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Adaptive Learning Technology in Higher Education: Lessons from an Economics Classroom in South Africa

By

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ABSTRACT

Many public universities in South Africa have increased their use of technology assisted learning tools in a bid to improve student retention and success. One such tool is adaptive learning technology, which aims to customise a learner's learning path to suit their individual learning needs using technology-assisted learning. Despite the growing popularity of adaptive learning technology in the global educational technology industry, little research has been done into adaptive learning and adaptive technology to prove its effectiveness on student learning in higher education and, more specifically, in the South African higher education environment. The aim of this study is to contribute to the growing literature on adaptive learning and adaptive learning technology by examining whether adaptive learning technology, in the form of McGraw Hill *Connect*, influences the learning experiences of first year Economics students in South Africa.

The study begins by providing an important summary of the literature related to adaptive learning and adaptive learning technologies. Subsequently, the need for adaptive learning technology at the studied university is contextualized. Thereafter, the study's methodology is described and a univariate analysis is applied to survey data from a 2016 cohort of first year Economics students at a South African residential university, where adaptive learning technology was used as part of the Economics 1 teaching strategy. Results support the study's hypothesis that adaptive learning technology has a positive influence on the learning experience of students. The study also provides some useful insights on the operational aspects of adaptive learning technology that could be used to improve teaching strategies, which encompass adaptive learning and learning quality, at the studied South African residential university.

1. Introduction

Guiding students to shape their own thought at the onset of their studies at university seems both sensible and efficient when thinking about human capital development within the context of higher education. After all, "the educational function of a university is to shape thought and conscience" (Anderson, 1993). However, the tools that exist in higher education spaces are not always used to encourage student engagement (Butler, 1992). Moreover, the present commercialisation of higher education has encouraged students to "have a degree" as opposed to "be a learner" (Molesworth, Nixon and Scullion, 2009, p.277).

One way to encourage students to "be learners" would be to promote student learning and enhance institutional effectiveness (Krause and Coates, 2008, p.493). Because students are individuals and usually learn as individuals, each student has their own learning path and learning style and this should be accounted for in their learning environments (Jacobson, 2001). Regardless of this, it remains common practice to present discipline-specific material and apply generic assessment techniques to gauge generic student success. Very little is done to tailor-make learning or assessment per student, especially in large classes (Basitere and Ivala, 2017**)**.

Adaptive learning presents the opportunity to "tailor-make" learning according to the needs of each student. And in an age where technology can be used and creatively adapted in the classroom, adaptive learning technology presents an even bigger opportunity to "tailor-make" learning per student. One example of adaptive learning technology is McGraw-Hill *Connect*, a digital learning environment that integrates a module's eBook, course content, assessments and grading to make the process of teaching and learning unified for educators and students. The eBook is not simply a portable document format (pdf) version of the hard copy prescribed textbook. It is a *SmartBook* which adapts to each users' learning pattern and establishes this pattern as each user progresses through the course material (McGraw-Hill, 2016).

Despite the innovative technology used in McGraw-Hill *Connect*, little is known about the role that the system plays in students' learning experiences. While McGraw-Hill's own effectiveness study does argue that *Connect* leads to a 10% improvement in student success, there is no independent research that evaluates its role in the learning process (McGraw-Hill, 2016). Subsequently, this research question is prompted: "Does adaptive learning technology affect the learning experience of first year Economics students in blended-learning environments?" In response to this research question, the purpose of this study is to examine whether adaptive learning technology, in the form of McGraw Hill *Connect*, affects the learning experience of first year Economics students in blended-learning environments at a South African residential university, hereafter referred to as "the university". In light of the aim, the objectives of the study are twofold: firstly, to establish whether adaptive learning technology proved useful to students in learning economics and secondly, to determine whether the adaptive learning technology was efficiently rolled-out to students. This study hypothesises that that adaptive learning technology has a positive influence on the learning experience of students and makes a significant contribution to the growing body of knowledge on adaptive learning and adaptive learning technology in the "developing" world.

2. Literature

2.1. Theoretical framework

This study is grounded in adaptive learning theory. Adaptive learning theory postulates that learning is improved when instruction is personalised (Murray and Perez, 2015). Adaptive learning gained popularity from the work of behavioural psychologist, Burrhus Frederic Skinner in the 1950s and 1960s, whose theories aimed to help elementary school-goers.

Skinner's theory of learning advocated for "learning by doing" and his theories argue that teachers should use creative teaching techniques to encourage learning in small segments and should adapt learning to each student's skills level, among other things. Skinner's own teaching strategy made use of a "teaching machine", designed to assist students with programmed learning (Skinner, 1961). The teaching machine used by Skinner, was a device that relied on a student tapping to the sound produced by the mechanical instrument as they answered short and focused questions which "self-managed" their learning. Each question was a build up to the next question and at the end of a session, each student's unique rhythmic pattern was produced as a printed score (Skinner and Holland, 1961).

While Skinner's teaching machine is commonly seen as one of the first forms of adaptive learning technology, it was Sidney Pressey who actually outlined a system of adaptive learning in 1921 long before Skinner's teaching machine gained popularity. Pressey, also a behavioural psychologist, assembled an "automatic teacher" from old typewriter parts which presented students with multiple choice questions that were ordered from least to most difficult. If a student answered a question correctly, they could move to the next question. If not, the machine would not move until the student answered the question correctly. Despite its immense potential to assist with learning, the automatic teacher was too expensive to manufacture and deploy to public schools. As a result, Pressey's automatic teacher was not actively used on a large scale at the time, but re-emerged in popular literature, as a result of the work by Skinner (1961) and a review of programming techniques by Klaus (1965). Pressey and Skinner's studies suggest that adaptive learning technology is an important part of the adaptive learning process.

2.2. The Benefits of Adaptive Learning Technology

According to McGraw-Hill (2016), adaptive learning and its associated technology can be seen as beneficial for a number of reasons. Firstly, adaptive learning technology usually adjusts to the learning pace of a student based on their answers to the multiple choice or short questions built into the learning management system. This ensures that students master basic concepts, often a precursor to more advanced concepts. Secondly, a student's prior knowledge is often taken into account by the instructor, who programmes questions at varying levels while aiming to accommodate different kinds of students and their diverse learning. Thirdly, adaptive learning technologies usually use each students' answers to the various questions to create diagnostic information. This diagnostic information helps educators and course convenors become familiar with their students' abilities and learning patterns. Moreover, this helps to empower educators to identify students who are falling behind or giving up. Lastly, adaptive learning technology allows for lecturers to focus on more advanced concepts in the (online or face-to-face) classroom and also provides an opportunity for increased and focused synchronous or asynchronous student engagement.

2.3. Modern Critics of Adaptive Learning Technology

Audrey Watters is probably the most well-known, modern-day critic of adaptive learning technology but not of adaptive learning itself. Watters (2005) supports adaptive learning but believes that adaptive learning technologies are impersonal and devalue the processes of learning, labour and care. Watters (2005) argues that educational technology companies exaggerate the potential of adaptive learning technologies and claims that the algorithm used in educational technologies does not adapt to each learner's individual learning needs. Instead, the algorithm serves as a "robot tutor" that simply allows a student to proceed to different levels of very narrow multiple choice questions. In addition, Watters (2005) argues that educational technologies do not necessarily help students to understand why the answer that they chose is

wrong. They usually come to this realisation on their own after they have selected a few incorrect answers. Furthermore, educational technologies are not able to account for students' misconceptions in a particular discipline nor are they able to actively engage with students without the presence of a synchronous and attentive tutor. Watters (2005) also emphasises that "computers do not care".

2.4. Modern Literature on Adaptive Learning and Adaptive Learning Technology

Modern literature on adaptive learning presents mixed evidence to merit its implementation. Papert (1980) argues that while computers are an important tool in the process of learning, they are designed to repeat prevailing educational practices. Likewise, Akbulut and Cardak (2012) present findings from over 70 studies on adaptive learning and find weak evidence in support of its effectiveness. Similarly, Murray and Perez (2015) and Reich and Ito (2017) suggest that adaptive learning has minimal benefit in higher education. Reich and Ito (2017) argue that "some rigorous studies show no effects of adaptive systems as compared to traditional instruction, and others show small to moderate effects". In addition, the authors argue that "most of what computer assisted instructional systems can evaluate are student computational skills, which are exactly the kinds of things that computers are much better at doing than human beings". On the contrary, Basitere and Ivala (2017) find that adaptive learning technology assists students with building their proficiency and effectively managing their time in the first year physics classroom.

2.5. Education equality at the university

In light of the "embarrassingly low" transformation of higher education in South Africa, some universities aim to improve education equality through their teaching and learning strategy, among other things. The university has one of the worst education equity efficiency indices (-10.4) among the 26 public higher education institutions in South Africa. This means that student graduations at the university are a poorer match to the national demographic profile than its student enrolments (Govinder, Zondo and Makgoba, 2013).

In 2009, the university embarked on a number of strategic campaigns to increase student retention and success in order to improve its overall education equality profile. The university initiated a number committees whose aim is to identify and explore the factors influencing retention and success of new and senior students at the university. The university also relaunched its academic development division and began promoting technology-assisted learning and analytics management in its attempt to provide greater academic support to its students.

2.6. Economics 1 and McGraw-Hill *Connect* at the university

In 2015, the university sought to meaningfully integrate technology with their teaching and learning strategy in a bid to improve student retention and success. Their argument was that present-day students show immense technology competence and thus, would benefit from using technology as part of their learning process. This idea received some criticism from academics who argued that technology use in the classroom would be "less exciting" than social use and that students would use the Wi-Fi to roam social media during class time. Others argued that youth at the university may not necessarily be as technology savvy as expected granted that many students at the university are from socioeconomic backgrounds where exposure to technology use is less likely. Nevertheless, the university continued to host seminars and workshops through faculties and the academic development division to encourage engagement among academics regarding technology as a tool for teaching and learning. Over time, many different tools and platforms were explored by a number of academics from diverse

disciplines at the university. Google classroom and Blackboard were among the more commonly mentioned platforms in teaching and learning spaces among academics at the university and are known for providing a diverse range of teaching and learning tools in addition to analytics features that could be used to analyse student success for the duration of a particular module.

Academics with larger classes began to examine tools that could also be used to innovatively attract more engagement with the content. Larger classes are typically characterised by large spaces filled with tightly packed seats which makes discussion in smaller groups undesirable for students and uncontrollable for instructors. Students find discussion in the larger group daunting and subsequently become passive observers in the large classroom. Instructors have to find a balance between crowd control and student engagement and are typically inaccessible to students until after the class has ended (Geske, 1992). This arrangement usually leaves the students to study large parts of the course material without any structured guidance outside of class time. While this may encourage students to take control of their own learning, it does leave room for students to under-engage with the material.

The Economics 1 classroom at the university has the stereotypical large classroom setup. Enrolment into the course usually exceeds 2000 students per semester as the course services students from diverse disciplines. The course follows a 14 week timetable per semester, with each student attending a compulsory lecture (90 minutes) and tutorial (45 minutes). 12 themes are covered over 12 weeks, leaving 2 weeks in between for semester assessments. The same lecture takes place 6 times in 1 week and the same tutorial takes place over 15 times in 1 week. Lectures take place in large halls and theatres, with the smallest venue holding up to 500 students and the largest up to 900 students. Tutorial sessions hold 50 students. Students may choose which lecture and which tutorial they attend depending on their timetable and, perhaps later on in the semester, the instructor. Economics 1 usually has 6 instructors and 12 tutors per semester.

Economics 1 is worth 12 credits per semester which is equivalent to 120 notional hours. The South African Qualifications Authority (SAQA) uses a system of credits to attach a value to every course registered with SAQA and the CHE. 1 credit is equal to 10 notional hours. Notional hours of learning are defined as "learning time that it would take an average learner to meet the outcomes defined. It includes concepts such as contact time, time spent in structured learning in the workplace, individual learning and assessment." (SAQA, 2000, p.12). First year students usually take about five courses per semester at the university and each one is usually worth 12 credits each. This means that each student has to spend 600 notional hours per semester and, when divided by the standard academic calendar of 14 weeks, has to spend 42 hours per week on their studies. In South Africa, a full time student should be able to dedicate 42 hours a week to their studies, considering that a standard work week is approximately 40 hours. Based on this calculation, a student is required to spend 8.6 notional hours on each course per week. It is very difficult to monitor whether a student is meeting their weekly notional hours outside of class and assessment times.

In 2015, the Economics 1 team was given a McGraw-Hill *Connect* demonstration and the product had the components needed to encourage student engagement with the Economics course material. The platform could also serve as a learning management system as it contained diverse assessment and analytics capabilities. McGraw-Hill *Connect* also comes with a *SmartBook*. A *SmartBook* is very different from an eBook in that the adaptive learning tasks are synchronised with the *SmartBook*. The adaptive learning component of McGraw-Hill *Connect* works similarly to the Skinner's teaching machine. It asks each student a series of multiple choice questions, known as *LearnSmart*. If a student answers incorrectly, they are

automatically directed to a highlighted part in the eBook containing information specific to that multiple choice question. A voice prompts the student to read the highlighted section and the student needs to place their cursor over each word to prove that they have read the word. Only after all the words have been read, will the student be directed to another multiple choice question. If the student answers the new question correctly, the next multiple choice question appears on the screen. If not, the student will again be redirected to the interactive eBook. As the student completes the *LearnSmart*, analytics are being processed in the background which are available to instructors. Every week, each student is required to complete a *LearnSmart* for the relevant theme or chapter. Thereafter, each student is given a weekly tutorial worksheet and a semester assignment. It is usually advised that the student completes the *LearnSmart* before the lecture or at least before the weekly tutorial worksheet. Analytics generated from the *LearnSmart* were used to engage with students who didn't complete the weekly *LearnSmart* or seemed to be falling behind. Because *LearnSmart* appeared to be a tool with the potential to encourage engagement with the course material outside of class and assessment time, accompanied by built-in analytics features, the Economics 1 team chose to begin using the McGraw-Hill *Connect* system in 2016 as part of their teaching and learning strategy.

3. Methodology

In September 2016, members of the Economics teaching team wanted to examine the role that the McGraw-Hill *Connect* system played in the learning experience of Economics 1 students. Thus, a voluntary questionnaire was issued in lectures and tutorials and students were encouraged to anonymously share their experiences of the McGraw-Hill *Connect* system. Students were free to leave their completed questionnaires in a folder after class at the front of the venue. The lecturer or tutor in the session was not permitted to discuss aspects of the questionnaire with the participants. The study made use of a descriptive research design and the questionnaire issued to participants contained 11 questions. Table 1 below outlines the structure of each question:

Question	Answer structure
1. Did McGraw-Hill LearnSmart assist you with learning Economics?	Yes or no
2. If yes, what was it about this system that assisted you in learning Economics? If no, what was it about this system that did not assist you in learning Economics?	Open-ended: participants were provided with 4 lines of space to respond.
3. Did the weekly tutorial worksheets assist you with learning Economics?	Yes or no
4. If yes, how did tutorial worksheets assist you with learning Economics? If no, why do you think the tutorial worksheets did not assist you with learning Economics and how can tutorial worksheets be improved to aid deeper learning?	Open-ended: participants were provided with 4 lines of space to respond.
5. Did the weekly homework worksheets assist you with learning Economics?	Yes or no
6. If yes, how did the weekly homework worksheets assist you with learning Economics? If no, why do you think the weekly homework worksheets did not assist you with learning Economics?	Open-ended: participants were provided with 4 lines of space to respond.

7. How difficult was it to download the Economics 1 textbook?	Difficult, somewhat difficult or easy
8. How difficult was it to submit homework/tutorial worksheets on the McGraw-Hill Connect online system?	Difficult, somewhat difficult or easy
9. If you had trouble with your eBook and obtained assistance, how quickly was your problem rectified?	Within 3 days, within 1 week or within 2 weeks
10. If you had trouble with McGraw-Hill Connect and obtained assistance, how quickly was your problem rectified?	Within 3 days, within 1 week or within 2 weeks
11. Which eBook did you use more – the offline or online eBook? Why?	Open-ended: participants were provided with 4 lines of space to respond.

Table 1: Author's own adaptation

Based on the validity criteria specified by Sullivan (2011) - mainly content and response process in this instance - the questionnaire used in this study is sound. In terms of the content, the questions were developed by the course designers interested in ascertaining whether students in the course were benefiting from the adaptive learning technology. Moreover, the student responses matched the questions.

Non-probability sampling was applied in this study as survey responses were voluntary. Out of approximately 2200 enrolled students, 308 students volunteered to participate in this study by completing the questionnaire. Responses to each questionnaire were processed and all responses were collectively used to conduct a descriptive analysis of each question. The data does not contain enough general demographic information over time, such as age, race, final course grades for Economics 1 and course grades for other courses, schooling quintiles and home language, to conduct meaningful bivariate and multivariate analyses. Furthermore, the questionnaire responses need to be matched to other measures of adaptive learning satisfaction to allow for sensitivity measures and robustness checks. Nevertheless, the univariate analysis does provide a useful starting point for measuring the learning experience of student participants who used adaptive learning technology.

4. Results and Discussion

The first question of the survey asked students whether they found *LearnSmart* activities to be useful in Economics 1. Results from the survey suggest that 217 participants (70%) found weekly *LearnSmart* activities to assist them in Economics 1 while 90 participants (29.2%) indicated that *LearnSmart* activities did not assist them. 1 participant chose not to respond to the question regarding usefulness of *LearnSmart* activities. In response to the study's first objective, the response rate to this question suggests that most participants in the study had a positive learning experience with respect to the weekly *LearnSmart* activities. The *LearnSmart* activities proved useful in the process of learning economics for most of the participating students.

The second question asked participants to provide reasons for their answer in the first question. 130 student participants (42%) found *LearnSmart* activities relevant and important for assessment preparation. 51 (16.5%) student participants felt that *LearnSmart* activities were too lengthy and too difficult and 25 (8%) student participants felt that the *LearnSmart* activities were irrelevant because they did not count towards their semester mark nor did it help them prepare adequately for assessments. 33 (10.7%) student participants chose not to provide

reasons for their answer in the first question. This result suggests that a large proportion of the participating students found it beneficial in preparing for assessments. The result also suggests that *LearnSmart* could be included in each student's semester grade in order to motivate them to participate. In line with the study's first objective, most participating students felt that adaptive learning technology assisted them in learning economics.

Thereafter, participating students were asked how quickly their McGraw-Hill *Connect* queries were resolved. 121 students (39%) reported that their McGraw-Hill *Connect* queries were resolved within 3 days. 42 student participants (13.6%) and 50 students (16%) had their McGraw-Hill *Connect* queries were addressed within 1 and 2 weeks respectively. 95 (30.8%) students chose not to answer the question. It appears as though a large proportion of queries were resolved within 3 days which is a relatively quick response time. This could be a key contributor to the positive learning experience of the student participants. In line with the second objective of the study, responses here suggest that most participating students had their queries addressed fairly quickly.

Lastly, students were asked whether they preferred an online version of the eBook or the offline version. 198 student participants (64%) of students preferred the offline eBook while 58 student participants (18.8%) preferred the online eBook. 52 student participants (16.8%) chose not to indicate their preference. This finding illustrates the importance of offline material. This could also be an indication that student participants do not have access to the internet or have access to limited internet outside of the university.

In relation to theories of adaptive learning, the results of this study suggest that learning is improved when instruction is personalised. In relation to similar studies, such as Basitere and Ivala (2017) and Akbulut and Cardak (2012), results from this study suggest that McGraw-Hill *Connect* appeared to assist student participants in learning economics, proved useful in terms of assisting them in preparing for assessments and was rolled out efficiently.

5. Conclusion

This study finds that McGraw-Hill *Connect* adaptive learning technology contributed positively to the learning experience of first year economics student participants at a South African residential university. Considering that *LearnSmart* activities per week can be pre-programmed to take up to two hours, McGraw-Hill *Connect* can assist in facilitating greater engagement with the course material while helping students to meet their weekly notional hours for Economics 1 at the studied university.

Furthermore, while adaptive learning technology does not typically tell a student why the answer that they chose is wrong, McGraw-Hill *Connect* comes a step closer to guiding students more specifically with the *SmartBook* as students are automatically directed to a highlighted part in the eBook containing information specific to the question that they answered incorrectly. More research needs to be conducted to improve the adaptive functionality so that it may provide more precise feedback.

Research-guided practice is critical for the development of effective adaptive learning technology solutions in any context. While it is important to implement strategies that may seem necessary or effective to improve student retention and success, it is important to follow the implementation up with research into the effectiveness of the strategy, especially when student retention and success is a priority. The survey used in this study was by no means comprehensive and does not necessarily imply that adaptive learning technology is superior to any other learning tool. Furthermore, the role that adaptive learning technology plays in improving student success and retention directly is yet to be determined. A logical next step

would be to analyse the value that adaptive learning technology adds to student learning objectively and its impact on student retention and success by means of a questionnaire that encompasses important demographic variables (such as age, race, final course grades for Economics 1 and course grades for other courses, national benchmark test (NBT) scores, schooling quintiles, home language, household income, province and area) over and above questions on adaptive learning technology.

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