



## Digital Footprints of University Students

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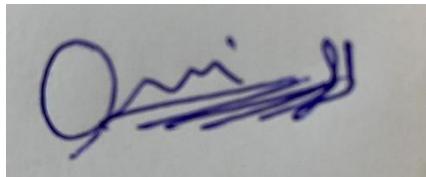
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Submitted to the College of Science and Engineering in partial fulfilment of the requirements for the degree of Master of Science (Computer Science) at Flinders University, Adelaide, Australia.

## Declaration

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

A handwritten signature in blue ink, appearing to read "Faisal Alhamami".

Faisal Alhamami

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## Abstract

Digital footprints create a personal digital identity for each person from the use of different applications and devices. The personal digital footprint can be utilized to get information about an individual's behaviour. Universities are now looking for approaches to analyze the students' digital footprints to improve their experience and enhance university services. This thesis explores a case study of students' digital footprints. It aims to find out what students' digital footprints are. It also aims to find out how and why students leave the digital footprints behind. The review of literature helped in understanding concepts of digital footprints, the different types and their sources. Use-case examples have been used to better understand the concept of digital footprints. A qualitative research method and a exploratory case study methodology have been adopted from Phondej et al. approach. To collect data, two systemized reviews of literature based on the keywords, "Digital footprint" and Student have been conducted. This study findings indicated that there are two methods that students' internet usage can be classified, these are active and passive methods of creating digital footprints. This means that students do not use the internet with same levels of knowledge, and they should be informed of the types of digital footprints they leave behind as well as their implications. The findings also provided categories of negative and positive impacts of student online activities, and these will assist the Flinders Campus Mental Wellness project to understand the virtual ecosystem of devices and applications.

## Chapter 1 Introduction

The existence of information and communication technology (ICT) and the Internet have changed people's social life, especially young people such as students [1]. This new method of communication introduced different threats but at the same time it provides a variety of benefits to an individual. A digital footprint is a trail of data, which is published while using the Internet [2]. There are different types of digital footprints and relevant case studies and examples in the literature [3] that will be reviewed in the next chapter. Today, a basic laptop or a mobile phone makes internet access easier for students. Therefore, they go online frequently and publish more posts, ideas, personal information such as their location or contacts [4]. These data are traceable and can be used by different organization for different purposes. Universities are interested in analyzing the student social behaviours by their digital footprints [5] [6]. However, the student digital footprints need to be anticipated and an in-depth understanding of domain is necessary. Therefore, a new approach to support enough in-depth data for the complex domain of student digital footprint is needed. This thesis will explore a case study of student digital footprints. It aims to address the following research questions:

- What are student digital footprints?
- How do students leave the digital footprints behind, and why?

The existing studies [7] [8] [9] [10] tried to provide some information based on experimental strategies such as questionnaires and surveys. However, the student digital footprint topic is too complex for only survey or experimental strategies. The scope of this study is defined based on the secondary review and analysis of the literature related to students' digital footprints.

This study scope is bound to the research strategies that do not need Human Ethics approval due to time constraints on this master project. A qualitative method is conducted through a seven-step single exploratory case study. This method assists the Flinders Campus Mental Wellness

project to understand the virtual ecosystem of devices and applications. The research demonstrates the usefulness of this approach through providing an in-depth impact analysis of students' digital footprints. Moreover, it builds a map of digital footprint and addresses the research questions.

Chapter 2 discusses background information pertinent to the research discussed in this study. It also encompasses relevant work in the area. Chapter 3 defines the methodology used to address the research questions. Chapter 4 details the design of a systematic review. It described the review criteria and provided the information in a tabular format. Finally, in chapter 5, the data are analyzed to discuss what impact the creation of digital footprints have.

## Chapter 2 Background and Literature Review

This section begins with a discussion of background concepts required to understand digital footprints and their sources. To begin this discussion, digital footprint types are discussed. Then, a selection of common digital footprint use-cases are presented. Additionally, the issues related to access on public and private digital footprint data are discussed.

### Digital Footprints

In this document, as in the literature, the terms digital trails and digital footprints used interchangeably. Digital trails can also be referred to as digital footprints [11]. A digital trail is a specific example of a footprint in which the digital footprint data is created while user is browsing through the Internet [11]. It includes the email data, browsing history, and the data user shares with online services like e-commerce stores. There exist two types of digital footprints: active and passive.

#### Passive Digital Footprints

Passive digital footprints are the digital footprints that users leave online unintentionally [12]. For example, when visiting a particular website, the IP address is elicited by the website, which identifies the approximate location and the internet service provider of user [13]. Furthermore, user's search history and preferences are saved by search engines and can be identified by the user profile (User Account) [14]. Logs of the data packets that users send on the (wireless) network remain there. The logs contain the source and destination address and the content of the packets being transmitted [15]. As much as the information being transmitted on the network is encrypted, it leaves a digital trail as it contains the information of the user who is sending and receiving the information [13].

We live in the era of Internet of Things (IoT) where almost everything is smart, and we have smart cars, smart homes, smart building, smartphones, and many others [16]. Increasingly the use of biometrics is being adopted for instance to unlock doors , where users have to use voice recognition or fingerprints [15]. Others use the retina or facial recognition. All of these types of data are kept in a server that is networked to store this data. As such, building data can lead to digital trails. Also, one common way that buildings contribute to digital trails is the use of CCTV cameras, that are either connected over the Internet or within a local network. Cameras constantly send video feeds to the servers thus maintaining a digital video trail of the users of the building [17]. A similar concept also applies to the campus environment where students have used clock-in systems to register for the day's classes. This data leaves a digital trail, and anyone interested can access it, as long as he/she has the authorization [15]. IoT Devices are rapidly increasing the digital trails of many users. The new generation of IoT devices is data-driven, but as it may sound effective and reliable, they leave numerous digital trails behind [18]. The pie chart below indicates the targeted IoT devices and other traditional IT devices, which are source of creating digital footprints at 2016 [19].

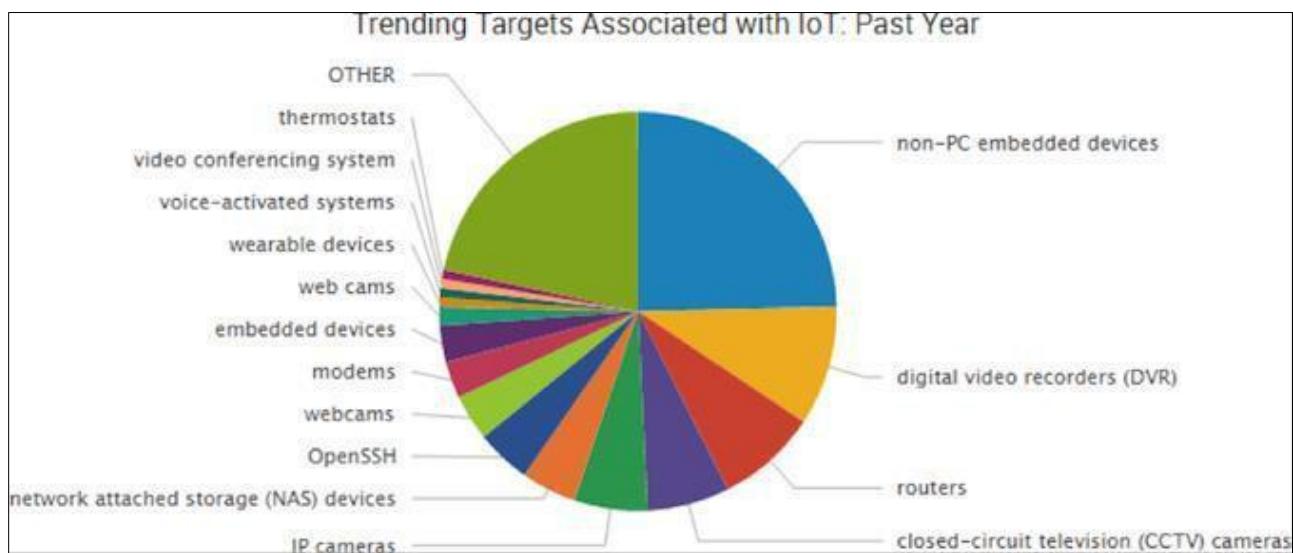


Figure 1 Trending Target Associated with the IoT

Mobile phones are also contributors to digital trails because a large number of the population owns one [18]. Users tend to download many applications on their phones without an understanding of how such applications connect to the Internet directly using different interfaces, or what data is collected and stored. The developer of the application is responsible for controlling how the app sends or receives data to and from other devices and services [11], over which the user has little or no control.

### Active Digital Footprints

On the other hand, an active digital footprint is made up of the information that user submits or shares intentionally online[12]. Actions like sending emails, contribute to active digital footprints as a self-reporting action. Messages sent over email may remain online (as a digital footprint) for a long time because most users store their emails online [20].

Some active digital footprints, such as those created on social media platforms, might not be accessible without user permission based on the level of security on the social media account. On the other hand, student portal forums are public and can be a contributing source of student digital footprints.

Although social media platforms try to maintain the user privacy, some parts of user profiles are usually public (with the user permission). For example, LinkedIn profiles are restricted for user's skill, endorsement, and mutual connections but the remainder of the users' information is available publicly [21]. Social media profiles create a user's social identity. These online identities are established all over the Internet when a user creates different social profiles intentionally and they can be considered as actively constructed presentations of them [22]. Users create these active digital footprints (e.g. LinkedIn profile) to expose and express their identity for different purposes

such as career development or establishing relationships. Active digital footprints can be observed by other users such as hiring managers or individuals looking for a partner. Therefore, they can be used by users to market themselves for aims such as job hunting (for example using their positive image on LinkedIn profile) or to formulate their identity in order to appeal to potential partners [23]. Such digital footprints can be used to predict the personality of users as well [24]. Some people choose to not use their real names online but there are some methods [25] [26] to find their online identity using their other social profiles

#### [\*\*The Importance of Digital Footprints and a Good Control of them for the User\*\*](#)

Many people in the world currently depend on the Internet and on social media for communication and for conducting their day-to-day business activities. These technologies such as social media sites, blogs, Google Maps, the Internet of Things and devices such as cell phones and tablets have created a platform where people can easily share their daily experiences through photos, videos, stories and locations. Despite the potential benefits, the use of these digital platforms leaves a footprint of data. This huge digital footprint usually analyzed to get some knowledge about the individual preferences, needs and behaviour. This information can even have an affect on the user's future when an employer or manager checks the individual's online identity (footprint). It is important for an individual to control the digital footprint to looks professional and positive.

The active digital footprint is the most controllable between two types of digital footprints by user. As long as the user is connected to the Internet, digital footprints get left behind [16]. What differentiates the users is the ability to secure themselves by using the various security mechanisms to protect themselves from being tracked and monitored. Some of the tips that the user can adopt are as follows [27].

- Utilize privacy settings
- Delete unused social profiles

- Avoid over sharing on social platforms
- Employ the use of digital tools to monitor and control digital footprints

## Digital Footprint Use Cases

The Internet has revolutionized the use of technology in everyday life. The flow of data and information in cyber-space is limitless [15]. This information includes digital footprints. Users' digital footprints can be used for different purposes, such as cyber-crime, law enforcement, marketing and health.

### Cyber-Crime Case

As users enjoy the immense technological benefits brought about by technological innovations, cyber-crime remains a problematic issue. Cyber-crime involves a coordinated, systematic attack through cyberspace [15]. Cyber-criminals use users' data to launch attacks on them [13]. Many users do not realize the impact of a shared Google location, a shared photo, or a video or intercepted credit card details. Online attacks such as social engineering attacks exploit the readily available information mostly shared by users innocently. This attack uses psychological manipulation to trick users into making security mistakes or giving away sensitive information [11].

### Law Enforcement Case

On the other hand, the interaction with various technologies over the Internet may leave crucial data that law enforcement agencies can also use to track the whereabouts of users [12]. In developed countries such as Australia, law enforcement agencies can create a timeline of how users had spent their day based on their digital footprints such as when the toll bridge was crossed, when the car's number plate was scanned, when the credit card was swiped and based on the mobile phone carriers' data records [28] [29]. Law enforcement might use digital trails to prove that a particular suspect committed fraud or was at the location of the crime at the time when the

crime took place [18]. This is possible because the phones that we currently use, have been designed to be more personal and contain GPS, which when turned on, can track a user's location. Digital trails also help the police to follow or track specific online activities of a suspect [12].

## Marketing Case

### *E-Commerce and Tech Companies*

Apart from the law enforcement agencies and the cyber-criminals, marketing agencies and major corporations such as E-commerce and technology companies have exploited the harvested digital trails to enhance their campaigns [12]. Companies like Google encourage people to create an account that Google can use to track their activities [13]. Search history includes how users use various search engines to look for different things on the Internet. Browsing history information includes the logs that the browser keeps of all the browsing activities on a computer [14]. By accepting cookies from some sites, permission could be granted to them to track users' browsing activities, including their browsing history [16]. With the increased demand for personalized advertisement, big data companies use advanced data analysis mechanisms and Artificial Intelligence to provide actionable data to marketing agencies [12]. Moreover, companies are keeping track of customers' digital trails such as phone and social media data, to identify their preferences and focus on fulfilling those preferences [12]. Companies have learnt to analyze customer interaction on the different sources to ensure that companies are up to date with the current customer trends and ensure that they remain competitive.

### *Hospitality Organization*

Yoon et al. [17] proposed a social visitor itinerary recommendation through the learning of many user-generated digital trails. The aim is to recommend a satisfying itinerary to users, with the presentation of an itinerary model in terms of the attributes that are extracted from the trails

generated by users. In addition, this itinerary model [17] presents a social itinerary recommendation framework for finding and ranking the itinerary candidates. Visitors leave digital footprint data in many ways involuntarily or voluntarily before the visits, during their stay and after their visit [30]. Through several log entries when they consult or take the help of digital maps or travel websites, they leave digital footprints [30]. During their visit, the tourists leave traces of their digital prints when they use wireless networks at public places and post photos and reviews online. This digital footprint data is present on the Internet Service Providers' servers, website servers, and the personal social media profiles of visitors [31]. This data can be accessed by organizations, particularly tourism companies through digital trails to see which restaurants, hotels, landscapes, sites, and sceneries tourists like, to develop their tourism marketing strategies following that information.

### Health Case

With the collection of continuous streams of data through digital trails as people regularly go about their lives, the mobile health technology captures the psychological data and patient insights, which are outside the scope of the traditional digital trail site. This allows the patients to remain in their own house while their biometric data travels. The concept of a technology like mobile health, which is continuously evolving with technologies like smart watches, makes it possible to collect a vast array of physical health and psychological health data of a patient, on a daily basis, including the vital signs like respiration rate, heart rate, glucose levels, oxygen saturation, activity data, sleep and calories burned etc., by using advanced digital trails and analytics techniques allowing the people to monitor their physical health and fitness from the comfort of their home without even visiting a hospital. This shows how positive digital trails and digital footprints of an individual could be, especially when considering clinical research [32].

The interest in digital trails is increasing, particularly in the use of mobile technology and mobile health for capturing the insights outside the traditional clinical settings [33]. The digital trails are seen and recognized as the vital components of providing new ideas and pathways of enabling the patient-centric trials designs that focus upon capturing the clinical signals.

#### **Background on Access to Public and Private Digital Footprints**

There are several social media platforms where users typically leave numerous digital footprints through the many posts and comments that they make [14]. It would be easy to know how a person feels because many social media users express their feelings and opinions on their public profile. However, the digital footprints of private profiles are only accessible to the organization that owns the platform. Examples of these social media platforms include Twitter, Facebook, Instagram, WeChat, LinkedIn, and many others [14]. Regularly posting social media updates and publishing blogs are some of the favorite ways of widening a person's digital trails [11]. Every post created on Facebook, every tweet published on Twitter, every video uploaded on YouTube and every picture posted on Instagram enhances a user's digital trail. The digital trail grows larger as one continues to spend more time on social network platforms; even a simple act of liking a post or a page on Facebook adds it to a user's digital trail [11].

The time students post and comment on posts from their peers on the student portal forums, they also add it to their digital trails, which are accessible to public [34]. Most of the student forums do not allow one to delete the post or comment after posting, and this post could remain even after they finish school. Even if a user removes them after publishing, there is no guarantee that it gets permanently removed, because other people could have seen or shared it [34], and there may be legal requirements of the platform to retain information despite being deleted from what is viewable by users.

### **Review of Digital Footprint for Commercial and Medical Purposes**

This section reviews the existing work on an individual digital footprint, with emphasis on the behaviour and the mental wellbeing of university student. We discuss what the existing literature has analyzed and measured to get the individuals' state of mind and behaviour based on their digital footprint. The section concludes with a summary of the perceived shortfalls and gaps in the current literature.

The existing literature on the use of digital footprints for medical and non-medical (commercial) purposes are discussed and compared. Specifically, passive digital footprints are a focus.

Kotikalapudi et al. [35] propose a passive digital footprint collection approach for medical purposes. This article provided an Internet-based intervention strategy for studying depression of college student at Missouri University of Science and Technology. Generally, they have focused on patterns with depressive symptoms. Their participants (students) used the campus Internet and the campus Internet data has been collected continuously, unobtrusively, and while keeping student's privacy using Cisco NetFlow V5. The NetFlow [36] technology is a protocol for collecting IP traffic information. The data generated by this technology (NetFlow) consists of several flows. The flows related to each participant were identified and stored based on their source IP field, user ID and campus email address on a monthly basis. They were statically analyzed and focused on three Internet usage features categories such as Aggregate usage, Application usage and Entropy usage categories. The Aggregate captures raw aggregates of Internet usage such as packet and duration. The Application usage captures application specific Internet usage features such as chats and email. The random features of Internet usage like flow capture and store in Entropy category, using the Kotikalapudi et al. [35] method would be beneficial for other studies that are interested in investigating the association of the Internet-based usage and mental disorders. However, their pool of participant and generated volume of data were small and therefore were

not sufficient for an accurate evaluation. Moreover, they did not consider (or combine) any environmental and ecosystem factor with their findings to enhance the efficiency of approach.

In the Internet-related services and products industry, search engines like Yahoo and Google are keen to predict their user future behaviour using historical digital footprints of users (passive digital footprints) [37] [38]. Generally, they utilize the user historical data to predict and analyze their behaviour using various algorithms such as machine learning [39]. These algorithms access the user data and derive useful knowledge from it. This helps to show more relevant advertisements (ad) to the Internet user and therefore, generate more leads for the advertisers. These digital footprints consist of page views, search logs, ad views, ad clicks and server logs. Based on the experiments described, these systems are great in handling billions of digital footprints (user histories). However, keeping and handling such huge data sets is costly.

Another study, by Choudhury et al. [40], proved that changes in language, activity, and social ties can be used jointly to construct statistical models to detect and predict depression. Their method consisted of 4 major parts. First, they used survey to collect assessments from 1500 Twitter users, who self-report that they have been diagnosed with depression. Second, they introduced several measures and used a matrix to quantify an individual's social media behaviour for one year. The measures were user engagement and emotion, egocentric social graph, linguistic style and depressive language use. Thirdly, they used these measurements to compare the behaviour of depressed users with normal users. Finally, they built a depression classifier to identify at-risk individuals. They combined the user active digital footprints such as user social media posts (and the post language style) with user passive digital footprints such as a graph of user interaction with others (that is accessible from social platform server). In addition, they combined user digital footprints data with a self-report survey in order to increase their approach efficiency. They

investigated a range of factors (passive, active digital footprints and survey) in their research but their pool of participants was small for a comprehensive evaluation. Moreover, the data from a self-report survey is limited, as the participants themselves reported their depression, which might be true or false and is a subjective measure.

## Summary

In this chapter, we have reviewed the approaches that use the digital footprint data for health analytics, cyber-crime analytics, law enforcement analytics and marketing analytics. In the digital footprint analysis process, both passive and active digital footprints are generally considered. The review indicates that it is important (1) to determine what constitutes a digital footprint for the domain of interest (in our case the first-year students' information), (2) to choose the best (feasible) method for analyzing the digital footprints (3) to understand how to predict user behaviour and what to predict. Finally, our goal is to come up with a strategy to improve the individual mental wellbeing based on the analysis result. There are currently several approaches [35] [37] [38] [40], which apply analysis methods to understand the user behaviours. Across all the research reviewed, the feasibility of methods is the common concern. Moreover, they could evaluate more participants' data instead of a small pool of them to gain more accurate evaluation result.

Furthermore, we have also summarized the tools, factors, measurements these approaches used in their own domain that can be useable for anticipation and formulation of students' digital footprints. Based on the important points highlighted above and to provide an in-depth understanding of students' digital footprints, the following research questions are considered:

- What are student digital footprints?
- How do students leave digital footprints behind, and why?

## Chapter 3 Research Methodologies

To address the research question, we need to have a plan (or choose a method) for creating the research design. The research method defines the plan to obtain sufficient data for addressing the research questions. There are three kinds of research method to choose from (1) qualitative research, (2) quantitative research and (3) mix of qualitative and quantitative research methods [41] [42] [43].

### Research Design

#### Qualitative Design

Qualitative research is an approach that provides an in-depth understanding of the ways people understand, act and manage their daily affairs in particular settings. The results of this research are in a text form (but not in a numeric format). This result is obtained by using methods such as observation, individual interview, focus group discussion and case study [44].

#### Quantitative Design

Quantitative research is an approach that provides information about quantities or numbers. Usually, there are measurement units associated with this information. This approach uses statistical models and figures to describe what is observed. The quantitative result is obtained by using methods such as experiments and surveys [45].

#### Mixed Design

Qualitative/quantitative or mixed research is an approach that provides sufficient information for research questions that need collecting and analyzing both qualitative and quantitative data. This approach result is obtained by integrating qualitative and quantitative methods and data. For example, a case study result can be extended using a quantitative method (such as questionnaires) results in order to better explain what is observed [46].

## The Seven Steps of Case Study Development

Among three types of research methods, this research will use qualitative research method. This method generates qualitative data that provides deeper / richer information for our subject of study (university students' digital footprints). Qualitative data can be used to discover the intent behind student's online actions or activities in the digital footprint context [43]. Among the qualitative techniques for collecting data, we will conduct a case study [46].

A case study method can be used to connect the micro level, or the actions of students, to the macro level, or large-scale social structures and processes. This technique helps to explore the boundaries and defining characteristics of cases [47]. We have adopted the Phondej et al. approach to set up our case study methodology. Phondej et al. [47] provides seven steps to conduct a case study approach, namely: (1) Justification for the research paradigm and research methodology, (2) Justification for the case study method, (3) Criteria for judging the quality of case study design (4) Designing the case study, (5) Criteria for selecting a case design, (6) Data collection, and (7) Case study analysis.

The research design based on this 7-steps case study methodology is detailed in the next section.

### 1: Justification for the Research Paradigm and Research Methodology

To choose an appropriate paradigm, examples of individual's digital footprints research have been studied and are detailed in the literature review chapter. Most of these studies use a mixed methods approach. Their paradigms include specific methodological strategies linked to their assumptions such as questionnaires, study groups and surveys. However, the student digital footprint topic is too complex for only survey or experimental strategies. Moreover, our study considers research strategies that do not need Human Ethics approval due to time constraints on the project topic. Therefore, this research will not employ any participant nor design a survey, questionnaire or use study groups. In the parent Flinders Digital Health Research Centre Campus Mental Wellness

project, of which this research is a component part, we study and observe students and report their interaction with the Internet and “why” and “how” they leave digital footprints. This research is social behavioural science research that uses existing studies in qualitative research and case studies. The qualitative research style is flexible and encourages slowly focusing on the topic throughout the study [47].

## **2: Justification for the Case Study Method**

Case studies are most appropriate for research questions that are of the “how” and “why” variety [48]. Therefore, a case study was selected as the most relevant to answer the research question. Case studies help generating new ideas that will be tested by other methods (such as Flinders Campus Mental Wellness project). Case studies are helping to show what are different sources of a student's digital life are how they related to each other.

There are several types of case study methods such as Illustrative, Exploratory, Cumulative and Critical Instance [49] [50] Illustrative case studies describe a situation, what is happening with it, and why it is happening. This type of case study is often helpful when the target audience is not familiar with the topic. Critical Instance case studies are best for investigating a specific event or situation. These studies can be utilized to provide cause-and-effect relationships for the studied subject. Cumulative case studies offer a better generalization of the multiple case studies results that have been conducted at different locations / times. This type of study allows for a larger data collection without the need to conduct an unmanageable amount of case studies at the same time. Exploratory case studies help to have an idea of what is going on in a situation. Among all types, illustrative and exploratory are appropriate for the student footprint study. The illustrative method can be used to introduce the target audience (reader) to the concept of digital footprints but an exploratory study helps to investigate and answer how and why research questions. Therefore, an

exploratory [51] type was chosen that provides detailed data for our research questions listed below:

- What are student digital footprints?
- How do students leave digital footprints behind, and why?

The exploratory case study provides an in-depth descriptive and exploratory analysis of the digital footprints of students. The analysis result will help us to achieve the followings:

- It helps to create a map of digital footprints.
- It provides a means for understanding students' digital footprints with greater clarity.

### **3: Criteria for Judging the Quality of Case Study Design**

Based on learning from Phon dej et al., to maximize the quality of the case study was ensured by following “reliability” and “validity” principles. Reliability refers to consistency with which the research will produce the same results if repeated. Validity refers to accuracy or correctness of the findings. Moreover, with regard to criteria for judging the quality of research designs, we empower the study with utilizing the following design tests and case study tactics described in Phon dej et al. work. To satisfy the construct validity test, this study uses multiple sources of evidences through using a systemized review [52] in the data collection research phase. Furthermore, to address the internal validity test, it uses thematic analysis of data.

### **4: Designing the Case Study**

This research chose exploratory case study as its methodology and is based on an in-depth investigation of university students' digital footprints. To address the questions in this research, a research design (blueprint) is needed. The case study design components that are as below:

- Study's questions: The study questions (defined in the second step) are “what, how” and “why” questions. An exploratory case study can be used for the “what” question as

research method [49]. Yin et al [49] also defined the case study method as preferable method for “how” and “why” questions. Therefore, this study choice of design is an exploratory case study.

- The proposition: Propositions are statements that limit the scope of the study. They can be found from the literature, or extracted from professional experience and/or generalizations based on empirical data [53]. This study does not contain a specific proposition. Therefore, there is no initial statement or proposition about the conditions and factors associated with students of Flinders University to be compared with the case.
- The unit of analysis: digital footprint is the unit of analysis for the case of digital footprints of university students.

The following two components have been named but not defined in the Phondej work [47].

- The logic linking the data to the proposition: This study aims to describe some potential patterns, and then compare the case study data to the patterns and see which one is closer. The patterns will be extracted from literature [35] [8] [54] [55]. They will be based on specific variables that will be defined.
- The criteria for interpreting the findings: This study uses the explanation building, which is one of the case study methods for interpreting the findings.

## 5: Criteria for Selecting a Case Design

According to Phondej et al [47], it is necessary to distinguish between single and multiple case study designs. This study research questions, and unit of analysis indicate that a single case design is sufficient for this study. A single case design is a common design for doing case studies [49]. In general, the single case design is justifiable under certain conditions [49] where the case represents (1) a critical test of existing theory, (2) a rare or unique circumstance, or (3) a representative or

typical case, or where the case serves a (4) revelatory or (5) longitudinal purpose. This revelatory study case is a representative or a typical case where the objective [49] is to capture the circumstances and conditions of student's digital footprint (an everyday or commonplace situation).

#### **6: Data Collection**

The usual methods for collecting data of a case study are interviews, questionnaires and surveys. These methods employ some participants and discuss the results based on their observation and experience. It is also possible to look at other reports exist in the literature that used the scientific experiments, surveys and other empirical methods for the research. This type of review is called "systematic review" [52]. A systematic review brings together all the published known knowledge on a research topic area. This study adopts a systematized review, [52] which has all the elements of a systematic review except the comprehensive nature of a systematic review by gathering the empirical data from the works exist [35] [8] [54] [55] in the literature by document review as a data collection instrument. This type of review will form the basis for a larger project such as the Flinders Mental Wellness project. The data will be categorized and sorted. Finally, the relevant data will be recorded.

#### **7: Case Study Analysis**

This study adopts one of the Phondej et al [47] analytic technique, which is explanation building. This study analyses articles and identify digital footprint themes and sub-themes. Moreover, it highlights the type of students and each article key learning point to summarize as the impacts of creating digital footprints. This is followed by grouping of the findings and identifying new categories of impacts.

## Chapter 4 Data Collection

This chapter implements the data collection method described in the sixth step of seven-step case study methodology. Two systematized reviews of literature were designed based on the keywords that repeated in relevant studies (relevant terms) and based on following combination:

- A phrase: “Digital footprints”
  - An operator: AND
- A term: students

The relevant studies also used terms “trails of information” or “data trails”. However, the frequency of digital footprints is extremely higher. Therefore, we have excluded the terms “trails” from our search terms.

### Systematized Review:

To increase the level of relevant material, a filter has been designed to retrieve all the materials that contain keywords certain keywords (all together) in any field (such as subject, title, user tag and so on) of an article using Flinders University library advanced search tool. To get the recent results, this filter retrieves only the articles that were published in last 5 years. Moreover, this study collected only full papers with either a related title or abstract. The review results are given in Tables 1 and 2.

Table 1 : review result with all relevant terms

Database Name	Criteria: Terms (sorted by relevance)	# of Results	Criteria: 2014<Year	Criteria: Full Paper (Journal Articles)	Criteria: Related Content (title, abstract)	Justification for the articles selected among the filtered articles (by the search criteria)
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IEEE Xplore	Students social media	730	479	31	1	This article [9] studied 25,000 tweets related to engineering students' college life. It has been selected to be analyzed in term of student digital footprint. The other 30 articles are irrelevant according to their title and abstract.
	Student Internet Usage	474	233	5	1	There are some articles if the "Year" in the second pass criteria could change to years = <2012 such as [35].
Central proquest	Digital footprint social media students	2154	1455	358	1	It [7] explores how and why medical students use Twitter for professional development. It has been selected due to similarities of research objectives to this study.
Proquest	Digital footprint social media students	5348	7252	1084	3	This article [56] addresses the type of digital footprints students use and questions such as how / why they create digital footprints. It has been discussed most of social media types.
						Another article [57] has been found in the 4 <sup>th</sup> page of sorted result. It has been discussed the impact of digital footprints on students using social media.
		5348	7252	1084		Another article [58] has been found in the 2 <sup>nd</sup> page of sorted result. It discusses the impact of social media usage within digital education.
Ebscohost	Students' digital footprints	3273	1765	946	1	This article [59] has been found on top of first result page. It discusses the student's digital footprint awareness.
	Disadvantaged students use the Internet	29560	11213	5026	1	This article [55] compares the digital footprints of advantaged and disadvantaged students. It can be found in the top first result page.
	Digital footprints	375,530	2,853	9,570	1	This article [3] found in the first page of results. It suggests using active digital footprint for positive digital identity.
Science Direct	Digital footprints social media students	6740722	1602827	683960	1	This article [60] found in the middle of first result page. It discusses the positive effects of digital media on social behaviours of students
Science Direct	university student social media	74819	32590	24497	4	This article [61] found as second article in the page. It discusses how social media activities affect students' sense of belonging, psychosocial well-being, and identity development.
		74819	32590	24497		This article [62] found in the second page of result. It discusses social life of students and especially social integration.

		74819	32590	24497		This article [63] found in the page six of results. It discusses the positive effect of online social networks when students adopt them.
	student internet in	85527	36687	27748		This article [64] has been found in the first page. It discusses Japanese usage of smartphones, primarily for e-mail, social media, and shopping and relationship of depression and internet usage.
	student internet in	85527	36687	27748	2	This article [10] found in the first page of result. It discusses the effect of internet and Facebook on student distractions.
		85527	36687	27748		This article [65] discusses the effect of internet usage on behaviour change.
	Student in internet digital footprints	1029	604	332	2	This article [66] found on top of the first page result. It discusses the negative effect of social media such as Facebook on young people such as students.
		1029	604	332		This article [8] can be found on top of first page if the year criteria includes 2012 articles.
	University students use social media	74822	32280	24280	1	This article [67] found on top of the first page. It discusses the student behaviours when use social media and mobile devices for different purposes.
SAGE Journals	Digital social media students	1447	782	607	1	This article [68] founds in the first page of the results. It's suggests finding ways of informally introducing aspects of the Protect Yourself/Protect Others dimension, such as digital security or digital health and wellness.
	Students digital footprints	2746	1348	1075	1	This article [4] found on the first page of results. It focuses on digital footprints of young student (mostly from Facebook).
Taylor and Francis Online	Digital footprints social media students	2546	1472	1472	2	This article [69] found on the page 6 of results. It discusses the influence of student digital multitasking on attention and learning.
		2546	1472	1432		This article [70] shows that social media plays a significant role with entertainment and also for educational purposes.
	Students Online Reputations	32518	14254	Database does not offer this (journal type) limiter	1	This article [54] can be found in the first page of result. It discusses the young student's reputation in social networks such as Facebook.

Informit Humanities & Social Sciences Collection	Students digital footprints	1	1	1	1	This articles [71] discusses the positive digital footprint of young student when they use social networks such as Instagram and Facebook.
DOAJ	Students footprints Online	5	-	5	1	There are some articles if the “Year” in the second pass criteria could change to years = <2012 such as [72]. This article found in the first page of the results.

The first systematized review used specified phrases that contained our terms. That setting was not promising due to having high number of irrelevant results. Therefore, a second systematized review was designed with combinations of search operator and specific terms. The Boolean operator “AND” helped to narrow down the results. Table 2 indicates the result for the second review. Searches of IEEE Explore, Proquest Computer Science, ScienceDirect, SAGE Journal, Taylor and Francis online databases were undertaken for related studies using combinations of the following search keywords: (1) Students (2) Digital footprints.

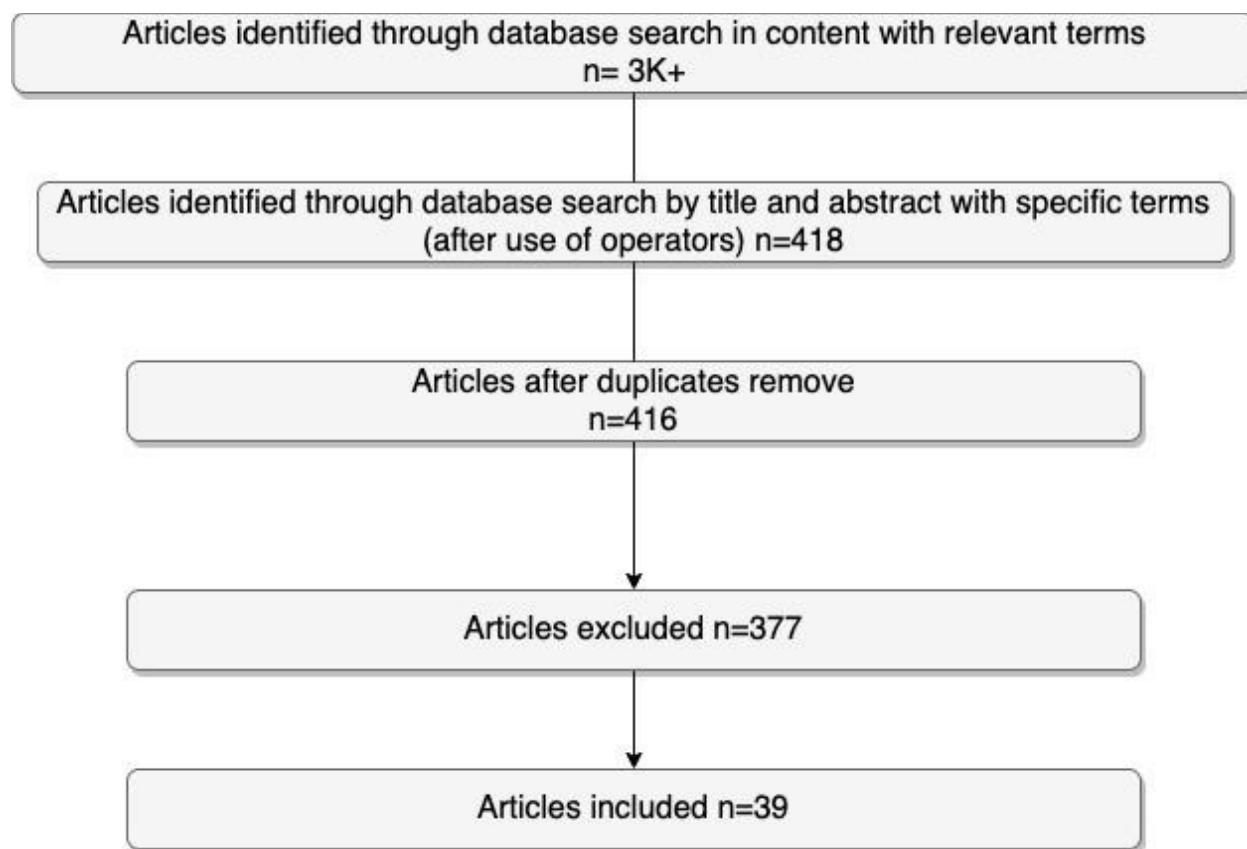
#### **Inclusion/Exclusion criteria:**

To increase the quality of selection, this study was interested in the articles that contain the search terms in the body of article. However, those that contained the search terms in their content but not in the article’s title and abstract, were deemed not directly relevant and therefore they were excluded, and the selection was limited only to abstract and title of articles. This process helped the researchers to identify the principal inclusion and exclusion criteria.

The studies published after 2014 and before 2020 were included. Moreover, the studies that were not article type (e.g. books) and not available in full text were excluded. Studies that used students (or young people) to investigate their passive or active digital footprints information through qualitative and / or quantitative experiments were included. Articles published in a non-English language were excluded even if they conform the mentioned inclusion criteria. The titles and

abstracts of the identified articles were reviewed and the inclusion and exclusion criteria (described above) applied. Limiting the identified citations to “digital footprints” and “students” related studies produced 416 citations. Their titles and abstracts were screened to determine relevance.

The following diagram indicates the number of articles:



*Figure 2 Result Flow Diagram*

*Table 2: review result with specific terms*

Database Name	Criteria: Terms (sorted by relevance)	# of Results	Criteria: 2014<Year	Criteria: Full Paper (Journal Articles)	Criteria: Related Content (title, abstract)	Justification for the articles selected from only first few result pages
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IEEE Xplore	"Digital footprints" AND students	3	2	2	1	This article is the second one in the search results. It talks about digital footprints of students [73].
Proquest Computer Science Database	“Digital footprints” AND students	108	74	36	2	This article [57] has been found in the first page of sorted result. It has been discussed the impact of digital footprints on students using social media.
						Another article found in the first page. Digital Citizenship: You Can't Go Home Again [74].
ScienceDirect	"Digital footprints" AND students	192	147	94	3	This article [66] found on top of the first page result. It discusses the negative effect of social media such as Facebook on young people such as students.
						This article found in the middle of the first results page. Collaborative competencies in professional social networking: Are students short changed by curriculum in business education? [75].
						This article “Cyberbullying: The hidden side of college students” found int the first page [76].
SAGE Journals	“Digital footprints” AND student	151	127	114	4	Found in the first page. No Kid Is an Island: Privacy Scarcities and Digital Inequalities [77].
						Found in forth page “Nobody Sees It, Nobody Gets Mad”: Social Media, Privacy, and Personal Responsibility Among Low-SES Youth [78].
						This article [4] found on the first page of results. It focuses on digital footprints of young student (mostly from Facebook).
						This article found in the second page with title “You never really know who's looking”: Imagined surveillance across social media platforms [79].
Taylor and Francis Online	“Digital footprints” AND students	214	170	170	3	Found on the second page. Identity, context collapse, and Facebook use in higher education: putting presence and privacy at odds [80].

					Found on the 5 <sup>th</sup> page. An open book on Facebook? Examining the interdependence of adolescents' privacy regulation strategies [81].
					Found in page 8 <sup>th</sup> . Young people, digital media making and critical digital citizenship [82].

## Chapter 5 Data Analysis

In this chapter, the data analysis is described of the data that was collected from each eligible article including descriptions of positive and / or negative impacts of creating digital footprints. The investigator read and analysed each article to identify the theme of a work. Table 3 indicates the result of this analysis.

*Table 3: thematic analysis table*

Themes	Sub – Themes	More Information about Article	Article Reference	Student Type
Social Media	Twitter	Introduced Prominent Themes	Mining Social Media Data for Understanding Students' Learning Experiences [9].	College Students
Internet Usage	Applications	It discusses some depressive behaviours as negative effect and learning as positive effect of internet usage	Associating internet usage with depressive behaviour among college students [35].	College Students
Social Media	Twitter	It Indicates Twitter as a positive tool when students use it for personal and professional developments	A Digital Ethnography of Medical Students who Use Twitter for Professional Development [7].	Medical Students
Social Media	Twitter, Facebook and Instagram	The article objective is designing social media law projects, to sensitize business students to appropriate and ethical digital practices, whether in the workplace or their personal lives	Creating Social Media Law Projects To Sensitize Business Students To Appropriate Digital Conduct [56].	Business Students
Social Media	Instagram, Youtube, Snapchat, Vine, Pinterest, Facebook, Twitter, Kik, GooglePlus and Flickr	This article claims that students create digital footprints with smart phones and laptops. Cyber bullying, digital identity, impact of digital footprints, and use of inappropriate social media are topics that the author discussed	Middle School Students' Social Media Use [57].	Middle and Junior High School Students
Social Media	Facebook, Instagram, and Snapchat	It explains the social media usage by students; this study claims college student leadership development through the impact of social media usage within digital education. So, it claims students used social media to develop digital skills and further social development	Social Media Usage By Millennial College Students: The Development Of The Digital-Age Student Leader [58].	College Students
Internet Usage	Applications and Websites	It discusses the digital lessons the students should learn and set some rules for their privacy when using internet	Can I Use This App or Website for My Class? [59].	The eighth-grade students
Internet Usage	Websites (news) and Email Services	It discusses the equal opportunity of using internet For advantaged and disadvantaged students	Are there differences in how advantaged and disadvantaged students use the Internet? [55].	Advantaged and disadvantaged students

Social Media	Smart Phone	College students use digital media to interact with others to fulfil their psychological needs and use social media and smart phones to interact with others	Digital Media Use and Social Engagement: How Social Media and Smartphone Use Influence Social Activities of College Students [60].	College Students
Social Media	Facebook and Twitter	In university, students and faculty members have increasingly adopted various social media tools to promote teaching and learning both inside and outside the classroom. Also, it listed some educational benefits associated with the use of social media technologies	Effects of social media usage and social media multitasking on the academic performance of university students [61].	University Students
Social Media	Facebook, Twitter and Instagram	It discusses the positive effect of social media on social integration of students	In the mix: Social integration and social media adoption [62].	Middle school Students
Social Media	Facebook, YouTube, Instagram, Twitter, LinkedIn, Pinterest, Snapchat and Blog	It discusses social media weaknesses, strengths	University students and online social networks: Effects and typology [63].	University students
Internet usage	Application	The concern of this article is internet addiction and depression	Relationship between internet addiction and depression among Japanese university students [64].	College Students
Internet usage	Facebook	It discusses that there are six key findings of the study with regards to the impact of the Internet and Facebook usage on academic distraction and academic achievement.	The Internet and Facebook Usage on Academic Distraction of College Students [10].	College Students
Internet usage	Application	It discusses the disadvantages of internet usage	College Students and Problematic Internet Use: A Pilot Study Assessing Self-Appraisal and Independent Behaviour Change [65].	College Students
Social Media	Facebook	It discusses the psychosocial distress such as negative interpersonal experiences of social rejection and victimization of bullying	The digital footprints of adolescent depression, social rejection and victimization of bullying on Facebook [66].	Teenagers but not students
Social Media	Facebook	The data that it collects, provide how students shape and also perceive their digital identity. Also, it claims that students are aware of their digital footprints	Self and Identity: Raising Undergraduate Students' Awareness on Their Digital Footprints [8].	Undergraduate Students
Social Media	Facebook	The objective of this article is to analyses the relationship between the use and the addictive behaviour of social media and the use of mobile devices, depression, and suicidal ideation	Measuring the relationship between social media use and addictive behaviour and depression and suicide ideation among university students [67].	University Students
Social Media	Facebook	This article suggests finding ways of informally introducing aspects of the Protect Yourself/Protect Others dimension, such as digital security or digital health and wellness. This claimed to be the weakest dimension of college students' digital citizenship in this article	Social media competence and digital citizenship among college students [68].	College Students
Social Media	Facebook and Instagram	It suggests that should be more awareness and management strategies for children's digital footprint	Post no photos, leave no trace: Children's digital footprint management strategies [4].	Students from last two years of primary school (ranging in age

				from 10 to 12 years old)
Internet Usage	Application	It discusses the influence of student digital multitasking (such as use of technology while listening to a lecture) on attention and learning	The influence of cultural values on U.S. and Danish students' digital behaviour: Exploring culture, new media, and social context [69].	University Students
Social Media	Facebook, Twitter, tumblr, Pinterest	The results of this article show that social media activity was the most popular and Facebook was the most popular social media platform among students	"iSpy": Seeing What Students Really Do Online [70].	College Students
Social Media	Facebook, Twitter, Instagram, Myspace, Tumblr	This article increases the awareness about online background checks for potential partners, college applicants, and job candidates, online search results could have an increasing impact on the future personal and professional relationships of students. This article discusses the need to pay attention to online reputation management as a part of college and career preparation for high school students.	How Schools Can Help Their Students to Strengthen Their Online Reputations [54].	High school students
Websites Social Media	Logs, and id (for websites)  Twitter, Facebook, LinkedIn, and Pinterest	This article suggests using active digital footprint for gaining positive digital identity for purposes such as employment	Digital Footprints: Creation, Implication, and Higher Education [3].	University Students
Social Media	Facebook, Instagram	The interesting point about this article is: it claims that not having a digital footprint can be as serious as having a badly managed one. It suggests teaching students how to develop positive digital footprints that will help, rather than hinder, them in the future.	Expert insights into education for positive digital footprint development [71].	School Students
Social Media	Facebook, LinkedIn MySpace, blogs, Twitter	This article suggests taking care of online history. It should reflect positively on users' personal brand, which has become a defining feature of their online life	Moroccan University Students' Online Reputation Management [72].	University Students

## Discussion

### Study Impacts

Students do not use internet with same levels of knowledge about this technology. They should be informed of the types of digital footprints leave behind and their implications. Moreover, students' online information that has been shared intentionally or unintentionally is not retractable (most of the time). Therefore, it creates implications for them. This discussion covers the students' digital footprint types and their implications. The focus of discussion would be the research questions

The result of this study's systematized review indicates that social media activity was the most popular and Facebook was the most popular social media platform among college students [70].

Moreover, students mostly use smart phones and laptops to create digital footprints [57]. Mining social media data for understanding major concerns, and issues that they encountered in their studies and life would be beneficial for educational institute to make decision on interventions for at-risk students, improvement of education quality, and thus enhance success [9]. Two categories of articles have been reviewed:

1. Articles that described the positive impact of creating digital footprints.
2. Articles that described the negative impact of creating digital footprints.

There are several articles that discuss the good impact of having positive active digital footprints such as online reputation management studies, digital footprint management studies or digital identity related studies. All these subcategories discuss the same topic (positive active digital footprints) but different views of looking at it:

**User's personal brand:** This article [72] studied the necessity of online history management. It reflects positively on students' personal brand, which will become a defining feature of his/her online life. As a social media platform, Twitter has been considered [7] as a positive tool when students use it for personal and professional developments,

**Online Reputation:** Some articles [54] [3] encourage to perform online background checks for potential partners, college applicants, and job candidates. Therefore, online search results could have an increasing impact on the future personal and professional relationships of students. These articles [54] [56] also discuss the necessity of paying attention to online reputation management as a part of college and career preparation for students.

**Digital identify:** There is no difference between having a badly managed digital footprint and not having a digital footprint [71]. There are articles [71] [8] [69] [57] that suggest to teach students how to develop and perceive positive digital identity that will help them in the future. To have a positive digital identity, having a management strategy is necessary for them.

There are some articles that discuss the benefit of using social media platforms for students. Generally, there are three common benefits for a student when use social media:

**Collaboration strength:** the strongest area of social media is information exchange collaboration. Students can have easy and cheap communications with other students. This increases their social integration and fulfils their psychological needs [60] [61] [62] [63] [58].

**Friendship strength:** Students use social media to maintain and support friendships with people outside the university and/or with their own university friends [63] [61].

**Learning strength:** Using social media as a teaching or learning tool, improves the student motivation for learning and classroom learning climate by utilizing course related posts and videos [63] [10] [35] [61]. Based on the information provided in [10], this fact is highly depended to the number of friends on social media. A student learns more when has fewer friends on the network. The student spends more time on the posts and videos that are related to the course rather than reviewing friends posts and interacting with them.

On the other hand, use of the Internet through social media applications may have negative impact on student's life and education. The following are the issues that are common among the reviewed articles:

**Time, addiction and attention issues (distraction):** Creating digital footprints on social is time consuming. The first problem of social media is the time spent on it, together with the fact that it can be addictive. This problem causes a student to become dependent on social media, with a possible reduction in the level of attention committed to studies. Students with a higher level of academic distraction tended to have lower academic performance [63] [10] [64] [65].

**Multitasking issue** [63] [69]: Students usually like studying and checking their social medial at the same time. However, trying to do several things simultaneously will have negative effects on their academic results.

**Health issue:** internet usage can have negative effect on students' health when they have negative interpersonal experiences of social rejection and victimization of bullying [66]. It might cause depression [35] [64], and suicidal ideation [67] as well.

**Privacy issue:** Using the Internet requires privacy management strategies. Few articles [68] [59] suggest teaching methods for introducing aspects of privacy and protection, such as digital security or digital health and wellness to students. So, privacy rules should be learnt and set before creating digital footprints.

The above results indicate that positive impacts of the using internet are more than the negative ones and the students can get benefit of this technology if they gain enough knowledge about it. This study highlighted the summary of the previous studies with a systematized style and discussed the students' digital footprints with more details in terms of the digital footprints' types, creation, motivations and implications.

- **Research Question: What are student digital footprints?**

The aim of this question was to investigate the type of data that students create and leave behind when using the internet. The analysis of the data from the systematized review confirms that there are three general categories of digital footprint sources (themes): social media, online applications and websites. Social media platforms can be accessed using a website or a social media mobile application. These platforms collect similar types of data from users (like students). These data types are as below:

- **Account Information:** username, ID, photo, gender, location, relationship status, date of birth and Job title
- **Network Information:** Log detail, platform type, device type, IP and MAC address
- **Personal information:** Ideas, interests, hobbies, friends, followers, photo gallery and posts

In addition, websites (e.g social media and blogs) collect information about the user's visits (and sometimes the user's login credentials) using cookies. Additionally, a user's comments on a blog post are another type of digital footprint that indicates the user's interest and / or ideas.

The following figure 2 represent the Digital Footprint Applications and figures 3-11 represent the type of data of each application. These social media companies change their public and private data policy. Therefore, the data might not be complete, and it is the sample representation of data by each application.

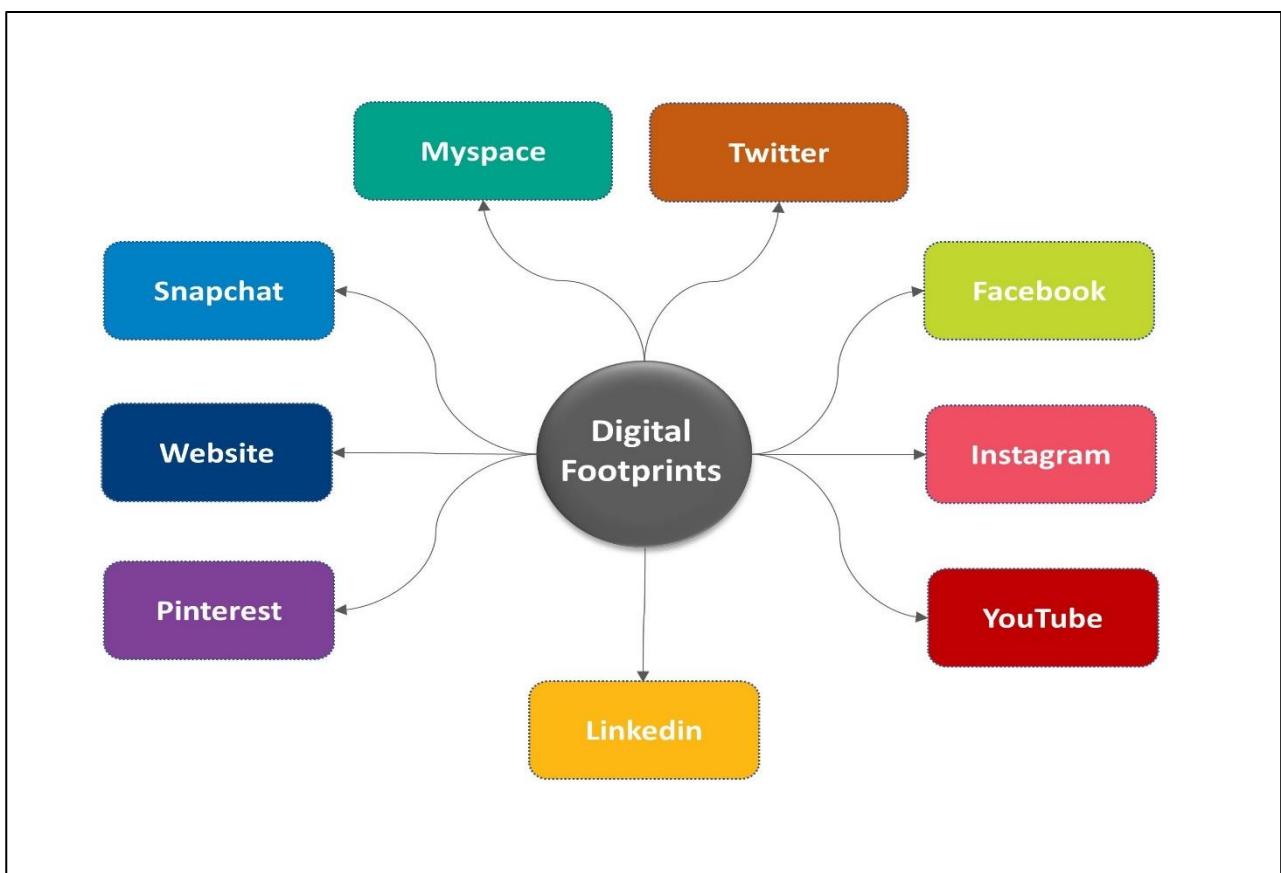


Figure 3 Digital Footprint Applications

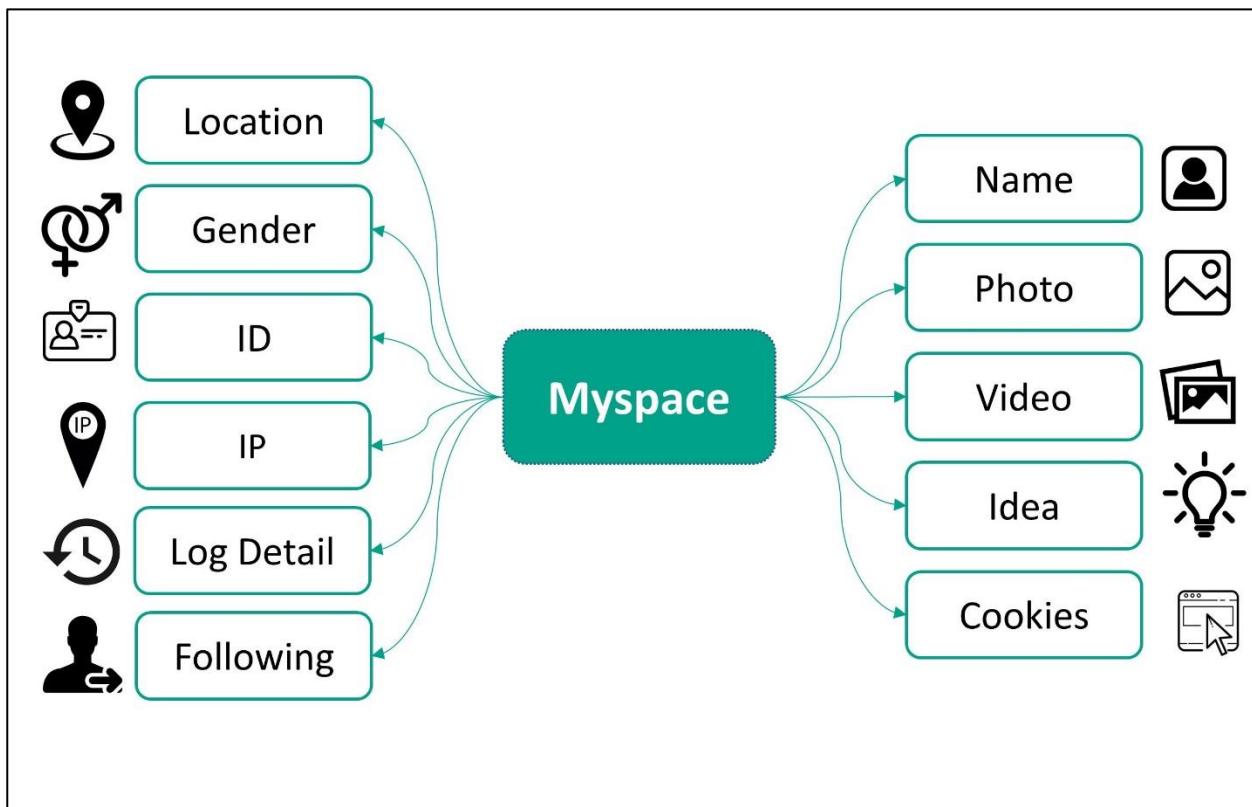


Figure 4 type of data related with Myspace

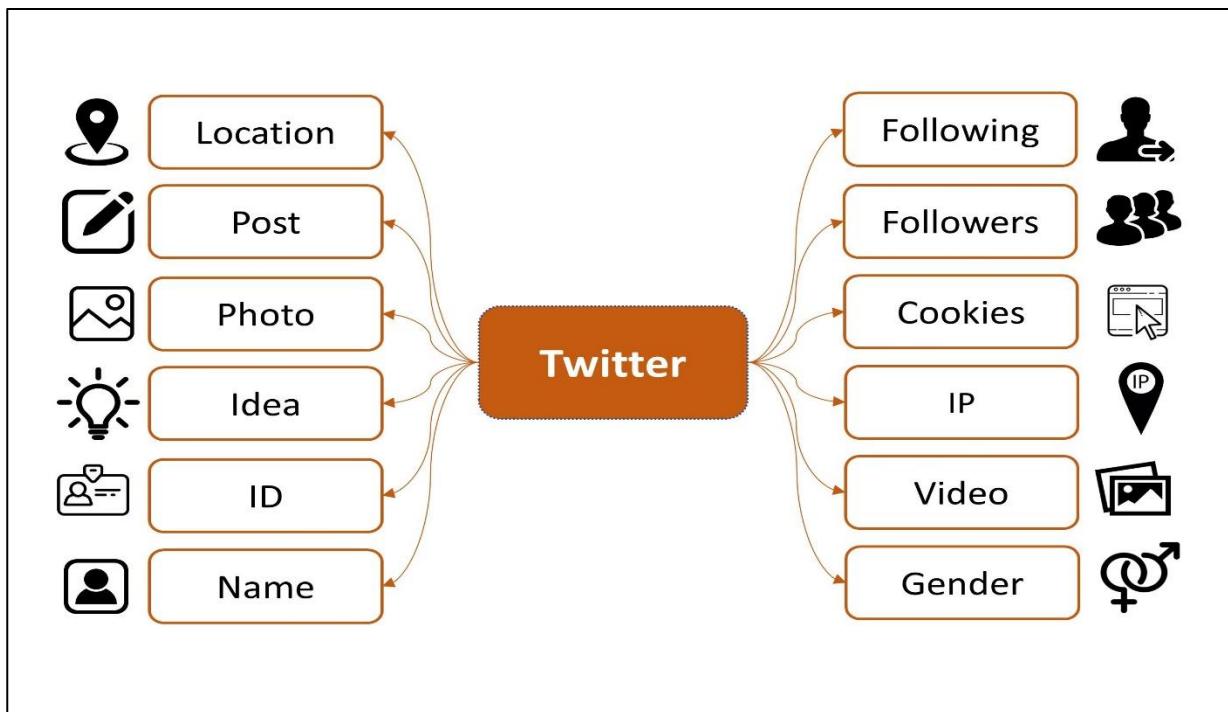


Figure 5 type of data related with Twitter

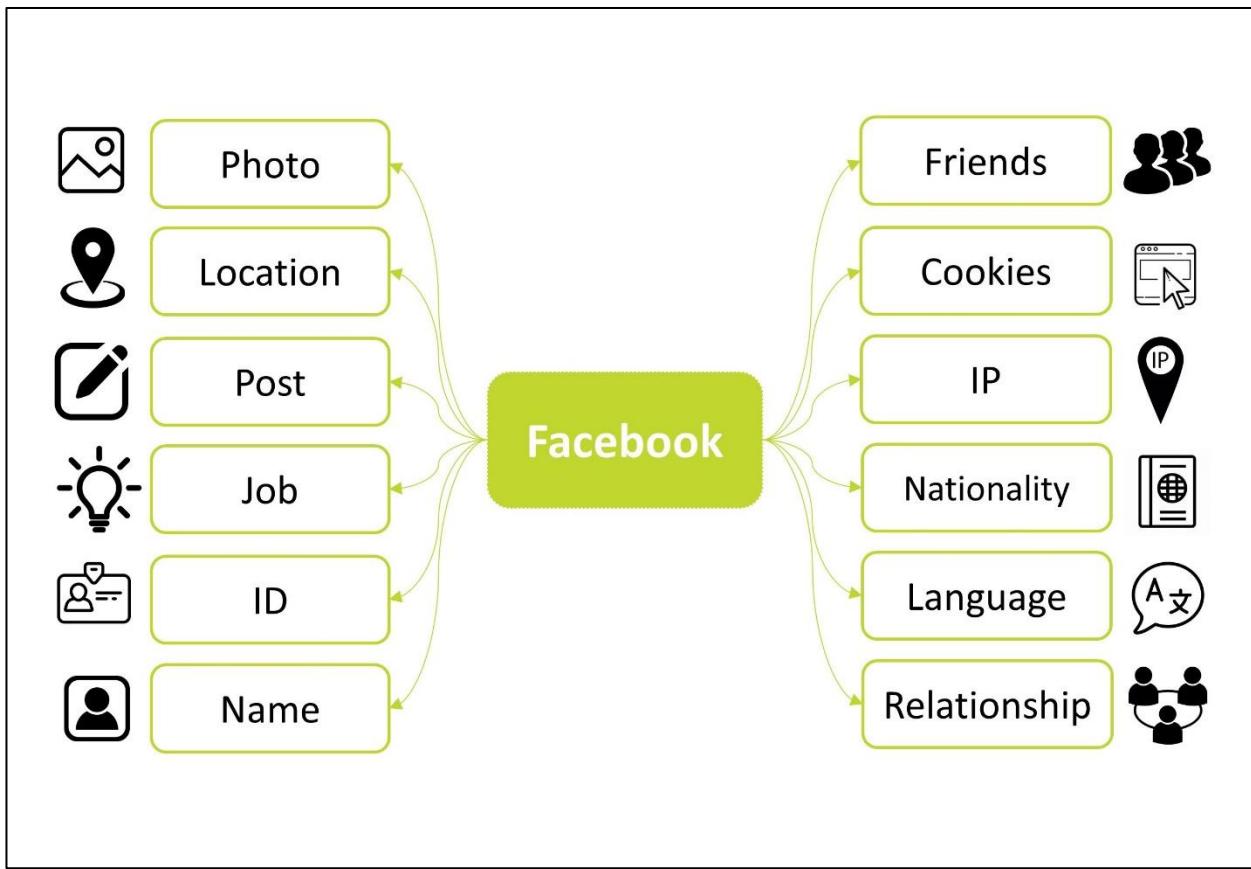


Figure 6 type of data related with Facebook

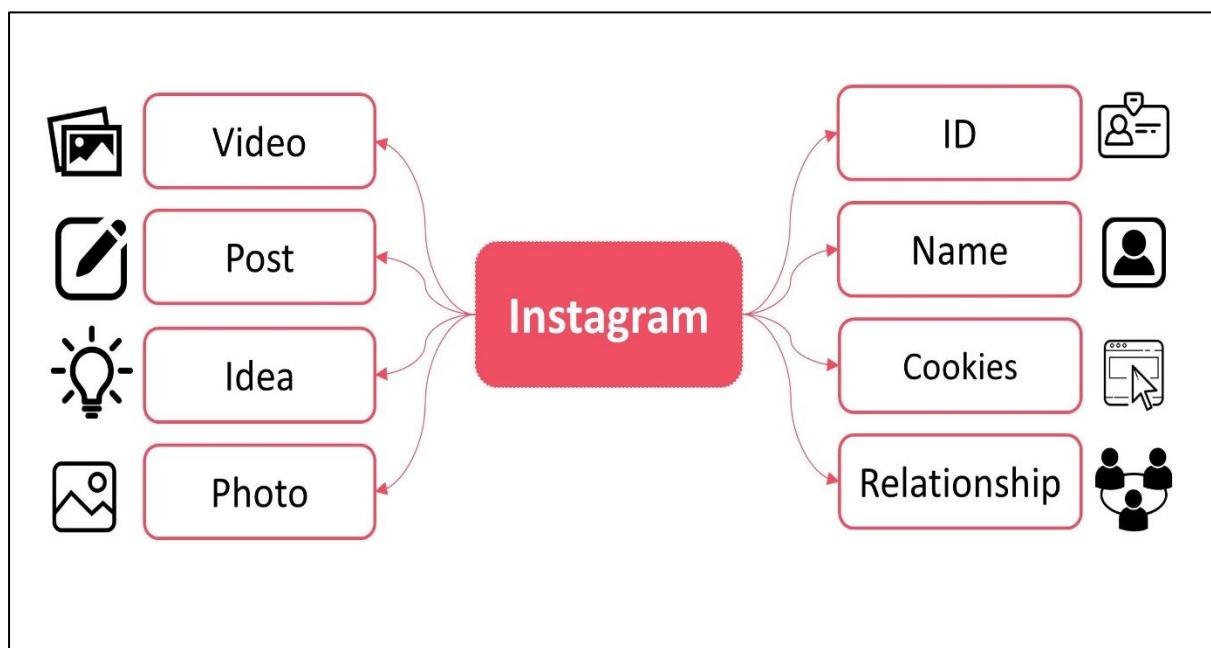
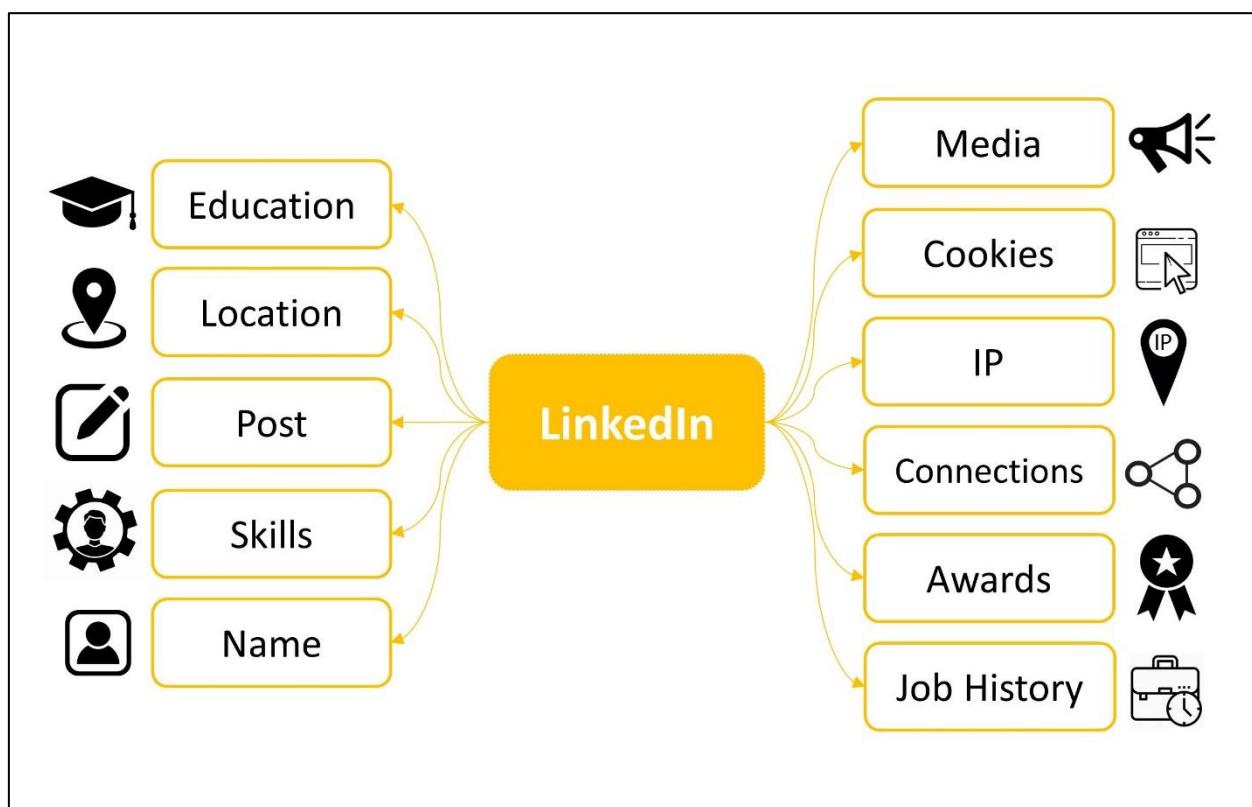
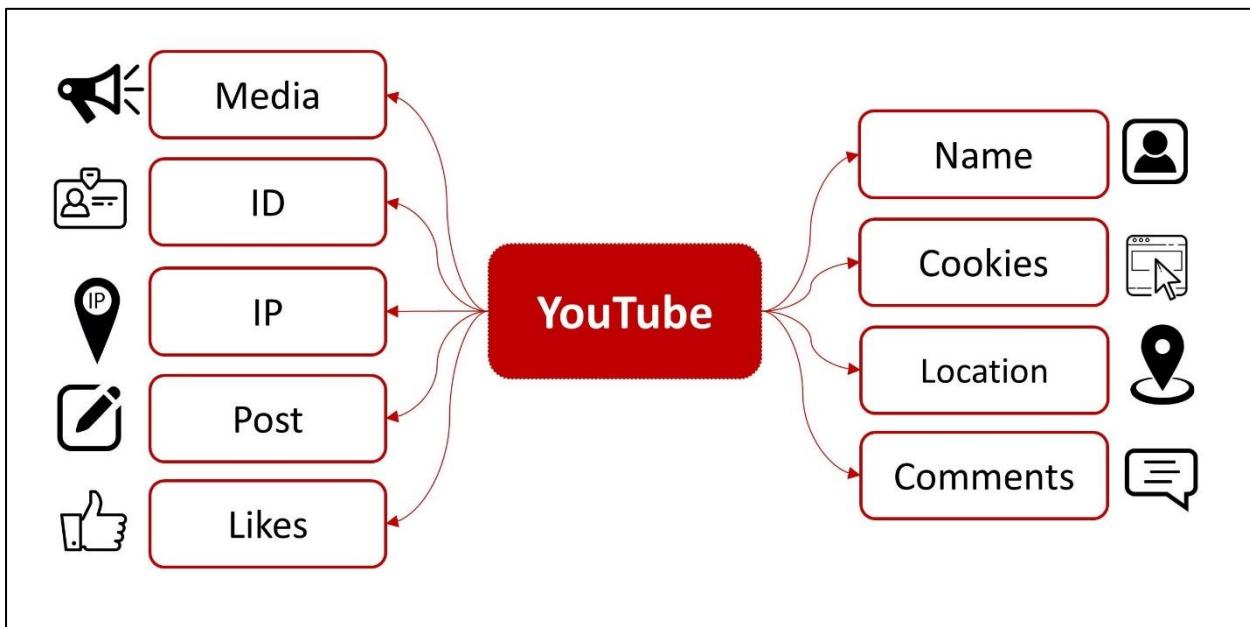


Figure 7 type of data related with Instagram



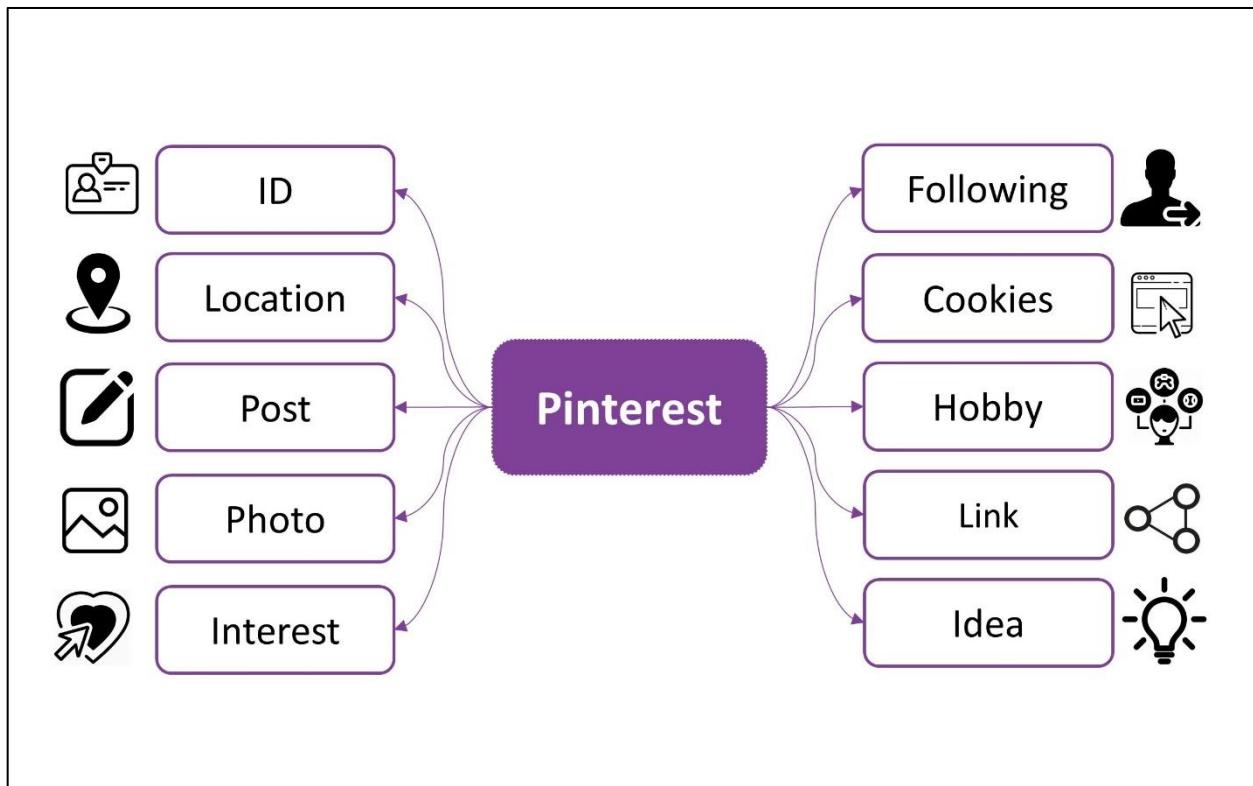


Figure 10 type of data related with Pinterest

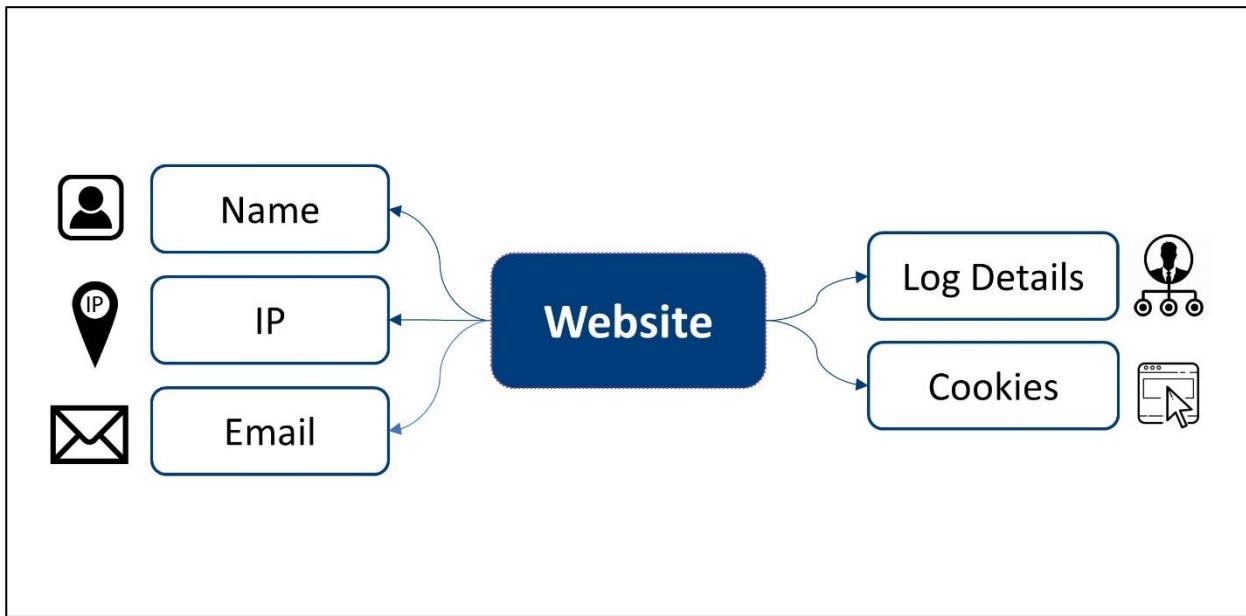


Figure 11 type of data related with Website

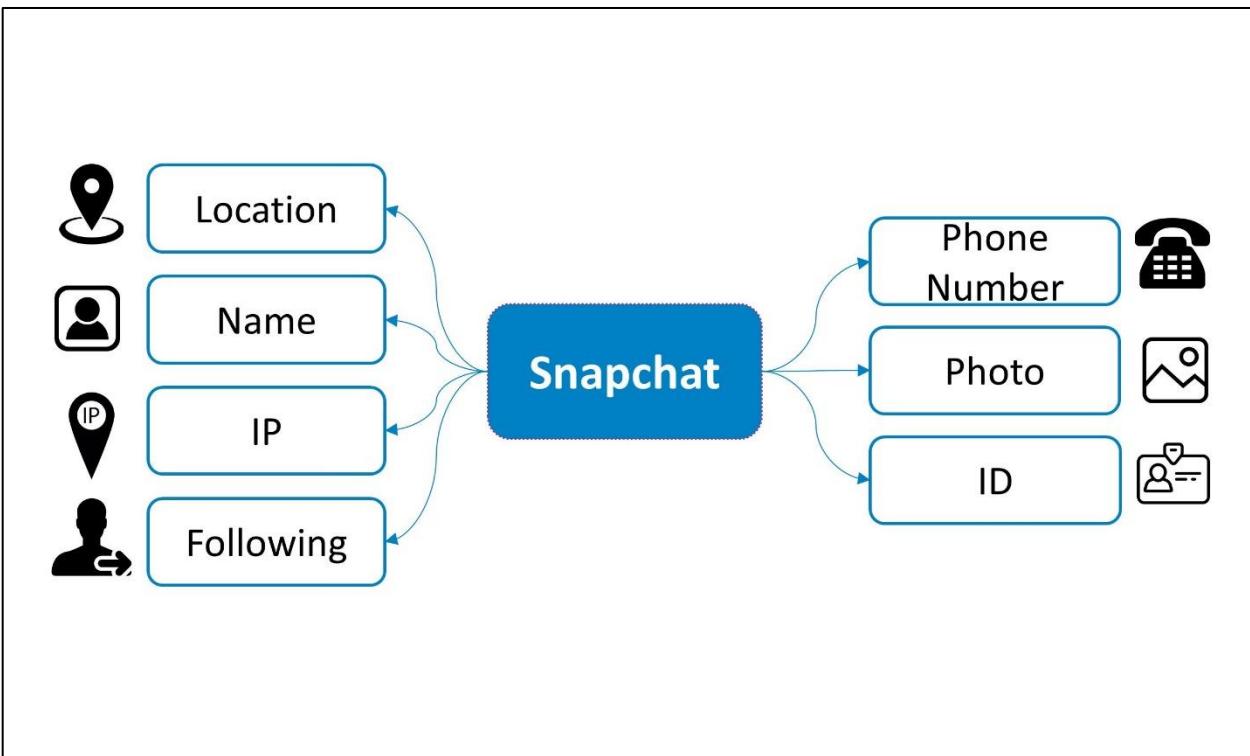


Figure 12 type of data related with Snapchat

- **Research Question: How do students leave digital footprints behind, and why?**

This study results indicate that there are two methods that students' internet usage can be classified, these are active and passive methods of creating digital footprints. In terms of active digital footprints, social media platforms allow students to create active digital footprints when they are required to create their account and each time, they share an idea, media and other personal information. Likewise, websites and blogs allow students to create active digital footprints when they leave a comment, express an interest or purchase an item. In terms of passive digital footprints, all the digital footprint sources (social media, online applications and websites) collect the students' network information (e.g. last login detail).

This research provides four reasons (motivations) for student's digital footprint creation. They use different (social media) applications or websites to learn new skills, find friends, exchange information for collaboration and create digital identity (personal brand). Based on this research impact analysis, all of those motivations are related to the positive impact of creating digital footprints when using the internet.

## Conclusion

ICT has changed many aspects of people's life and especially the students' life at university. Students use the internet for different types of activities such as learning, collaboration and making new friends. These activities create digital footprints that leave behind information about their behaviour. Flinders Campus Mental Wellness project aims to analyze the students' digital footprints and improve their experience and to enhance university services. This research is contributing to developing knowledge about students' digital footprints. This helps to understand various issues and/or benefits of using internet and having digital footprints.

The main contribution of this research is in the identification of where digital footprints are created and that most student online activities are through social media, particularly using Facebook, Twitter and Instagram applications, and these can have both negative and positive impacts on their life. This provides a general picture of what data is left behind by students and will provide the Flinders Mental Wellness project with the knowledge of what are the digital footprints and better understanding of them to facilitate the analysis of digital footprint sources for their usefulness to the project. However, this was not the purpose of this study. Moreover, this research has demonstrated the utility of employing a single exploratory case study method to explore student online interactions. This approach provided an in-depth impact analysis of students' digital footprints that has formed the basis for a larger project or researches. The topics might be various from psychology to security (privacy) or education (online teaching).

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