers find direction, alignment and commitment, similar to the DAC leadership model (Drath et al., 2008). Later, their leadership was described as distributive, contributing to the school's success (Bills & Howard, 2019). It can be said that the ASMS leadership developed their unique leadership model while building sustainability for the interdisciplinary learning environment. Significantly, the way the ASMS leaders tailored their leadership shares consistency with recommendations from literature, including leading (not only managing) the reform (Aldridge & McLure, 2023) and focusing on professional development and supporting pedagogical change for teachers (Grice, 2019; Leithwood et al., 2020).

5.2 The emerging of the authority for extensive partnership

The yellow part of the portrait (Figure 4.1) presents the extensive partnership of the ASMS. School context includes the external environment, including community, policy, and societal values (Bascia, 2014). The ASMS has used external resources well to enhance the student's learning opportunities. Significantly, throughout the narratives, the presence of Flinders University accompanies the formation and development of the ASMS, which is also mentioned in the literature (Bissaker, 2014; Davies, 2006). Moreover, the narratives indicate a proactive approach to working together from Flinders University and the ASMS, including solving the problem of the lack of students entering the sciences field or supporting programs and teachers' professional

development. In addition, the ASMS also establishes relationships with other organisations from the industry and local neighbouring schools.

The ASMS's extensive partnerships brought attention to the school's authority. The ASMS must have extended authority to maximise the school's goals. For example, the ASMS could allow academics to contribute to the school's teaching and learning activities flexibly or send its students to other schools for particular subjects flexibly. In addition, Professor J from Flinders University also had his authority enhanced. These include the formation of a special committee to allow ASMS to use interdisciplinary curricula, the direct support and teaching participation of academics under the payment of a grant from the Australian government to contribute to innovation in tertiary teaching or allowing the ASMS students to work actively in research laboratories at the university (mentioned in the narratives). I argue that the ASMS leaders and the University's academics were enhanced collaborating authorities.

5.3 Recommendations for integrated STEM education through building interdisciplinary learning environments

Combining recommendations from the literature review with the findings from the formation of the ASMS, I suggest some factors should be considered in building interdisciplinary, particularly integrated STEM education.

Table 5.1. Recommendations for building interdisciplinary learning.

Literature reviews	Consolidation from ASMS case
A well-planned interdisciplinary STEM curriculum is required	Extended students' agency, including their interests and self-inquiry.
Improvement and consensus about instructional practices are required, including project/problem-based, inquiry-based, and collaborative learning.	
Co-teaching is recommended	Fixed teacher teams can be created based on themes/modules.
Limiting learning assessment based on the final product.	Learning outcomes should be assessed by demonstrating learning, including the products and processes.
A collaborative school culture needs to be developed through shared/distributed leadership.	The contributed leadership model also has the potential to enhance teacher and student leadership.
School leaders need to lead, not only manage the change.	School leaders can tailor their leadership depending on the context.
Paying enough attention to the professional development of both teachers and school leaders.	
	Proactively building partnerships with outside organisations to increase support.
	Enhancing the authority of the schools to increase their flexibility in building and maintaining the new learning environment.

Despite its unique aspects, ASMS can still contribute helpful information in reducing challenges for interdisciplinary learning, especially in integrating STEM education.

5.4 Insights and gaps in Vietnam education

The narratives show that, in building the ASMS, the founding team also looked at some good practices and tailored them to fit the ASMS's context. Therefore, Vietnamese school leaders can also learn and tailor the recommendations for integrating STEM education. To do that, it is necessary to point out some insights and gaps in Vietnamese education, especially educational leadership.

Insights for consideration

The problems underlying this study (Chapter 1) are the lack of an official Vietnamese STEM curriculum, quality STEM teacher teams in Vietnamese schools, inconsistent and unqualified teacher training activities, lack of commitment to teachers' beliefs about STEM education, and differences in teachers' perspectives about STEM education. What follows is a discussion of how this study might contribute to these issues. In a broad sense, these contributions include the vivid picture of building the ASMS, which can help increase the commitment to teachers' beliefs and consistency in teachers' perspectives about STEM education. Second, although the ASMS has a unique interdisciplinary STEM curriculum, we can still focus on promoting themes-based and project/problem-based curricula in creating the official STEM curriculum for Vietnam. In addition, we can learn to arrange this curriculum into modules for easy use, particularly when applying to extracurriculars. Third, the idea of bringing other professions back to the classroom as teachers to support current teacher teams should be considered. Finally, the co-teaching, project/problem-based, and student-centred approaches must be focused on improving teachers' professional development and consistency in training.

Gaps for caution

In comparing Vietnam Education (Table 2.1) with the recommendations for interdisciplinary learning (Table 5.1), there are many things that Vietnam Education needs to do to integrate STEM education. I particularly point out some gaps in the school leadership that need to be considered.

The ASMS case shows that it is essential for school leaders to tailor their leadership based on their context. Meanwhile, Vietnamese school leaders tend to replicate or borrow the best ideas and are unlikely to seek localised solutions (Le, 2020). In addition, shared/distributed/contributive leadership models can face some challenges with the nature of leadership in Vietnam. For example,

the power-concentrated culture and hierarchical nature of relationships may hinder those leadership styles' interactive and co-experience factors. Therefore, it will be challenging for Vietnamese school leaders to adopt those leadership models. Besides, as Vietnamese school leaders avoid uncertain and ambiguous situations (Hallinger & Kantamara, 2003), they will need strong encouragement in adopting and tailoring a localised leadership model.

The literature and the ASMS case emphasised the importance of school leaders leading the reform through a collaborative learning culture. However, there is a big gap as instructional leadership is not the normative role of Vietnamese school leaders (Dimmock et al., 2021; Nguyen et al., 2023). They also lack the flexibility to adjust practices due to the centralised political system (Walker & Hallinger, 2015) and maintain the high-power distance characteristic (Hallinger & Truong, 2016). It can be argued that Vietnamese principals will likely manage the change through imposition rather than leading and collaborating with teachers. The literature also highlighted the lack of attention to Vietnamese principal development (Walker & Hallinger, 2015). Therefore, I strongly agree with Maheshwari (2022) that a focus on developing instructional leadership in Vietnamese schools is required. Vietnamese school leaders need to show their roles by setting role models or good examples for new learners during the integration of STEM education (Truong & Hallinger, 2017). They need to be more active and insightful in leading their teachers to sustainable overcomes the challenges of integrating STEM education. This means Vietnamese principals will need a strong understanding of STEM Education, which will require targeted training.

Although Vietnamese schools now have more autonomy to develop curricula on the characteristics of students and local conditions (Tinh, 2021) and flexibility to work with external organisations under the policy from Vietnam (2021), unique characteristics of leadership in Vietnamese society may bring some risks such as abusing authority to impose actions or increasing

tension between schools and the local government bodies (Nguyen, 2019). The development of the ASMS is an example of the need to expand the authority of schools, which, however, came with a quality leadership team and the awareness of not breaking the system. Therefore, implementation guidelines for school administrators on the setup and management of the reforms need to be carefully conducted. In addition, Vietnamese school leaders must take advantage of their extended authority with new collaborative skills to build partnerships with universities or academic agencies to improve the school capacity, including teacher professional development, rather than increasing their political relationship.

5.5 Conclusion

This chapter presents my discussion based on the findings of the study. The findings helped to answer the research questions through many consistencies with the literature and the emergent idea relating to the ASMS's extended authority. I then summarised some recommendations for building interdisciplinary learning, particularly integrated STEM education. Looking back on the problems underlying this study, I discussed some insights from the findings. However, some critical gaps need to be clarified under the differences between the cultures and contexts of Vietnam and Australia.

CONCLUSION

6.1 Summary of the study

The primary aims of this thesis have been to examine the process of building an interdisciplinary learning environment, particularly integrated STEM education, to examine the experience of school leaders in implementing the interdisciplinary learning environment, and to explore the potential insight into the context of Vietnam education. These aims came from considering the current state of development of STEM Education in Vietnam (See Chapters 1 and 2) after issuing the new general education program focusing on STEM education.

The ASMS, established in 2003 in Adelaide, South Australia, maintains an interdisciplinary learning environment and is considered to have specific successes (Chapter 2). Therefore, I chose to examine this school's development process as a case study focusing on capturing the early years of the school from 2003 to 2010 to bring an overview to school leaders and teachers in Vietnam about the nature of the process of building interdisciplinary education.

The portraiture method was used to present the findings of this study using unique portraits and narratives capturing the early years of the ASMS in a way that enhances understanding of the process of building interdisciplinary learning for broader audiences. The data was collected from school observations, reviewing public documents, and especially the interviews with the ASMS's founding principal.

The findings first add and consolidate recommendations for integrated STEM education through building an interdisciplinary learning environment. Aiming to find potential insight from the ASMS model to the Vietnamese context, I then pointed out some ideas to consider in

integrating STEM education in Vietnam. Moreover, I discuss gaps between Vietnamese education and interdisciplinary learning recommendations, particularly in Vietnamese school leadership.

6.2 Lessons from ASMS case.

The ASMS Cycle of Re-thinking (Davies, 2006) is an excellent example of the process of building an interdisciplinary learning environment. ASMS exhibited its characteristics, including a unique theme-based interdisciplinary curriculum, collaborative learning culture, student-directed approaches, enhancing demonstration of learning, and extensive partnerships.

For interdisciplinary STEM education, instructional practices, including inquiry-based learning or co-teaching, were applied at the ASMS from the beginning with the advancement of teacher-team arrangements. Enhancing student agency is always a goal that the ASMS aims for and contributes to the school's success. The ASMS do not want to place barriers to students' learning and try to find an effective way to assess learning through demonstration of learning. In addition, the ASMS' extensive partnership with external environments to enhance student learning, especially in leading-edge technology, also contributed to the school's success. The school's autonomy was expanded to take full advantage of partnership opportunities, such as the strong involvement of Flinders University in many areas of the ASMS.

The ASMS directly contributed to the sustainable development of an interdisciplinary educational environment, especially integrated STEM education. Moreover, the ASMS leadership had to tailor their unique contributive leadership to operate successfully. The ASMS leadership experience helps strengthen the role of school leaders in leading educational reforms, primarily through instructional leadership.

6.3 Recommendation for Vietnam Education

The vivid picture of the process of building the ASMS can help to increase the commitment to teachers' beliefs and the consistency of teachers' perspectives about STEM education. Vietnam should promote themes-based and project/problem-based curricula structured as modules in developing an official STEM curriculum. Besides encouraging the professional development of teachers, training activities focusing on co-teaching, project/problem-based learning, and student-centred approaches should also be paid attention to. In addition, Vietnam education also needs to consider bringing other STEM-related professions to the classroom as teachers to support the process of integrating STEM education. Finally, Vietnamese schools should be encouraged to build partnerships with universities to gain support for building the school's capacity.

Changes in school leadership show the potential to make a difference for teachers in Vietnam and directly contribute to the reforms (Leithwood et al., 2020; Maheshwari, 2022). However, they need strong encouragement to adopt and tailor a localised leadership model for integrating STEM education rather than trying to adopt from outside. In addition, Vietnamese school leaders must pay attention to their professional development activities to lead (not only manage) the reforms (Aldridge & McLure, 2023; Walker & Hallinger, 2015). The instructional leadership need more attention from Vietnamese principal and can be seen as their normative roles besides the political and bureaucratic responsibility (Hallinger & Thang, 2014; Nguyen et al., 2023). Finally, Vietnamese school leaders must be careful when using their extended authority to integrate STEM education, primarily partnering with universities to support teacher's professional development.

6.4 Call for further research

Notably, the ASMS student agency contributed to the school's success through the contributed leadership (Bills & Howard, 2019). However, there is a lack of research on student agencies for K-12 education (Hooshyar et al., 2023). In general, student agency refers to the student's ability to define and act on their own goals (Vaughn, 2018), and it is critical to learning (Andre, 2021; Hooshyar et al., 2023; Stenalt & Lassesen, 2022). Therefore, I suggest that we need more research on student agency, particularly during the integration of STEM education and in the Vietnamese context, as there is a strong sense of hierarchy in the teacher-student relationship.

6.5 Call for the caution in integrated STEM education in Vietnam

One of the pioneers in promoting STEM education in Vietnam disappointedly commented that after many years, we are still just wandering around definitions (Dang, 2023). From personal observations, I also see many inconsistencies or misunderstandings about STEM education in Vietnam, not only among students and parents but also among teachers and school leaders. Although we are making great efforts and displaying enthusiasm in integrating STEM education and improving the quality of future human resources, we also need to be careful to fully and adequately integrate towards the sustainability of the reform. Therefore, it is essential to properly understand the nature of interdisciplinary learning, specifically STEM education, and the process of building and developing it. I hope the information from the ASMS can partly contribute to educational change in Vietnam, but my recommendation needs careful consideration of contextual conditions before adoption. Continuation of dialogue about factors of significance to successful interdisciplinary STEM education is an important starting point for Vietnamese stakeholders.

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APPENDIX A

ASMS's belief

- Respond to the current and future interests and needs of its students to establish critical and transparent models of excellence in science and mathematics education.

- Provide a learning environment of leading-edge and enterprise-oriented science, mathematics and technology.

- Provide a learning culture for its students that derives from the learning culture of its staff, which in turn derives from their interaction with university and industry scientists and educators.

- Prepare young people to be creative, critical, informed and motivated contributors responding to professional, personal and social issues.

- Increase participation and success of senior secondary students in science, mathematics and related technologies and transform students' attitudes to science and mathematics as career paths.

- Be an agency for change and enhancement of science and mathematics education for the state of South Australia and then nationally and internationally.

APPENDIX B

Contributive leadership from Bills and Howard (2019)

- Contributive leadership views all staff as contributing learners, encouraging them to express ideas and be creative;
- Contributive leadership is work across school boundaries, such as partnerships with other schools. ASMS staff think about lending support to the education community;
- Contributive leadership provides nuanced support for teachers to build a curriculum that is related to the students, enabling them to play in the field of ideas;
- Contributive leadership gives opportunities for teachers to turn their own interest into learning materials;
- Contributive leadership can lead to difficult and challenging conversations among employees which is in fact an expectation of working creatively with new ideas in a rich learning community; and
- Contributive leadership requires an intuitive knowingness for contributive leadership as "timing and trust are of the essence" for supporting teachers.

APPENDIX C

ETHICS APPROVAL

Flinders University

HUMAN ETHICS LOW RISK PANEL

APPROVAL NOTICE

Dear Dr Michael Bell,

The below proposed project has been **approved** on the basis of the information contained in the application and its attachments.

Project No:	6252
Project Title:	Insights from a historical case study in building STEM Education for Vietnam Education
Chief Investigator:	Dr Michael Bell
Approval Date:	08/08/2023
Expiry Date:	01/06/2024
Approved Co-Investigator/s:	Mr Long Nguyen

Please note: *For all research projects wishing to recruit Flinders University students as participants, approval needs to be sought from the Pro Vice-Chancellor (Learning and Teaching Innovation), Professor Michelle Picard. To seek approval, please provide a copy of the Ethics approval for the project and a copy of the project application (including Participant Information and Consent Forms, advertising materials and questionnaires etc.) to the Pro Vice-Chancellor (Learning and Teaching Innovation) via michelle.picard@flinders.edu.au.*

APPENDIX D

Recruitment email

Dear …,

My name is Long Nguyen, and I am a Vietnamese Flinders University master's student. I am undertaking this research as part of my degree. The research title is 'Insights from a historical case study in Building STEM Education for Vietnam Education'. In taking this research, I and my supervisor, Dr. Michael Bell – College of Education, Psychology and Social Work of Flinders University, hope to investigate the beginning of building the interdisciplinary learning environment of the Australian Science and Mathematics School (ASMS), which was initially established in 2003 in Adelaide South Australia to focus on STEM education. After nearly 20 years of operation, ASMS maintains its interdisciplinary educational characteristics and develops more robust interdisciplinary activities. Therefore, insights from the beginning of ASMS can be a valuable source of information for school leaders in Vietnam, especially in helping them to know how leadership can lead STEM education in Vietnam from the beginning.

I spent five years working as a STEM teacher and an after-school program manager at Fablab Danang, Vietnam. I had the opportunity to witness many changes in STEM education in Vietnam, and it exploded after the Vietnamese Ministry of Education and Training officially launched a new general education program, clearly demonstrating their determination to promote STEM education. This is our great effort to meet the increasing demand for high-quality human resources for Industry 4.0, as we are transforming ourselves into the new factory of the world. However, we are trying to implement it in a rather hasty way and still do not have much experience. Although the concept of STEM has appeared in Vietnam for the past 10 years, no school in Vietnam is successfully building an effective STEM education. Although spending huge investments in building facilities such as Maker Innovation Spaces, we have been unable to operate them effectively. Therefore, I am looking forward to learning about the formation of ASMS.

We aim to a) examine the process of building an interdisciplinary learning environment, including designing curriculum and learning material, building teacher support, and implementing the change process from the school leader; b) examine the experience of both leaders and teachers in implementing the interdisciplinary learning environment; and c) explore the potential process of transferring the two aims above into the context of Vietnam education at the school level.

From the findings, we hope to help Vietnamese schools and educational systems better understand the actual requirements of school leaders and teachers in developing a new learning environment that promotes interdisciplinary learning and the processes they use to undertake these developments. Moreover, this research will contribute significantly to formulating school organisational designs and processes that offer more active leadership of school leaders in change through a better understanding of organisational and personal change processes.

To bring the best for this study, I hope you can:

- attend the one-on-one interviews with me.
- respond to questions regarding your views about the beginning of building the ASMS, including the recruitments, pedagogies, and learning materials.
- share your experiences during the beginning of the ASMS related to the essence of leading the change and setting up across the various domains of educational leadership.

A 45–60 minute interview will be scheduled at a time that works for you. We also can arrange an online interview in case a physical interview is not possible. Honestly, as the study aims to bring in-depth insights

into ASMS formation, I would be more than happy if you agree to participate in more than one interview. However, I cannot place too much burden on you, so the number and length of interviews will be completely up to you as long as you are as comfortable as possible.

Being in this study is completely voluntary and you do not have to take part. I understand that being a principal of such a challenging learning environment is not easy and is also a testament to your dedication to education in general. I believe that you still want to be able to use your accumulated knowledge and experience for many years to continue to support society. I hope to spread your knowledge and experience to more places, support more teachers, and bring more benefits to our beloved students. Honestly, in the context of doing this research, the greatest benefit to your participation is my appreciation of using the tremendous value you've done with ASMS to change our education positively.

The project has been approved by Flinders University's Human Research Ethics Committee (6252).

Your participation will be a great contribution to our research. I hope to get your approval.

Best regards,

Long Nguyen

Master of Leadership in Education Candidate (Class of 2024)

Flinders University, College of Education, Psychology and Social Work

APPENDIX E

PARTICIPANT INFORMATION SHEET AND CONSENT FORM

Title: Insights from a historical case study in building STEM education for Vietnam Education

Chief Investigator

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Dr. Michael Bell

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My name is Long Nguyen, and I am a Flinders University master's student. I am undertaking this research as part of my degree. For further information, you are more than welcome to contact my supervisor. His details are listed above.

Description of the Study

This project will investigate the beginning of building the interdisciplinary learning environment of the Australian Science and Mathematics School (ASMS), which was initially established in 2003 in Adelaide, South Australia, to focus on STEM education. After nearly 20 years of operation, ASMS maintains its interdisciplinary educational characteristics and develops more robust interdisciplinary activities. Therefore, insights from the beginning of ASMS can be a valuable source of information for school leaders in Vietnam, especially in helping them to know how leadership can lead STEM education in Vietnam from the beginning. This project is supported by Flinders University, College of Education, Psychology and Social Work and the Australian Award Scholarship.

Purpose of the study

This project aims to: a) examine the process of building an interdisciplinary learning environment, including designing curriculum and learning material, building teacher support, and implementing the change process from the school leader; b) examine the experience of both leaders and teachers in implementing the interdisciplinary learning environment; and c) explore the potential process of transferring the two aims above into the context of Vietnam education at the school level.

Benefits of the study

Sharing your experiences will help Vietnamese schools and educational systems better understand the actual requirements of school leaders and teachers in developing a new learning environment that promotes interdisciplinary learning and the processes they use to undertake these developments. Moreover, it is hoped that the research will contribute significantly to formulating school organisational designs and processes that offer more active leadership of school leaders in change through a better understanding of organisational and personal change processes. This will be explored through a historical case study that examines the beginning of building an interdisciplinary school and how pioneers created the foundation to maintain this new learning environment. However, in learning from abroad, explicitly borrowing policies based on best practices to shorten the time, educators need to consider the influence of culture on educational practices. Therefore, this study also carefully considers the impact of cultural differences in assessing the potential of insights gained during the research.

Participant involvement and potential risks

If you agree to participate in the research study, you will be asked to:

- attend up to three one-on-one interviews with a researcher that will be audio recorded.
- respond to questions regarding your views about the beginning of building the ASMS, including the recruitments, pedagogies, and learning materials.
- Share your experiences during the beginning of the ASMS related to the essence of leading the change and setting up across the various domains of educational leadership.

Each interview will take a maximum of 60 minutes, and participation is entirely voluntary. Interviews will be scheduled at a time that works for you.

The researchers do not expect the questions to cause any harm or discomfort to you. However, if you experience distress due to participation in this study, please let the research team know immediately. You can also contact the following support services:

- Lifeline – 13 11 14, www.lifeline.org.au
- Beyond Blue – 1300 22 4636, www.beyondblue.org.au

Withdrawal Rights

You may decline to take part in this research study. If you decide to take part and later change your mind, you may withdraw at any time without providing an explanation. You also have the right to review all the transcripts. To withdraw, please contact the Chief Investigator, or you may just refuse to answer any questions. Any data collected up to the point of your withdrawal will be securely destroyed.

Confidentiality and Privacy

Only researchers listed on this form have access to the individual information provided by you. While all publications will use a general term (for example, 'one of the pioneer principals'), because of the profile of the school, members of the public may be able to identify you and the specifics of your comments.

No data, including identifiable, non-identifiable and de-identified datasets, will be shared or used in future research projects without your explicit consent. Please provide your consent to this by ticking the appropriate box on the Consent Form at the end of this form.

Data Storage

The information collected will be stored securely on a password protected computer and/or Flinders University server throughout the study. Any identifiable data will be de-identified for data storage purposes unless indicated otherwise. All data will be securely transferred to and stored at Flinders University for five years after publication of the results. Following the required data storage period, all data will be securely destroyed according to university protocols.

Recognition of Contribution / Time / Travel costs

If you would like to participate, in recognition of your contribution and participation time, I will be responsible for the costs associated with the location of the interviews.

How will I receive feedback?

On project completion, a short summary of the outcomes will be emailed to all participants.

Ethics Committee Approval

The project has been approved by Flinders University's Human Research Ethics Committee (6252).

Queries and Concerns

Queries or concerns regarding the research can be directed to the research team. If you have any complaints or reservations about the ethical conduct of this study, you may contact Flinders University's Research Ethics and Compliance Office team either via telephone (08) 8201 2543 or via email human.researchethics@flinders.edu.au.

Thank you for taking the time to read this information sheet which is yours to keep.

If you accept our invitation to be involved, please sign the enclosed Consent Form.

CONSENT FORM

Consent Statement

☐ I have read and understood the information about the research, and I understand I am being asked to provide informed consent to participate in this research study. I understand that I can contact the research team if I have further questions about this research study.

☐ I am not aware of any condition that would prevent my participation, and I agree to participate in this project.

☐ I understand that I am free to withdraw at any time during the study.

☐ I understand that I can contact Flinders University's Research Ethics and Compliance Office if I have any complaints or reservations about the ethical conduct of this study.

☐ I understand that the information collected may be published and that my identity may be revealed.

I further consent to:

☐ participating in an interview

☐ having my information audio-recorded

☐ my data and information are only used in this project.

Signed:

Name:

Date:

APPENDIX F

The second interview's questions and clues

Expected Content	Questions + clues
Learning Commons	In the first days at learning common, you arranged to guide everyone on how to adapt to it and what their impressions/confusion were with this "classroom-less" space.
Studios	What happens in "studios" that makes them different from the labs in regular schools?
ASMS's pace of life	Can you tell me about the general atmosphere of a school day at ASMS (I imagine that if I walked in through the main door, what would I encounter when walking along the learning commons, when accidentally browsing the teachers' working corners, students' home bases) - Popular voices/sound? - Popular movements
Emerging areas	I found your quote in an article: "The school's principal said the field of new sciences was where the jobs will be for young people". Can you tell me more about how ASMS chose the areas?
University Modules	I really want to hear you talk about a class session in a university module, including a brief outline of the plan, how it actually happens, who teaches, the excitement of the students and ASMS staff, and how you use the facilities.
The interdisciplinary	- "Creating interactive online drama" stories. - Hi-tech theft harsh lesson for students - "Controlling or be controlled" (Communication system central study)
Independent study	Can you describe how a student conducts his or her independent study?
24/7 access to learning material	Do you remember any story about the student's experience with this innovation? I know this was a huge upgrade for a school at that time, and we still do not apply it in Vietnam now.
mentoring/Coaching	How did a mentoring/coaching session happen? How often does it happen in ASMS?
Co-teaching	How did the teacher prepare for the co-teach? (preparing the content, timetable, location, materials…)
No-textbook	I would be happy if we could extend the no-textbook stories you told me last time (a student came to you and asked where the textbook was?)

Third interview's questions and clues

Expected Content	Questions + clues
School structure	Can you summarise the composition of the teacher/staff groups at ASMS? - Teacher - Academic…
Human resources	Can you describe the role models of teachers at ASMS to me? - I read two articles about 2 of ASMS's first teachers (Andy Stone and Cat Stone) and their stories about their transition to becoming teachers. I assume that in ASMS, there are two groups of teachers: those already teachers and those who have just become teachers. I really want to know more about the process of becoming a teacher at ASMS. Moreover, if they were a role model, how would you describe them?
Recruitment	How have you built your school's teachers and staff? Prompts: - Were there particular criteria given in the selection of teachers? - How could you attract the attention of teachers? (Professional development plan, salary, promotion...) - Did you have any difficulties?
Pedagogical supports	Do you have a specific plan or strategy for training and supporting teachers in the early stages of ASMS? Prompts: - How do you get them ready to teach? - How can we help them overcome the initial difficulties? - How do they maintain their trust in ASMS as at the beginning?
Teacher teams	How did you build interdisciplinary teacher teams? Prompts: - Do you arrange to study from the beginning or leave them to choose? - Do you have special requirements for these teams? - How would you rate the performance of these teams? - How would you remain with these teams?
School leadership	Can you describe some of the difficulties or challenges you experienced during your early years from a leadership perspective and how you overcame them?
School leadership	As a school leader, did you initially set any strategy for yourself in school leadership with a particular school like ASMS?
School leadership	Has anything changed regarding school leadership during the early years of ASMS until it was on track?

APPENDIX G

ASMS early years stories

Story 1: *Inspiration from Zoo School*

> The school was like a big gymnasium, but it had this mezzanine floor and go upstairs to the mezzanine area. And what I saw was these sorts of little pods, alcoves, probably about the size of this room with, student workstations around the edge. And I asked some questions and said, you know, what's happening here? How's this happening? …When the students first come to school here, we put them in there, a group of, I think they said 10, it might've been eight, but we put them in there and for their first three days of school. Most of what they'll do is develop the protocols about how they will act and behave as a community. How will we work together as students? You know, so I thought, whoa, that's really, really interesting because you know, what was going through my head was school community and kids getting along with each other, issues about learning from each other and so on. But this sense of building the community and through student agency, rather than here's the list because the tradition in Australian school…

Story 2: *The studios*

> They're not just there for science technique; they're there for assisting people to go in and come out, conduct some sort of work in there in the laboratory or the studio and come back out into mainstream… the studio is there to assist with this sort of inquiry methodology that we were adopting as well.

Story 3: *Netball T-shirt - nanotechnology*

> There was a group of girls who were netballers who played netball, and they designed netball uniforms that were made of nanomaterial that were touch sensitive. So, because in netball, you're not allowed to make contact with the other player. So, they designed a shirt that if I touched it, it would all illuminate and so on. They change the colour.

Story 4: *A day at ASMS*

> You certainly would not see a teacher standing at a whiteboard. You might see one for 10 or 15 minutes. So, that whole sense of the teacher being the sage on the stage. We tried to get away from that. You would see student's particular times of the day in small groups of 10 or 12 students, which would be their tutor group. One teacher, 10 or 12 students, 40 minutes a day, every day, talking about how do you learn? How can your learning be supported? What is he learning? What is she learning? What is your inquiry project, and so on and so forth? Lots of collaboration in around things.

Story 5: *No-textbook*

> This bit of calculus, off you go, research what that means for you, what you can find out, how it builds on your previous knowledge and so on. Come back and we'll do a sort of like a roundtable seminar. What did you find out, what did you find out, what did you find out, and what was going on? Students were writing their sort of textbook, a personal development of an understanding about a particular aspect of maths.

Story 6: Team teaching

> So, there might be a 40-minute or one-hour period on Monday mornings where one teacher was doing sort of like a lecture to the whole group. But later that day, the other three teachers might be in small groups, smaller groups doing individual things and rotating those groups through those three and so on. There might have been something to do with some physics, for example,

Newtonian physics or something. So, the physics teacher was doing some lecture about this bit of Newtonian physics. But there might be the history teacher sitting alongside and going, "But remember that our understanding of energy supply through electricity today wasn't there when Newton did this bit of conservation or motion or whatever".

Story 7: Milk box story

The kids had been out on morning break…And that came back in, and up on the first floor, there were probably 50 students all gathered around, and they're rah, rah, rah. What's going on? I thought, what's happening here? And what happened was a student had one of those cartons of chocolate milk, you know, and had spilled it on a desk. And what they were all gathered around was, *Hey, who did this? Clean it up. This is our space. You can't; we're working on this together*. So it was an interesting, just a small example. And I went, whoa, I like this, you know, that model of collaboration and sense of community. We all belong to this.

Story 8: Teachers' classes

We structured the school day around four and a half days of schooling rather than five full days of schooling… Tuesday afternoons devoted to professional learning, the staff…would be doing individual research about all sorts of things, everything from sort of pedagogical practice or I remember a teacher did some high-quality work on developing rubrics for students so that they could understand how, you know, go back to the assessment stuff and how one might develop a whole school approach to that… But importantly, what she would do is consistent with models of collaborative learning for students. We would do seminars where people … would do a presentation to the rest of the staff… importantly, at the part of that process was how does this new knowledge … be applied across the school? How can other teachers use this?

Story 9: FP's leadership experience at ASMS

What it talks about is leadership as found in the collective, in the group, not hierarchical leadership. It's so a collective of people finding a direction together. And the analogy goes back to central studies development teams. They find the direction. And then it's about alignment, getting all of the people aligned in that central purpose or central direction. And all contributing. And direction, alignment, commitment. And the commitment is essentially about, and it focuses in on a whole lot of change theory and so on as well, but the commitment is about all of the players subsuming their own self-interest for the good of the whole. So, the common good is found through all of us working in this sense of direction.

Story 10: Lunchtime sport program

So they would go, well, we'll have an ultimate Frisbee competition, you know, or a basketball competition or something. And develop some teams. And so, there'd be teams that would be one teacher and three students in a team or, you know, like that. Who wanted to be the umpires for this competition? Students would put up their hands, and so on and so forth… There were lots of celebrations… And there'd be a small trophy for the winning team, and the team that came last always got wooden spoons.

Story 11: The demonstration days

… inquiry project is nanoscience, you know, is it fact or fiction or whatever, do some research. At the end of the semester, we're going to close everything else down in the school, and it's going to be the nanotechnology demonstration day. You have to design a nano product that's never been invented by anyone else in the world. You'll set up a marketing stall, an interdisciplinary process, to market your product. We'll also bring in your parents, people from the university, and anybody else we can get to come into this market day. And they're going to assess the quality of your product and give us feedback, give you feedback. They will ask you questions about

what you did to design and develop and what you understand; tell us about this, tell us about that.