

AN ECOLOGICAL MODEL TO UNDERSTAND THE VARIETY IN UNDERGRADUATE STUDENTS' PERSONAL INFORMATION SYSTEMS

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ABSTRACT

A first-year undergraduate course in Information Systems in a South African university includes an opportunity for students to reflect on their own use of information and personal information systems. Their reflections provide data about the technologies and tools that they use to find and manage everyday life information, as well as academic information, and about the sources of information they draw on. This paper analyses data collected over three years and reports on the dominant technologies and information sources that students use. We then adapt the ecological model of information seeking and use developed by Williamson (1998) to make sense of the diversity of information sources and students' choices in engaging with them. The results show that students rely to a very small degree on traditional university information sources. The study offers insights into the information contexts and behaviour of students and argues for the importance of a flexible range of information sources to support students in the complex process of managing information for academic success. The results will be of interest to those involved in designing and delivering undergraduate programmes, as well as those providing information services and infrastructures.

KEYWORDS

personal information system, information behaviour, undergraduate students, information technology, information seeking, information sources, personal informatics

INTRODUCTION

"Fundamentals of Information Systems" is a one-semester course offered in the first year of the Bachelor of Commerce (B.Com) degree at the University of the Witwatersrand, South Africa. It is a compulsory course for all B.Com students and an elective course for students from other faculties, with the aim of teaching them enough to be an "educated end user" of information systems, while gaining a basic understanding of Information Systems applied to the individual, organisational and societal levels.

During 2013, the course underwent a major change in approach to introduce more of a systems focus and to move away from the traditional presentation of information systems to novice learners, which tends to build up from hardware components to networking, databases and software, to business concerns (Stair & Reynolds, 2013). As this course is focused on students who will go into business, the public sector or non-profits in a range of capacities, our goal was to produce users of information systems who will understand the role of information systems in organisations, be familiar with the key elements of an information system, and be able to engage constructively with IS professionals in selecting, designing or implementing information systems in their workplaces. In addition to this organisational focus, the course also encourages students to think about the effects of technology on the individual and on society, thus addressing the three levels mentioned above.

In order to manage the variety and volume of information associated with university study, students need to develop complex personal information systems that incorporate both physical and digital elements (Mizrachi & Bates, 2013). Thus a secondary aim of the course is to address the very different levels of exposure to information technology and information sources that students have when arriving at university and to ensure that those who are not experienced in using these tools quickly learn enough to be able to make use of them. To this end, the course includes an exploration of personal information systems, during which students are introduced to and encouraged to share information about technologies and information sources that might be of use to them. Students are therefore made aware that they have a personal information system and are also encouraged to think critically about its composition and effectiveness.

As university lecturers, we are interested in the information behaviour of students – how they source, store, manage and use information – to inform our teaching. We teach students who are "millennials", born between 1979 and 1995 (Murray, 1997) and are regarded as skilled in and accepting of information technologies. However, these students' information behaviour has been informed by ready access to information selected chiefly for its social and entertainment value and they are arguably ill-equipped to access and evaluate academic information, which activity may require perseverance and judgement (Becker, 2012). In particular, students newly arrived at university need to be able to access knowledge that they do not yet know that they lack and a personal information system that facilitates this would benefit them.

From student assignments conducted during the course, we have gathered insights into what information technologies and information-seeking behaviours students use. This study replicates other studies that have looked at the sources and information-seeking strategies of students (Ajiboye & Tella, 2007; Chung & Yoon, 2015; Given, 2002;

Lee, Paik & Joo, 2012; Ossai-Onah, 2013; Sin & Kim, 2013), but does so using the idea of a personal information system, whereas other studies looked at information behaviour from the perspective of Information Science. It also adds to a limited number of studies that examine the devices that students use (Chung & Yoon, 2015). By examining data over three years, we are able to observe trends in the use of devices. In addition, observing that past research into student information behaviour is frequently descriptive and lacks theoretical framing, this paper examines a range of theories of information behaviour and proposes an ecological model of students' information behaviour, which has important implications for practice.

PERSONAL INFORMATION SYSTEMS

Research into personal information management began in the 1960s, with studies that focused on how academics and researchers organised their information gathering and storing activities (Parker & Paisley, 1966; Soper, 1976). The term *personal information system* was used in the 1980s to describe the sources of information and the information gathering practices of individuals, and particularly managers, following Mintzberg's study of the nature of managerial work and how managers made use of information to inform their decision-making (Mintzberg, 1973). Around the same time, studies emerged that examined personal information management in computerised contexts (Burton, 1985; El Sawy, 1985).

More recently, the term personal information system (or personal informatics) has been used to mean an information system that stores personal information, for example about one's health and fitness or personal finances, that is used by individuals for self-improvement (for example Kamal, Fels & Ho, 2010; Li, Medynskiy, Froehlich & Larsen, 2012). The term personal information system in the former sense has since been largely replaced by the term *information behaviour*. In library and information science the term information system was replaced by the term *information-seeking behaviour* because "behaviour is observable" (Wilson, 2005, p. 34) and later by the term *information behaviour* to encompass the behaviours associated with the storage, management and use of information.

In the "Fundamentals of Information Systems" course, we introduce students to the idea of personal information systems in both senses. We prefer to use the term personal information system to describe students' information behaviour, because we want students to draw analogies to business information systems, recognising that people, processes, places and technologies form part of both. We also make them aware of the second use of the term personal information systems. In a sense though, a student's personal information system (information behaviour) is also a system that stores personal information, or at least information that is highly personalised in terms of what is gathered and how it is captured, organised, used and shared. This system does have a goal of self-improvement in the broadest sense, since it will be used to manage information pertaining to all aspects of students' lives, both academic and beyond.

STUDENTS' INFORMATION BEHAVIOUR

The ways in which students engage with information has been extensively studied, particularly within the Information Science literature. Some studies focus exclusively on information behaviour related to academic tasks (Lee, Paik & Joo, 2012), although others recognise the interconnectedness of everyday and academic information needs (Given, 2002; Sin & Kim, 2013) and that distinguishing between the two is a "false dichotomy" (Given, 2002, p. 18). In our study we took the latter view, that students' information systems include tools and behaviours for accessing both academic and everyday information.

Studies of students' information behaviour have variously focused on students' information needs (Chung & Yoon, 2015; Ossai-Onah, 2013), their information-seeking strategies (Ajiboye & Tella, 2007; Nadzir, 2015; Ossai-Onah, 2013), and the range of resources that students consult (Ajiboye & Tella, 2007; Chung & Yoon, 2015; Lee, Paik & Joo, 2012). These studies have resulted in catalogues of information needs, information resources consulted and information seeking strategies, as well as analyses of the relative importance of such needs, resources and strategies.

A few studies investigate the devices and technologies that students use in the process of accessing, storing and using information (for example Chung & Yoon, 2015), something of interest to us from the perspective of Information Systems. Our study adds to this limited literature.

Many of the studies of students' information behaviour are descriptive, making little attempt to develop or frame their results in terms of theoretical understandings. Some have sought to relate needs, strategies and sources to student characteristics such as level of study, field of study and gender (Ajiboye & Tella, 2007; Sin & Kim, 2013), while others emphasise the situational nature of information behaviour (Given, 2002). One framework that has been used in understanding information behaviour (Given, 2002) comes from Savolainen's (1995, p. 268) concept of "mastery of life" or how people "keep things in order" that analyses problem solving behaviours in terms of the activities of (1) prioritising problems, (2) selecting information sources and channels, (3) seeking broader, orienting information and (4) seeking applicable, practical information, with these activities being influenced by situational factors. Savolainen (1995) identified four approaches to "mastery of life" that reflect whether individuals approach tasks optimistically or pessimistically and the extent to which tasks are viewed as cognitive or individuals allow affective factors to dominate their actions.

Towards the end of the 1990s, researchers began to explore the idea that not all information seeking was goal directed (Erdelez, 1997; Erdelez 1999; Savolainen, 1995). Bates' (2002) "integrated model of information seeking and searching" encompasses both purposeful, or goal-directed information behaviour and what is termed *incidental information acquisition*. In the former, the individual is aware of an information need and sets out to find information to meet that need. In the latter, the individual becomes aware of information as a result of being in a place, or as a result of some interaction or engagement, rather than in a directed fashion (Williamson, 2005). Bates argued that the majority of knowledge is acquired through "being aware, being conscious and sentient in our social context and physical environment" (Bates, 2002, p. 4).

Williamson's ecological model of information seeking and use (Williamson, 2005) builds on Bates' (2002) model and considers the use that an individual makes of a range of information sources as being influenced by "ecological" elements". The model was influenced by a view of people as "self-creating, but within contexts" (Williamson, 2005, p. 130), where those contexts might include biological, social, economic and physical circumstances. The emphasis is on the relationship between the individual and the information sources, which Williamson identified as including institutional sources, media and personal networks. Williamson's more recent work has applied her model in diverse contexts and has been particularly interested in people's preferences for different information sources and the creation of user-centric information portals that deliver information suited to self-select user types (Williamson & Manaszewicz, 2002).

The recognition that the ways in which people approach information-related tasks is closely linked to their approach to life in general (Savolainen, 1995), as well as the idea of information behaviour emerging from an ecology of contextual elements (Williamson, 2005), appear to be useful in understanding the behaviour of undergraduate students in all its variety.

RESEARCH QUESTIONS

Our interest lies in understanding the technologies employed and the information behaviour of students entering university and the role that university resources play in their personal information systems. Technology devices are of interest to us as they enable the access to information sources, as well as the means to capture, organise and share information. We are particularly interested in students' information behaviour in the university context and how students use the information sources that the university provides as part of our ongoing interest in improving student learning. This paper therefore addressed the following research questions:

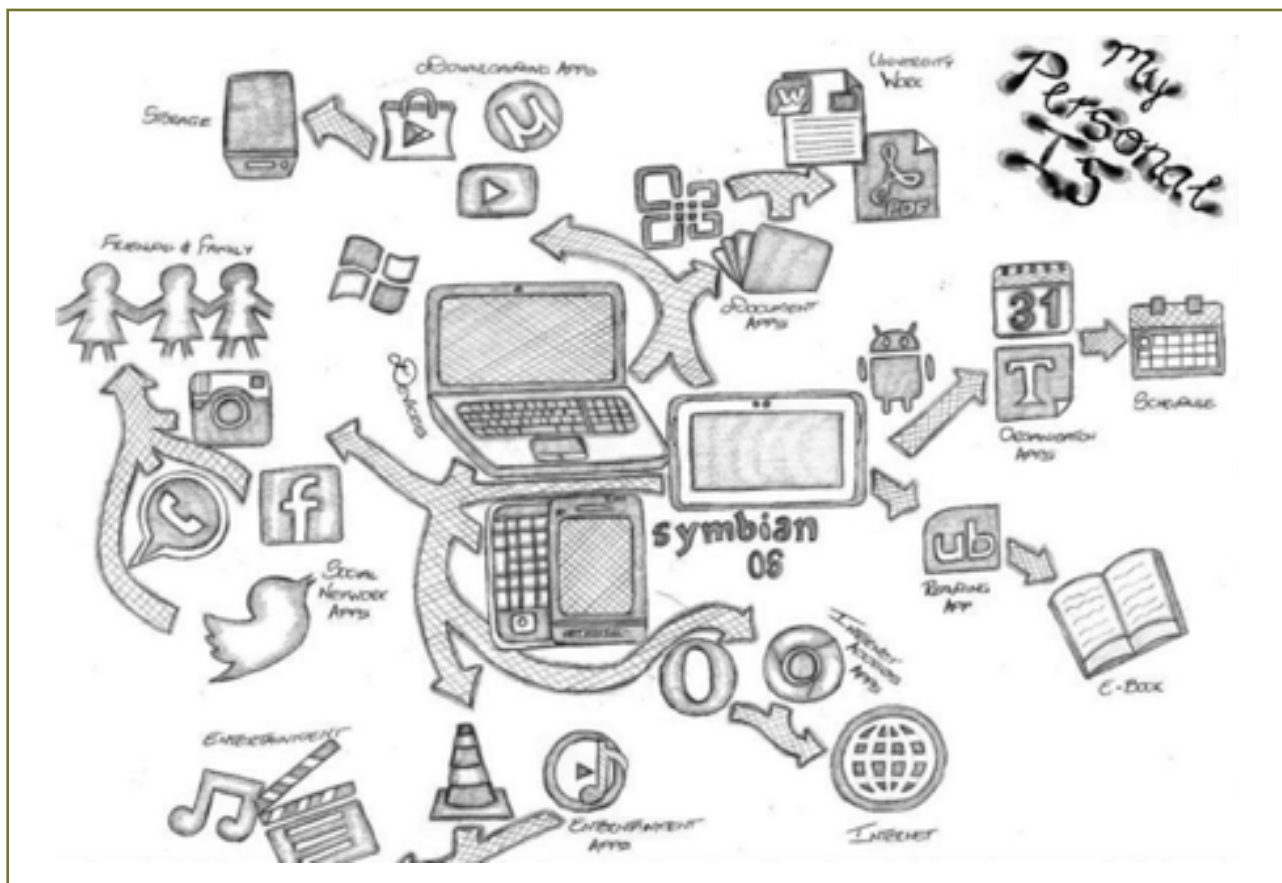
- 1) What technology devices do students use to access and manage information?
- 2) What sources of information do students use?
- 3) To what extent do students use the information resources provided by the university?
- 4) What theoretical models aid understanding of the variety in students' personal information systems and the implications of this for universities?

DATA COLLECTION

In the first two weeks of the "Fundamentals in Information Systems" course, students are encouraged to reflect on the information tools (both traditional and electronic) that they use to find and manage information. "Tools" include both the technologies ("devices") and applications ("apps") that they use or may want to use. Students share information about their favourite information tools and how they use them through an online forum. They are also challenged to try out new tools and comment on the posts made by other students.

Students are also asked to draw a "rich picture" of their own personal information system. Rich pictures are a tool used in Information Systems to depict the complexities of system components and their relationships (Avison & Fitzgerald, 2003) and are one of the Information Systems tools that students learn about during the course. Students were asked to draw a rich picture depicting the different sources of information and the tools to access and manage information that they were either currently using or intended to use during their university studies. An example of one of the pictures submitted is shown in Figure 1.

FIGURE 1: EXAMPLE “RICH PICTURE” OF A STUDENT’S PERSONAL INFORMATION SYSTEM



Pictures were submitted electronically in a variety of formats. Some were drawn using software tools such as Word, PowerPoint or Visio and submitted in software-specific or pdf formats. Some students constructed collages or drew pictures freehand and scanned or photographed the results, submitting them in pdf or jpg formats. Students uploaded their pictures to the learning management system (LMS). In total, 325 pictures were collected in 2013, 456 pictures in 2014 and 240 pictures in 2015.

ANALYSING AND INTERPRETING THE DATA

For the purpose of this analysis, the pictures were downloaded from the LMS and any identifying information (names and/or student numbers) was removed. Each file was renamed with the year and a unique number and saved in pdf format. The three data sets (2013, 2014 and 2015) were then imported into Atlas.ti for coding. A millennial coder was employed to identify and code each item on each picture. The coder's brief was to identify the specific technology or application that was referenced in the pictures. It was important to use a coder who was familiar with the technologies and applications in use by the students and who was sufficiently "at home" online to be able to track down references (textual and graphical) to obscure applications and technologies.

Once this initial coding was complete, the researchers created code families to group related concepts together. For this paper, given our research questions, the focus was firstly on the technology devices used to source and manage information and secondly on the sources of information that students consulted. Technology devices were fairly easy to group into categories such as cellphones, laptops, tablets and desktops.

Analysing the sources of information in the student's personal information systems proved more difficult and resulted in some debate as to what constitutes an information source. We distinguished between sources of information and tools used to store, organise and share information once it had been collected. The latter were not analysed for this paper. So, for example, an app used to manage tasks was not considered a source of information, despite the fact that students might consult such an app daily to identify tasks. Similarly, a book was considered an information source, while files were considered tools for managing information. In analysing the information sources, we grouped sources based on the characteristics of the providers of information, in keeping with Williamson's (2005) model, but identified different categories than those in the original model.

In interpreting the data, there are two areas of uncertainty to be borne in mind. Firstly, although students were asked to depict the information systems that they were using at the time, they were also in the process of exploring new tools for information management. They were exposed to alternative technologies and information sources through viewing and commenting on other students' personal information systems. So in interpreting the data, it is important

to remember that the pictures may to some extent represent aspirational information systems that students could see themselves using in the future. While this means that we cannot draw firm conclusions about the information system that the students were using, we believe that the data still gives a fair reflection of students' information behaviour.

Secondly, for most of the students this data was collected in the second and third weeks of their first semester of study. This means that their personal information systems may have reflected more of their concerns with social information, which would have been a priority during the recent long vacation following the end of school and a socially intensive university orientation programme. On the other hand, the data may also have been biased towards the information that they would need for their university studies, as they were freshly arrived in the university context and actively involved in trying to navigate the new environment. Without further investigation it is difficult to know to what extent these biases are present in the findings.

WHAT TECHNOLOGY DEVICES DO STUDENTS USE?

Table 1 shows the frequency with which different devices appeared in the students' pictures from 2013 to 2015. Note that some pictures included more than one reference to a device and so (1) the number of references to a device could exceed the number of pictures analysed and (2) the percentages shown are not strictly the percentage of pictures with references to a device, but they are indicative of the prevalence of the device in the data as a whole.

Almost all the pictures included references to cellphones and some included more than one reference. In 2013, all but nine of the cellphones depicted were recognisable brands and models of smartphones, in 2014, all but five cellphones and in 2015, all but one cellphone. While some of these may represent student's aspirations, it seems clear that most students have smartphones and view them as a central technology in their information-related activities. (In the table below, only smartphones are counted as computing devices; cellphones that could not be identified as smartphones have been omitted.)

Laptop computers are more prevalent than desktop computers in students' personal information systems and in 2015 almost all students made mention of laptops. Tablet devices are similarly appearing increasingly often, with 63% prevalence in 2015. The prevalence of desktop computers declined between 2013 and 2014, but in 2015 more students included desktop computers in their diagrams, perhaps indicating that more students had access to multiple devices. These results are not dissimilar to what has been observed in other studies. Chung and Yoon (2015) ranked the use of devices by international students at the University of South Florida, from most used to least used as: laptop computer, smartphone, tablet computer, eBook reader, and desktop computer.

Although there are many references in the student pictures to cloud storage, a large number make use of external storage devices such as external drives, USB drives and memory (SD) cards to store information. This may well be a reflection of some challenges in connecting to remote storage services, including reliable access and cost. In 2014, three students made references to wearable computing devices, one to Google Glass and two to smartwatches. These may well have been aspirational, however.

TABLE 1: REFERENCES TO TECHNOLOGY DEVICES IN STUDENTS' PERSONAL INFORMATION SYSTEMS

Device	2013 n=325	2013 %	2014 n=456	2014 %	2015 n=240	2015 %
Smartphone	324	100%	445	98%	348	145%
Laptop computer	247	76%	355	78%	225	94%
Tablet device	94	29%	162	36%	150	63%
Desktop computer	113	35%	134	29%	149	62%
External storage	106	33%	273	60%	400	167%
Wearables	0	0%	3	1%	0	0%
Portable music device	88	27%	75	16%	39	16%
Television	58	18%	18	4%	22	9%
Radio	29	9%	12	3%	3	1%
Digital camera	55	17%	7	2%	2	1%
eBook reader	13	4%	21	5%	7	3%
Gaming console	17	5%	21	5%	20	8%
Printer	8	2%	5	1%	2	0%
Scanner	4	1%	2	0%	1	1%

The convergence of devices can be seen in the decline from 2013 to 2015 in the number of references to devices such as television sets, radios, digital cameras and music players. Because students still made references to radio and television programmes and music websites in 2015, we can assume that they are using their other computing devices to access this content. The diagrams included references to streaming television and radio apps and music apps, but this data has not yet been analysed.

The prevalence of e-book readers and gaming consoles in students' personal information systems did not change much between 2013 and 2015. This may reflect a reasonably constant proportion of students with interests in reading and gaming respectively. However, the prevalence of these devices does not necessarily reflect the full extent of the use of e-books or gaming, since students may also access e-books and games from their computers or tablets. Students also made references to e-book applications and gaming applications, but this data has not yet been analysed.

Students' information systems are largely paperless, with printers and scanners playing an insignificant role. This may be due to the cost of printing or to students embracing environmental concerns, but that cannot be established from the data.

WHAT SOURCES OF INFORMATION DO STUDENTS USE?

Lee et al. (2012) classified the information sources students' use as human, printed, online and mass media, similar to the classification used by Nadzir (2015). These classifications relate more to the seeking strategy and hence the format that information is stored in, and so do not give insight into other information characteristics like the credibility or the nature of the information being sought. Williamson (1998), working with the information behaviour of older people, identified three types of information sources: institutional sources, media and personal networks, which gives greater insight as to the origins and nature of the information. The data that we had did not allow a similar categorisation. Instead we categorised information sources as generic, academic and specific, based on the extent to which we could perceive the nature of the information being sought, as explained below. The academic sources align with Williamson's institutional resources, the generic resources include personal networks, as well as other tools available to individuals to use, while the specific sources are provided by organisations, in the same way that media companies provide information.

All items in the students' pictures that could be considered information sources were identified and then similar types of information sources were clustered together based on the type of information that we could deduce was sought from this source. Table 2 shows the types of information sources identified. The indented rows show the most frequently depicted information sources within each type.

Some information sources were clearly associated with specific types of information, for example the website of a retail organisation would provide information about their products and a weather service would provide information about the weather. However a large number of information sources were generic in that it was not possible to discern what kinds of information might be provided from that source. Generic information sources were analysed in three categories, social media, people (not associated with academic roles) and other generic sources. References to people in academic roles were categorised as academic information sources.

TABLE 2: TYPES OF INFORMATION SOURCES IN STUDENTS' PERSONAL INFORMATION SYSTEMS

Nature of source	2013 n=325	2013 %	2014 n=456	2014 %	2015 n=240	2015 %
Generic information sources						
Social networks	1045	322%	1538	337%	1032	430%
WhatsApp	242	74%	380	83%	260	108%
Facebook	280	86%	369	81%	213	89%
Twitter	201	62%	281	62%	131	55%
Other generic sources	399	123%	465	102%	208	87%
Internet	53	16%	181	40%	10	4%
YouTube	159	49%	137	30%	140	58%
Google	149	46%	73	16%	37	15%
People (not academic)	250	77%	323	71%	18	8%
Friends	132	41%	203	45%	8	3%
Family	53	16%	62	14%	3	1%
Academic information sources						
All academic sources	294	90%	252	55%	261	109%
LMS	98	30%	149	33%	64	27%
Books	74	23%	75	16%	40	17%
Sources of specific information						
Retail information	93	29%	207	45%	147	61%
Leisure and cultural	160	49%	99	22%	97	40%
News media	164	50%	85	19%	89	36%
Transport and travel	21	6%	52	11%	148	62%
Weather	16	5%	7	2%	26	11%
Business and investing	9	3%	5	1%	13	5%

Social media dominates students' personal information systems and it is clear that students consider social media their most important source of information. All pictures included one or more references to social media with an average of three distinct social media for each student, somewhat more than the 2.5 social media per student identified by Chung and Yoon (2015). The social media that dominate are WhatsApp, Facebook and Twitter.

People (other than those that students encounter in their academic pursuits) included friends, family and depictions of unspecified people. Students no doubt use social media applications to communicate with people in this category and we debated whether to analyse people and social media together. However, social media puts students in touch with a far wider range of people (as is evident in the more frequent references to social media), so these types of information sources seemed to warrant separate discussion. The 2015 data included far fewer references to people than the earlier data and it is not clear why.

Other generic information sources referenced included the Internet and search engines, such as Google or DuckDuckGo, used to access the World Wide Web, as well as general information sites such as YouTube and Wikipedia.

Several information sources are clearly associated with academic activities, the most frequently depicted being the university's learning management system. Books, e-books, textbooks and reference books such as dictionaries were

the second most often mentioned academic resource, although few students included the library in their information systems (nine students in 2013, four students in 2014 and zero students in 2015). This aligns with a study carried out in Botswana, where only 6.4% of students used the library (Ajiboye & Tella, 2007) in favour of online resources.

Few students depicted lectures as a source of information (sixteen students in 2013, nine students in 2014 and four students in 2015) and even fewer included academic staff in their pictures (two students in 2013 and zero students in 2014 and 2015). A study that looked specifically at information behaviours around academic tasks has shown that undergraduate students rate academic staff highly as information sources (Lee et al., 2012), but that was carried out in Korea and might reflect different cultural approaches to studying. Other people that students encounter in the academic context, including classmates and project teammates, were represented and we identified them as sources of academic information. Educational websites such as Khan Academy, Mindset Learn and Master Maths were also mentioned by students, although infrequently.

Specific information sources reveal categories of everyday information that students seek. Retail information sources were frequently depicted in students' pictures, showing that information for making buying decisions is important to them. Less important is information about leisure and cultural pursuits including music, movies and television series, events, sports, games, dining out and religious activities. Traditional news media featured as information sources, including television, radio, magazines and newspapers, although several of these are consumed in electronic form. Students access information relating to their travel and transport including applications for bus and train timetables, navigation tools and websites and applications providing traffic information. A few students seek information about the weather and access websites relating to business and investing. The kinds of information sought are not dissimilar to previous studies, which have shown that, in addition to academic information, students seek information about health, personal development, current affairs, entertainment, business, transportation and accommodation (Chung & Yoon, 2015, Nadzir, 2015, Ossai-Onah, 2013, Sin & Kim, 2013).

The increase in 2015 of the use of these specific information sources seems to reflect an increase in the availability of such sources and the number of students that have access to them. In particular, the student pictures in 2015 make mention of a greater variety of mobile apps that fall into this category.

DO STUDENTS USE UNIVERSITY INFORMATION RESOURCES?

In answer to our third research question, the sources of information provided by the university are depicted in students' personal information systems less often than other generic and specific information sources. It may be tempting to suggest that social and generic sources of information dominate because students compiling these personal information systems were only two weeks into their first year of university at the time. However, at this point they are likely to be beginning to apply their minds to the sources of information that relate to their academic work; they are fresh from campus introduction activities that include tours of the university libraries and yet the library gets very little mention. Similarly low use of such sources was reported by Chung and Yoon (2015), whose study applied to students at all levels of study. Chung and Yoon's study showed that while students frequented libraries, they seldom used librarians and library catalogues in their information-seeking strategies.

Lectures and lecturers were alarmingly absent from the personal information systems that students depicted. In presenting earlier versions of this paper to colleagues and to the South African Computer Lecturer's Association conference (SACLA 2015), we found academic staff quick to find reasons why this should be so, and to defend the relevance of universities' traditional information sources, particularly the role of lecturers, but the very dramatic differences in the frequency with which academic sources feature ought to sound a warning and suggests that universities might want to pay attention to developing more user-centric information sources (Williamson and Manaszewicz, 2002).

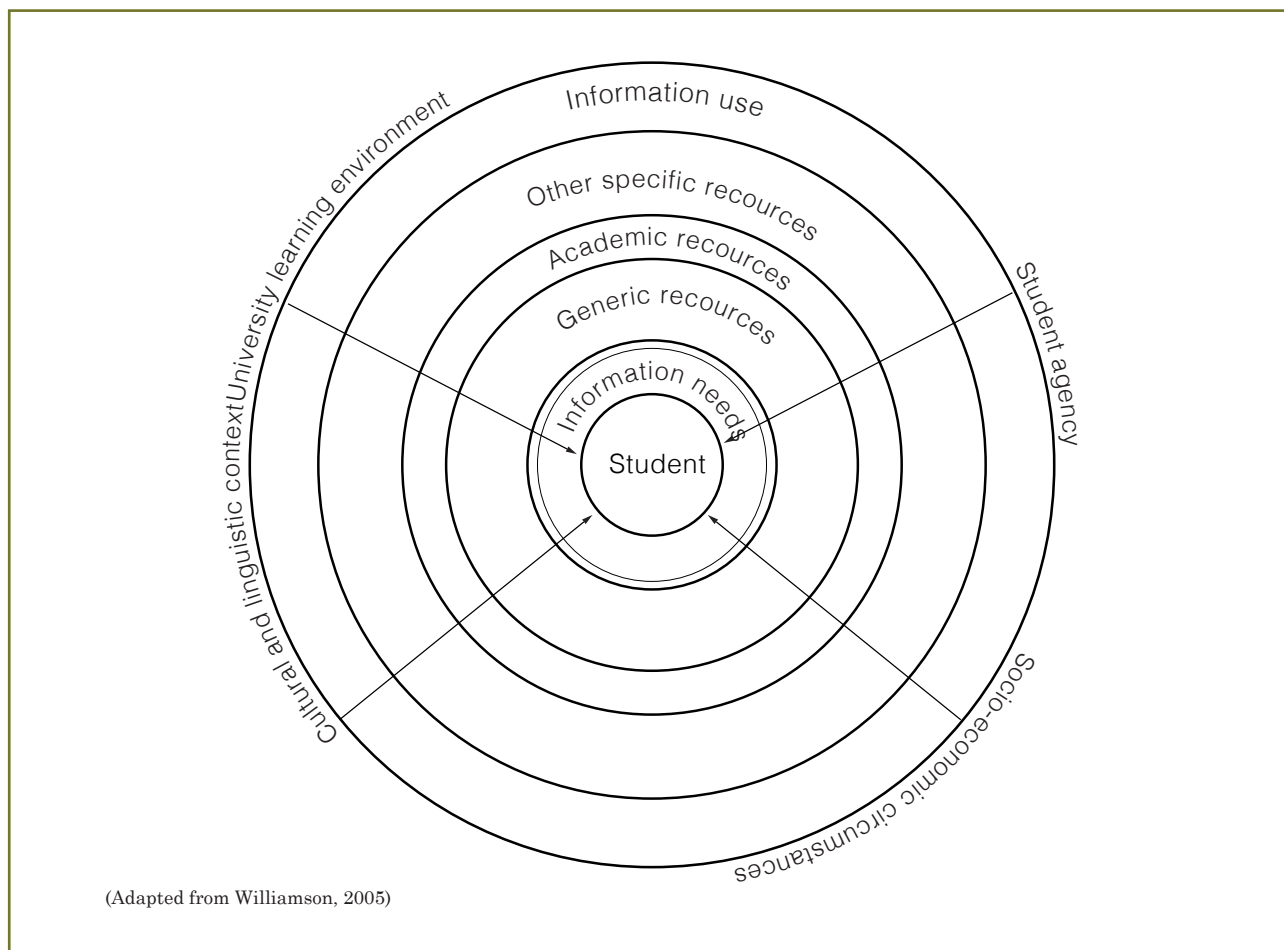
WHAT THEORETICAL MODELS AID OUR UNDERSTANDING?

Williamson (2005) made the point that information seeking and use is highly contextual and that contextual constraints frame these behaviours. In her study of the information behaviour of older people, she identified biological, social, economic and physical circumstances as providing these contextual constraints. We sought ways to understand the contextual constraints that students face.

Prior research into student success at the University of the Witwatersrand has identified three sets of conditions that impact on student success; firstly the student's biography, which includes their socio-economic, cultural and linguistic background; secondly, the learning environment created by the institution; and thirdly the student's agency or the extent to which the student can negotiate the teaching and learning processes (Cross, Shalem, Backhouse & Adam, 2009). Thus we propose using these elements as the contextual constraints for an ecological model of student information-seeking behaviour based on Williamson's (2005) model (the outermost layer of Figure 2).

In the inner layers of the model we depict the three different student information sources that we identified from the data as concentric bands where the size of each band reflects the frequency of use of each source. How the use of these sources is mediated by the contextual constraints is discussed here, based on literature.

FIGURE 2: ECOLOGICAL MODEL OF STUDENT INFORMATION SEEKING AND USE



Students’ socio-economic, educational and linguistic backgrounds influence the technologies that they have access to and experience of, and so constrains the configuration of their personal information systems. By making explicit the idea of a personal information system and exposing students to a range of devices and applications that are available, they are encouraged to develop a richer set of information behaviours that they can draw on in their studies. The pictures reveal that most students, whether aware of it or not, already have a rich personal information system incorporating digital and physical resources, but it is also clear that some are more sophisticated than others.

Most students in our study have access to more than one digital device to access information, and the university supplies desktop computers and Wi-Fi access for mobile devices. Although students at the University of the Witwatersrand make extensive use of digital and online resources, studies of student information behaviour in other African universities (Ajiboye & Tella, 2002; Baro et al., 2010; Oladokun, 2010) show that students depend on physical resources when electronic resources are not available or are difficult to access. Thus the information services provided by the university, both traditional and digital, are an important contextual influence on students’ information behaviour.

Research has shown that all students newly arrived at university are disadvantaged by their lack of understanding of the academic discourse and expectations (Mgqwashu, 2009) and that some lack specific skills or the self-efficacy needed to succeed (Cross, Shalem, Backhouse & Adam, 2009). Students need to develop sophisticated and highly individual personal information systems that can deal effectively with degrees of visibility of information, task urgency and workflows (Mizrachi & Bates, 2013). Each student’s ability to do this effectively depends on their “mastery of life” approaches (Savolainen, 1995), skills, access to technologies and creativity, as well as prior exposure to effective information behaviour.

In particular, adjusting to the university environment requires accessing information about the university discourses, resources and expected behaviours that students do not know that they lack. A rich information system that caters for both goal-directed information seeking (used, for example, to find information to complete an assignment) and incidental information acquisition (used, for example, to understand expected ways of behaviour), can assist students in acquiring the knowledge and skills that are critical to successful navigation of university studies (Cross, Shalem, Backhouse & Adam, 2009; Mgqwashu, 2009), particularly the knowledge that they do not yet know that they need. Incidental information acquisition also has the benefit of resulting in positive feelings that boost a student’s sense of agency (Erdelez, 1999).

Williamson's model distinguished between goal-directed information seeking and incidental information acquisition. The data that we have does not enable us to make this distinction, but goal-directed information seeking is likely to make use of academic and specific sources, while prior studies suggest that students will find incidental information from social media and other generic sources (Erdelez, 1999). These generic information sources may thus be important for students in developing their understanding of the expectations of the academic environment needed to succeed at university (Cross, Shalem, Backhouse & Adam, 2009; Mgqwashu, 2009).

This ecological model of student information behaviour assists our understanding of the variety of student information behaviour and suggests that providing uniform information resources for students is unlikely to be a successful strategy.

WHAT DOES THIS MEAN FOR PRACTICE?

Latham and Gross (2011) observed the Dunning-Kruger effect in the context of information literacy skills. This is when people with low skills in a particular domain are unable to recognise their own deficiencies in the domain (Kruger & Dunning, 1999) and are thus unlikely to take action to learn the skills that they do not know they do not have (Gross, 2005). This effect makes it important to make students aware of the range of information tools and resources that are available to them and to develop skills in information literacy. Such interventions not only teach applicable skills, but can also work to counter the Dunning-Kruger effect, changing students' conceptions of what information literacy is and developing a more realistic idea of their own information literacy skills (Latham & Gross, 2011).

Training interventions do not, however, always result in long-term changes in information behaviour (Chen, 2015), a finding supported by Savolainen's idea of how psychological types influence information behaviour. By taking an ecological perspective of students' information behaviour, the need to develop information sources that are tailored to different kinds of student becomes clear. This may need to go beyond flexible digital information portals to consider changes to traditional modes of teaching and introducing the flexibility for students to be able to self-select modes that suit them best. Reflective and collaborative exercises such as the one described in this paper expose students to multiple information tools and behaviours and facilitate each student building their own particular personal information system.

CONCLUSIONS

Students' information behaviour can be understood in terms of an ecological model that maps the information sources they use and the contexts that influence their success in accessing information. University students have to develop a complex personal information system and master a range of information behaviours in order to succeed in their studies.

Students access a wide range of generic information sources, with social media applications dominating their information behaviour. These generic sources of information have the potential to support students' incidental information acquisition, which is important in addressing their common lack of knowledge about academic discourses and expectations on entering university.

For students, the learning management system is the most important academic information source, with traditional academic activities of lectures playing a small role in their information gathering. In particular, members of the academic staff are not seen as significant sources of information for students. This observation supports moves towards blended learning and away from traditional modes of instruction. The role of academic staff may well need to shift from being presenters of academic information towards being choreographers of learning materials delivered through other media. Uncomfortable as this change appears, refusing to renew higher education pedagogies in the face of mounting evidence that existing pedagogies are considered irrelevant by students seems irresponsible. Rather, the university might take steps to better understand and own the information behaviour of its students and proactively aim to both adapt pedagogies and to improve the ways in which students work with information.

Most undergraduate students use smartphones and laptop computers, with desktop and tablet computers as an alternative. Although students use cloud storage options, they mostly make use of physical storage devices that do not depend on access to networks. This suggests that it might be worth the institution providing smartphones to the few who do not have them in order to (1) facilitate access to information sources that will provide much-needed incidental information and (2) facilitate teaching and learning activities designed to take advantage of the capabilities of smartphones. The provision of reliable, free wireless network access should also be a priority for institutions.

This paper has examined students' information sources and the technology devices they use to access them. Further research is needed to better understand the types of information that are being accessed through generic information sources and students' uses of academic information sources, as well as more in-depth evidence of how context impacts information behaviour. In 2015, we expanded the assignment from which this data was collected to include additional elements which will facilitate such further investigations.

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