THE EXPERIENCES OF FIRST-YEAR STUDENTS IN MATHEMATICS IN USING AN E-LEARNING PLATFORM AT A UNIVERSITY OF TECHNOLOGY

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ABSTRACT

Universities of technology in South Africa have been trying to deliver efficient and flexible education practices to cater for influx of enrolling students in the institutions who come from diverse educational backgrounds. One of the challenges arising from students' poor educational backgrounds is their limited experience in freely available technologies for teaching and learning. Mathematics teaching, particularly, is made more difficult because of the large number of students who have many misconceptions as a result of problems from the basic education that they were part of, for a period of 12 years. Consequently, number of them do not make it to the mainstream education system due to poor performance in first year mathematics. This article reports on the impact that an e-learning platform could have on mathematics first year students when used as a supplement to the traditional methods of teaching. The study utilised quantitative and qualitative methods, with the qualitative data being used to interpret and make sense of the quantitative data. Participants were 35 first year students in the Civil Engineering Department at a university of technology. Data was generated from questionnaires and focus group interviews. It was found that the actual use of the system is dependent not only on student developmental objective to use the system, but external factors also contribute negatively to the actual system use. Some external factors that were identified include poor internet connectivity, insufficient computers and an inflexible timetable. The study recommends that universities of technology should take great care in designing their academic calendars, so that it alleviates instead of tighten the constraints under which students work

Keywords: adoption, e-learning platform, perceptions, technology challenges, mathematics, engineering, first-year students, computer skills, the Internet

INTRODUCTION

The introduction of a democracy in South Africa led to large increases in student numbers at institutions of higher learning doing mathematics. However, the lack of students' preparation to pursue studies in engineering at universities of technology[1] (UoTs) leads to many problems. This under-preparedness is one of the factors contributing to the low graduation rates in science, technology, engineering and mathematics. This impacts negatively on the country's pursuit of improved economic and social development. Multiple studies indicate that the teaching of mathematics still causes content-related misconceptions by students, which are a result of major pedagogical and curriculum transformations from the basic education level that have occurred over a period of 12 years (Alexander 2001; Vermeer 2001).

Many students experience problems in their first-year of study. This is the stage where, student commitment and individual feeling of the demands of university study culture is built. This is the crucial period for first-entry university students, as it impacts on their future educational progress, retention and success. Consequently, many students do not advance further than the first-year of study and even those that do, stay in the system beyond the minimum regulation time.

There are numerous studies in mathematics teaching and learning using technology in the university sector (Forster 2006; Kaplan-Leiserson 2006; Monaghan 2004). Most of studies have focused on students' use of technology in a traditional university and very few concentrated on universities of technology. They have also not focused on first-year students from disadvantaged backgrounds who have not performed well at the basic school education level because of diverse cultures and environments. According to Mooketsi and Chigona (2014), there is still a need to conduct research on the adoption of technology by UoTs' first-year students who come from an environment that has not been using technology as a means to supplement teaching in the classroom. Mooketsi and Chigona (2014) indicate a need to investigate the influence on teaching and learning for students who have not been exposed to technology amid rapid advancement of information and communication technology (ICT) in the teaching and learning environment.

Prior experience in using technology for studying, is critical to enable students' transition from basic school to university education level, which relies on computer-based learning. Therefore, this article explored the potential of e-learning practices as a bridge and source of intervention to improve first-year mathematics students' learning at UoTs in South Africa (SA). The objective was to investigate the forms of technology-related provisions needed by the first-year mathematics students in order to adopt e-learning platforms. Accordingly, the article was

underpinned by the main objective which was to explore how an e-learning platform could enhance mathematics teaching and learning for first-year students at a UoT. The following questions, governed the current study: (1) What are the factors that influence students' adoption of technology in their learning of mathematics? and (2) How do university structures enable/constrain the adoption of e-learning practices at a UoT? It is hoped that this article will lead to improvements in the teaching and provisioning of technological support systems, particularly for mathematics in the UoT sector, which is often a barrier to succeed to mainstream university education. The current study will impact to the knowledge organization about first-year students' adoption of technology and university structures enabling and constraining the adoption of e-learning practices in mathematics teaching and learning in SA.

LITERATURE REVIEW

A study shown by the South African Council on Higher Education (2016) that included all UoTs in South Africa indicates that the graduation output of higher education students does not meet the country's demands. This study also indicates high failure and dropout rates. A cohort study by Gibbs et al. (2004) indicates that there are still major challenges in South African higher education, even after the establishment of democracy, when various mitigation efforts in the sector were introduced and monitored. An out numbered group of 18 per cent (20–24 year age group) Grade 12 students who join the higher education sector complete their studies in the required time. A considerable figure of first-time-incoming students (30%) drop out in Year 1. The findings of the study by the Council on Higher Education (2016), combined with that of the study by Gibbs et al. (2004), indicate an uneasy representation. Student persistence and graduation national rate, has shown undesirable difference over the decade and UoTs are performing equally poorly (Smit 2012).

Several research studies on mathematics education have been conducted, indicating that first-year students registered in faculties of Engineering find it difficult to join mainstream programmes due to poor performance in mathematics (Makgato and Mji 2006). According to Badat (2010), several students in the South African education system are not equipped for achievement in the higher education sector in the disciplines of mathematics and science. This is to an extent ascribed to the mathematical knowledge disparity shown by learners from Grade 12 level and the experience essential for first-year entry into mathematics courses (Makgato and Mji 2006). The knowledge disparity includes lack of ability to utilise technology in mathematics learning because their previous environment did not include technology-related platforms. According to De George-Walker and Keeffe (2010), there may be changes in students' performance in mathematics if technology can be embedded in teaching and learning

of first-year mathematics classroom and outside of this environment. This can be observed when students demonstrate technology-influenced ability, encouraging attitudes, beliefs and thoughtfulness (Oblinger 2003). Soh and Roberts (2005) suggest that universities could investigate technology broadly for the purposes of increasing students' interest and aptitude to familiarise themselves with technology and come across their individual needs. The introduction of ICT in teaching and learning, as supported by Conole et al. (2004), is proposed to be effective if it can be combined with direct teaching activities that will promote learning collaborations and interaction among students. Muirhead and Salmon (2002) confirm that there are benefits for students in using ICT.

Multiple studies confirm that the interaction of students in mathematics using an e-learning platform in the classroom creates prospects for gaining access and understanding various demonstrations of mathematical concepts (Forster 2006; Swan 2010). Although this finding is of great importance, students coming from the basic school level do not have the necessary computer skills for learning purposes and this is expected to cause problems in terms of interaction with e-learning platforms in their new environment. It is in this context that we performed research on the impresssion of a technology-related platform for first-year mathematics students in a faculty of engineering at a UoT.

THEORETICAL FRAMEWORK

In this study we were interested in exploring factors that influence students' adoption of e-learning as resources for learning mathematics at a UoT. Adoption implies the acceptance or carrying out innovation. It is commonly used in reference to the use of physical technologies. However, the term has relevance to a wider field, including pedagogical aspects of models used in teaching and learning. The adoption trajectory of students will be shaped by their impression of the perceived benefits of a system. Knowing students' intentions and understanding the factors that influence students' take-up of technology can help academics and administrators identify ways in which they could help students improve their learning practices.

A person's conduct is influenced by social interaction which embrace networking, interacting, inspirations and persuasions. Learning may be seen as a mindful act of making a determination with two processes central to learning: accommodation and assimilation. If roughly does or does not fit in with a current thinking, or yields or does not produce knowledge, then the individual accepts these experiences as part of his/her learned skills. The individual may then change his/her current view by taking on the innovative experience. These developments consequently, refers to fundamental natural process that combines accommodation and assimilation (Atherton 2013). Various adoption models and derivations are

available. For the purpose of this article, we considered the Technology Acceptance Model (TAM) (see Figure 1).

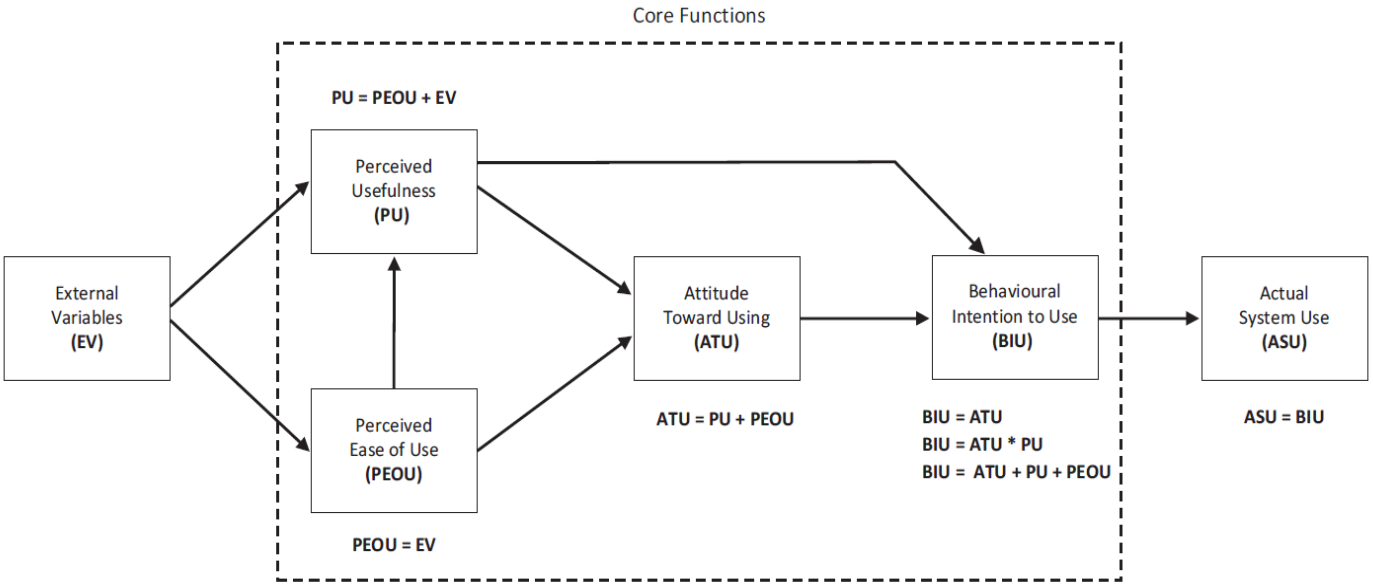

Figure 1: Technology Acceptance Model (Davis, Bagozzi and Warshaw 1989, 982–1003)

Based on reasoned action theory, Davis, Bagozzi and Warshaw (1989) proposed the TAM. The model deals precisely with the likelihood of the adequacy of knowledge technique. This model predict the suitability of a tool and to distinguish the modifications that must be effected to the system for making it acceptable to users. We have considered it in our study so that it can afford the core for discovering the influence of exterior factors on internal beliefs, attitudes and purpose (cf. Davis, Bagozzi and Warshaw 1989). According to Bytheway (2011, 179-192), the TAM helps us understand "the behavioural intent to integrate ICTs". In addition, the study by Park (2009) indicates further that the TAM can be used to trace how external factors influence beliefs, attitudes as well as intentions to use a system to improve the job or task at hand. In this study we considered the job or task as being the learning of mathematics at a UoT.

According to Davis, Bagozzi and Warshaw (1989), the interest of an individual to acknowledging and adopting technology is influenced by external variables. External factors (EF) refer to circumstances that influence the intention and actual use of e-learning platform. In the TAM, actual system use (ASU) denotes the extent an individual actually uses the e-learning platform in his/her learning of mathematics. The actual use is mediated by students' behavioural intention to use (BIU) the platform. Behavioural intention to use refers to the extent to which the students take steps towards putting the technology into practice.

The students' intention to use is mediated by their attitude towards using the technology (ATU) as well as their perceived usefulness (PU) of the procedure. PU is considered as the

extent to which a person considers that using the particular technique would increase his/her learning (adapted from Davis, Bagozzi and Warshaw 1989). The students' PU is also influenced by the students' perceived ease of use (PEOU). Davis, Bagozzi and Warshaw (1989, 985) define PEOU as "the level to which someone considers that using a particular technique would be free of effort". The TAM provides a basis to follow how the external variables influence students' belief, attitudes, intention to use and actual use, as illustrated in Figure 1.

The importance of the PEOU construct is strengthened by Bandura's (1982) study on self-efficacy. Davis, Bagozzi and Warshaw (1989) argue that self-efficacy beliefs can be central determinants of behaviour. The study by Bandura (1982) suggests that the main underlying factor of self-efficacy is intrinsic motivation. Davis, Bagozzi and Warshaw (1989) point out that self-efficacy is somewhat different from outcome judgements, which is concerned with the extent to which a behaviour, once successfully carried out, is believed to be linked to valued outcomes. Based on Davis, Bagozzi and Warshaw (1989), the individual student attitude is amongst factors that influences his/her actual use of an e-learning platform; another factor is centred around the impact it may have on the student's execution. Consequently, the likelihood that a student will utilise the technology in learning mathematics is elevated provided he/she understands that the technique will improve his/her performance in the classroom.

Davis, Bagozzi and Warshaw (1989) found that the factors that influence perceived usefulness include job effectiveness, productivity and time saving, as well as the importance of the system to the job. In terms of PEOU, some influences identified in Davis, Bagozzi and Warshaw's (1989) study were the physical and mental effort required and ease of use.

RESEARCH DESIGN AND METHODOLOGY

The approach ensued in the study was that of design-based research. This is an iterative research process and was introduced by Brown (1992) and Collins (1992), who were the first contributors to this area of study. This is an approach that is used to a great extent in education to examine innovation using initiatives that are based on technology. Design-based research involves four processes, namely "analysis of practical problems analysis by researchers and practitioners in collaboration, development of solutions informed by existing design principles and technological innovations, iterative cycles of testing and refinement of solutions in practice, and reflection to produce 'design principles' and enhance solution implementation". This article is focused on the analysis phase.

The participants in the project were 35 first-year mathematics students from Department of Civil Engineering in the Faculty of Engineering at a UoT coming from township and private schools. The students participated in a questionnaire to identify skills in using technology in

mathematics learning, and interviews were done with two students from township schools[2] and three from private schools.[3] The focus group was made up of three female and two male students who were students in the first-year programme. The idea of the focus group interview was to establish the students' fundamental problems in learning mathematics at the first-year level of study at a UoT. The interview also investigated students' level of computer competency in using electronic learning material in promoting effective mathematics learning. The interview was audio-taped with the permission of the participating students. The transcripts of the interviews were then analysed using the categories described in the theoretical framework.

FINDINGS AND RESULTS

The results are organised according to the categories described in the TAM (Davis, Bagozzi and Warshaw 1989). There were some external factors that seem to have impeded them from making the effort to change their behaviour towards taking on board the university technology tools which are described next.

External factors

Almost all the first-year students that were interviewed explained that they had very limited experience in using technology for learning purposes. This was due to the fact that most of them came from schools without computer laboratories. There is therefore a need for them to receive the necessary training on utilisation of technology for learning purposes and also to work on an online platform. Although many of them come to the university with some technology tools such as cell phones, iPads and computers, and some students do not realise that these can be used for learning purposes. Issues such as how to download mathematics videos from the Internet and accessing other learning materials were a challenge to these students. This indicates that technical support is very important for these students to adopt technology in mathematics learning. Internet connectivity in the computer laboratories and wireless connectivity should be improved and available for students to use them on their computers, cell phones and iPads.

One student from a township school recounted his frustration in trying to access the Blackboard learning management system:

> "So for instance if the lecturer says that he has posted notes on Blackboard, In case, I don't have a laptop I will try to go to the computer laboratory at the university, which is not always available. When trying to use my phone, I find it very difficult because none of us actually knows the link very well. It is not written anywhere in the university accept in the computer laboratory with very small font, and sometimes it is not easy to recognise it. The lecturer has to make sure that the subject appears under each student and sometimes some of us unfortunately we had a problem with some subjects [not appearing] for us under Blackboard. In some cases, the lecturer will refer

> us to the learning management system for the learning material he has posted and you go there and you don't find that material because the system is down or there are just technical problems."

Another student from a township school also indicated that there is an issue with Blackboard, the learning management system of the university:

> "Most of us struggle to login with our usernames, which are student numbers. Though it's a wonderful initiative, in future it would be better if every student could easily get access to the platform."

A student from a township school explained his frustration in trying to get help from administrators:

> "To search for books you need technology, but surprisingly, at this university people at the front desk will not assist and teach you how to access a book. They would expect you to use the computer and search for books yourself. Even though we were given a very short training on the first day, using the system is difficult and as new students we need someone to assist us on how to use the computer to search for books until we are confident enough to use it on our own."

Students that participated in the study, attempted to connect to Blackboard, but external factors relating to difficulties with respect to accessing the online platform made it impossible to actually use the system optimally. The comments above indicate that there were insufficient computers available and that the system was not configured to enable them to access it from their cell phones. Furthermore, it seems as though technical support was a major problem, as not all the students were enrolled on the learning management system, and for such students, the learning management system was of no benefit.

PERCEIVED USEFULNESS

Many comments were made related to the perceived usefulness of the technology, mainly by students who had already experienced the benefits of using technology as part of their learning activities. The students from private schools spoke about the value of watching their lessons on PowerPoint at school (in contrast to only being taught using the chalkboard):

> "At school we used technology and all our lessons were in PowerPoint. It is fast and efficient and going forward, this should be a way to go."
>
> "I believe, technology should be used to learn mathematics."

Other comments related to the perceived usefulness construct explained the benefits of using

technology rather than the chalkboard. Two students from township schools stated:

> "Using the e-learning platform helps me learn on my own."
>
> "In the e-learning platform, information is available at any time, learning occurs from the system at my own time and there is accessibility of learning material at all times."

A student from a private school remarked as follows:

> "... Creating opportunities for networking and sharing solutions to the problems and easy access to electronic resources such as multiple choice tests and short tests in preparation for major tests and examinations."

These comments show that the students could see the benefits of incorporating the technology into their learning because it helped them learn individually, while others explained that the use of the technology creates opportunities for networking by sharing solutions. Other benefits that were identified were greater access to tests and assessments that could be used when preparing for examinations.

However, students' perceptions of the usefulness seemed to have been clouded by issues such as the concern that the platform may erode teacher-to-learner communication. As remarked by one student from a township school:

> "I think that the technology approach is good as long as we will still maintain that teacher-to-learner communication. Just as when we use chalk and board, in technology also there should be step-by-step instructions. Since we are still in the first year of study at the university, we should be instructed on how best to utilise the available learning resources and not be just thrown in the deep end."

Perceived ease of use

Some students were optimistic about the ease of use, as shown by the following comments, firstly by a student from a private school followed by one from a township school:

> "Learning to work on the platform is not a challenge for me."
>
> "Working on the platform is easy to do what I want to do."

However, there were others who are not influenced by ease of use of technology. One student from a private school stated:

> "It is difficult without support ... interacting with the Blackboard learning management system is often frustrating."

Two students from township schools remarked:

> "Computer basic skills and how to search for relevant information must be taught."
> "To become skilful at using the platform, much effort is needed."

These comments reveal that students' self-efficacy influences their perceptions. There were students who felt that they would not be able to access the system if they were not provided with training. This shows that they did not feel that they had the capability of working with online teaching tools and they displayed apprehension about being able to use these tools confidently.

Attitude towards using the technology tools

Many students displayed a positive attitude towards using technology, but seemed to prefer social media such as Facebook and WhatsApp instead of the university learning management system. They felt that these media tools would be more beneficial for them to access after-hours as well as for them to discuss their work with their fellow students. Examples of these comments (made by the students from township schools) are given below:

> "The only way I have ever used technology for mathematics is when I WhatsApp a friend a sum I find very difficult or helping each other with other questions."
> "In Facebook, people can spend time doing problems, talk to one another and they can share their experiences through the media and begin to teach one another."
> "We are not utilising e-learning platform owing to insufficient knowledge and very limited access to computers."
> "There is inadequate technological resources and lack of institutional support since most academic staff members do not promote the use of technology in their subjects."

Facebook may allow them an opportunity to continue with the learning of mathematics even if they are not in the classroom. The WhatsApp platform has significant role, because after a student does a problem and gets stuck, he/she can post it to other students and get the solution. The students' comments emphasise once again that they prefer the more well-known social media tools because they have already experienced the benefits.

Showing a behavioural intention to use the technology

As explained in TAM, whether the students actually use the system depends on whether they change their behaviour so that they can incorporate technology in their learning experience.

Some students showed willingness to make the effort to take up the technology, as confirmed by the following quotes by two students from private schools:

> "I have learnt to use technology to understand mathematics."
> "I also made the effort to discover how to use the Internet in looking for books."

The latter student explained in more detail how she was able to access a textbook on the Internet, which made her studies easier to manage:

> "So I can't afford to buy the prescribed textbook and I went on the Internet and downloaded the free version and other relevant books that are freely available on the Internet."

It is essential to observe that these students showed evidence of intending to use online tools, but these were not the ones provided by the university as part of their technological provisions.

Actual system use

In general, factors related to behavioural intention to use ICT or to the final stage of the TAM, which is actual use of ICT, could be clustered into four groups: individual context, social context, system context and structural context. While individual context means personal influence on the acceptance of the use of ICT, social context develops from students' collaboration among themselves or with the instructor. System accessibility as a structural factor was reported to be affecting students' adoption of e-learning. Some examples of students' comments on the use of the system are given below:

> "In my view, the e-learning infrastructure in the university does not promote the use of technology since in the lecture halls and residences, we do not have access to internet."
> "We are introduced into the e-learning platform with one subject out of six, there is a need to incorporate it into the entire curriculum."
> "There seem to be computer illiteracy of students in the university."

This result is a true reflection of learners' experience of basic education in South Africa, as ICT infrastructure is a challenge to almost all the schools and many learners do not have Internet access at school and home. This indicates a need for the university to provide easy technology access to first-year students. The two constructs of PU and ease of use had absolute outcome on the first-year students' intention in utilising e-learning. These constructs contributed to students' positive attitudes towards the e-learning platform. Consequently, it is essential that administrators and designers of e-learning practices support students to improve their insight

positively through the online platform. This satisfaction in turn will encourage students to successfully consider actual system usage.

DISCUSSION

This study investigated how e-learning adoption and implementation enhanced students' learning practices. In view of the obstacles indicated by the students, such as training in the use of technology and technical support, a dependable, established technology infrastructure and students' computer centres are essential for positive adoption and implementation of the e-learning platform at the UoT in question. Furthermore, it seems that the learning management system (Blackboard) used at this UoT does not support them, as they are to be the crucial beneficiaries, owing to uncoordinated endeavours to promote the use of online media for teaching and learning and poor internet connectivity on campus. This will impact negatively on the e-learning platform usage owing to the fact that students cannot view and download course material and other learning materials such as previous tests and examination papers. A study by Heirdsfield et al. (2007) indicates that it is improved accessibility of technology that most influences students to adopt it. The lack of learning opportunities in the learning management system, diminished chances for deliberations with other students and a less efficient learning process are however not peculiar to this UoT, as these factors are also indicated in the studies by Liaw (2008) and Yang and Cornelius (2004) as increasing the level of students' dissatisfaction. A university learning management system should not increase the level of students' isolation from their peers and lecturers, as also indicated in the study by Dickey (2005).

The group of students coming from technology disadvantaged schools who participated in the study experienced challenges in adopting technology. Approximately 45 per cent of this group of students were prepared to take the initiative to try something challenging. These students are categorised as innovators, according to the categorisation used by Kapoor, Dwivedi and Williams (2014). Following this literature, the analysis of the students' questionnaires on the innovation adoption of the e-learning platform indicated that 2.7 per cent of students' participating, were able to consider the proposal of using technology in learning on their own. Approximately 12.3 per cent of the participants proved to be early adopters of the e-learning platform. Most of these students came from the private schools. Using the innovation adoption classification label by Kapoor, Dwivedi and Williams (2014), we established that 34.5 per cent of the participating students found it difficult to change to a new system without proper training, 34.5 per cent of the participants were doubtful, unwilling to transform and are hard to influence and 16 per cent were adamant in resisting change to adapt to the university's learning culture

of using e-learning practices.

Overall, it is clear that some students have progressed towards actual system use, while some have indicated behavioural intentions to use. These are the students who can be considered as early adopters. The students who have made progress to these stages of the adoption trajectory have experienced some external factors that have prevented them from actually using the system. These issues need to be addressed by teaching, administrative and management staff because they are related to the accessibility of the system. Students' challenges at this stage do not emanate from their beliefs, attitudes and/or perceptions. It is striking that the students demonstrated actual system use of some technological tools; however, these tools are different from the ones designed and offered by the university.

External factors do not only negatively affect those students who are early adopters, they also affect students who find it difficult to change to a new system without proper training and who eventually become adamant to resist change. The external factors of poor Internet connectivity, insufficient computers and inaccessibility by cell phones make it even harder for students at every phase of the TAM to adopt the concept of the e-learning platform. These external variables prevent students from moving from displaying a behavioural intention to actually using the system. In addition, the difficulties with respect to access make the students that are not confident about using technology even more fearful and cause them to question themselves about whether they have the necessary skills. We have seen that the external variables become an overriding concern and can also influence perceptions of usefulness.

The findings from this study suggest that advancement and functioning learning management system should not be confined to a particular system, but that further exploration of the use of other technologies such as cell phones, Facebook, Edmondo, and so forth should be considered. The use of cell phones, as indicated in the study by Cobcroft et al. (2006), can be considered as a learning platform for students, as it allows them an opportunity to construct knowledge, and also allows possible collaboration with peers and learning groups within and beyond the classroom environment or university computer centre. For this to happen, using the findings of the study, we recommend that the UoT should consider launching wireless networks in student areas such as residences, classrooms and libraries, enabling computers to connect to the Internet at any given time, and making the learning management system more accessible to run on smartphones without compromising the UoT's Internet security.

NOTES

1. A university of technology offers technological career-directed educational programmes, focuses on innovative problem-solving research and engages with government/business/

industry with communities as end users (SATN 2008) and were formed in 2002

2. In South Africa, township housing areas originated as racially isolated, low-cost accommodation for black employees to live nearer to the cities and towns for employment purposes (Smit 2008; Xaba and Xaba 2006).
3. Private schools, also known as independent schools, are schools that are not owned by the state. They are usually owned and operated by a trust, church or community, or by a for-profit company (Bush and Heystek 2003; Hammett 2008; Onwu and Stoffels 2005; Prinsloo 2005; Tihanyi and Du Toit 2005).

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