# SACLA 2019

## Proceedings of the 48th Annual Conference of the Southern African Computer Lecturers' Association

Northern Drakensberg, South Africa, 15 to 17 July 2019

Bobby Tait
Jan H. Kroeze

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# FOREWORDS: SACLA 2019 PROCEEDINGS


## Foreword from the Conference Chair

Dear authors and readers

It is with great pleasure that I write this foreword to the Proceedings of 48th Annual Conference of the Southern African Computer Lecturers' Association (SACLA 2019), held in the northern Drakensberg, South Africa, 15 to 17 July 2019. The northern Drakensberg is particularly well known with many famous features such as the Amphitheatre, which rises a thousand metres straight up over a distance of five kilometres, and the Tugela Falls, which is the second-highest waterfall in the world.

SACLA is a relatively informal association of people involved in the teaching of Computer Science and Information Systems at universities throughout Southern Africa. The objective of SACLA is to promote co-operation among South African and Southern African universities, specifically in order to further the method and contents of university education in the field of computing. The annual conference brings together lecturers, researchers, students, industry and society, and for this reason it provides an opportunity to network and learn from one another. The conference theme for 2019 was **Computing Matters of Course!** In line with this

theme, we invited national and international submissions that focused on practical experiences and successes in computing education at tertiary level, in the following topic areas:

- Classroom innovation, and assessment of the impact thereof
- Novel tools developed, or novel use of existing tools, for learning and/or assessment
- Research undertaken to investigate aspects of computing education

A selection of conference papers appears in a Springer Communications in Computer and Information Science (CCIS) publication (visit the conference website at http://sacla2019.unisa.ac.za/ for the link). The proceedings appearing in this publication are complementary to the CCIS volume, and include the balance of full papers, short papers and extended abstracts, as well as CCIS abstracts. Together, these two publications provide specialists with innovative ideas and new information as it relates to the field of computing education.

I wish to thank the programme committee chairs, Bobby Tait (CS), Jan Kroeze (IS) and Stefan Gruner (CCIS volume) for their hard work, as well as Ms Cecile Koopman for the editorial duties performed. A final thank you to the local and international panel of reviewers, the authors and participants for their contributions, and last but not least, to the organising committee and our sponsors, without whom this conference would not have realised.

Mac van der Merwe (School of Computing, University of South Africa)

# Foreword from the Programme Chairs

The SACLA 2019 Proceedings contain the revised selected papers of SACLA 2019, the 48th Annual Conference of the Southern African Computer Lecturers' Association, held at Alpine Heath Resort in the northern Drakensberg, South Africa, from 15 to 17 July 2019.

The programme committee comprised 54 members, 43 of whom were from outside Southern Africa. Each submitted paper was reviewed by at least three members of the programme committee in a rigorous, double-blind mode, whereby especially the following criteria were taken into consideration: topic choice, problem choice, helpfulness for the ICT lecturer's self-improvement, coverage of related work and accuracy of references, empirical findings, solution development, and language and technical editing. Of the three reviews for each submission, at least one was provided by an international reviewer (from outside Southern Africa). After the international dissemination of our call for papers, 57 submissions were initially received and carefully reviewed; 25 of them were chosen for presentation at the SACLA 2019 conference as full papers (which represents a 44% acceptance rate), 6 as short papers and 12 as extended abstracts, 31 of which were eventually presented. Of the full papers, a selection of 16 revised papers were finally included in a volume of Springer's CCIS series. Nine full papers are published in these complementary proceedings, while the short papers, extended abstracts and abstracts of the CCIS papers all appear in addenda as well.

We were fortunate to have Dolf Steyn as the keynote speaker. His topic was: *Is big data a DNA or a diet problem? Either way, it does not fit comfortably yet.* Moreover, the paper by Pakiso J. Khomokhoana and Liezel Nel (*Decoding source code comprehension: Bottlenecks experienced by senior computer science students*) received the conference's best paper award. Affiliated with our conference were three workshops: The South African Computing Accreditation Board (SACAB); Academic Writing for Junior Informaticians/Computer Scientists; and Amazon Web Services (AWS) Educate and Academy Programs.

We extend our thanks and appreciation to the conference's chair, Mac van der Merwe, the organising committee, colleagues and friends who contributed to the success of SACLA 2019.

Thank you to the authors for having chosen SACLA 2019 as the forum for communicating their noteworthy insights and interesting thoughts. A further word of thanks goes to the members of the programme committee, who all provided extensive and insightful reviews. Throughout the remainder of this book, ICT stands for information and communication technologies, comprising computer science, information systems, information science and related areas of studies (which cannot be sharply distinguished from each other). We wish our readers a fruitful reading experience with these proceedings!

October 2019

Bobby L. Tait (School of Computing, University of South Africa)
Jan H. Kroeze (School of Computing, University of South Africa)

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# FULL PAPERS

# Design Guidelines to Develop E-textbook Readers: A Task-technology Fit Approach

**Full Paper**

**SACLA 2019**



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**Abstract.** Electronic textbooks are gaining traction as the medium of choice in educational institutions across South Africa. The way in which readers engage with e-textbooks differs from the way in which they would read recreational e-books. E-textbook functionalities should assist readers with the construction of new knowledge and skills. These functionalities are not embedded in the e-book itself, but rather in the e-book reader software used to read the e-book. The task-technology fit (TTF) theory was used as a theoretical framework for the paper and semi-structured interviews were performed to collect data from secondary school learners. The aim was to determine the tasks required by learners when using an e-textbook, and consequently the functions which e-readers should contain to support these tasks. A set of guidelines is proposed which e-textbook reader developers could use to ensure the reader applications which they develop deliver a good fit to the task requirements of its users.

**Keywords:** E-book, E-textbook Reader, TTF Theory.

## 1 Introduction and Problem Statement

### 1.1 Background

The use of e-book reader software has recently been highlighted due to the State of the Nation address in which President Cyril Ramaphosa stated that the South African Government "will over the next six years, provide every school child in South Africa with digital workbooks and textbooks on a tablet device" [1].

E-books are already gaining traction as the medium of choice in educational institutions across South Africa, replacing traditional printed textbooks in both private and public schools. An e-book can be defined as a "digital object with textual and/or other content, which arises as a result of integrating the familiar concept of a book with

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features that can be provided in an electronic environment" [2]. Three components are required to read an e-book: the e-reader hardware, the e-reader software and the e-book file [3]. The hardware refers to the device that displays the e-book. This can be a dedicated e-reader such as the Amazon Kindle, or a multipurpose device such as a desktop PC. The software is the application running on the hardware that renders the e-book to display on the device. This application typically offers more functionality than simply rendering the book content such as highlights, annotations and printing. The e-book file is the content of the book stored in a format the application can depict.

The use of electronic textbooks (e-textbooks) is different from that of recreational e-books as readers engage with these e-books in a different manner. E-textbooks should focus on the "additional goals of learning, even memorizing portions of the text" [4], where fictional e-books are purely read for pleasure. The difference in usage can be observed in the basic functionality of the e-book such as navigation, where readers typically do not navigate e-textbooks in the same linear fashion as they would in recreational e-books [5] or in more advanced features such as highlighting and making annotations [6]. In order for e-textbooks to be utilized it needs to differentiate itself from a recreational e-book by adding functions that assist readers with the construction of new knowledge and skills [7].

In this paper we report on a study which was done to determine the tasks that secondary school learners perform to construct knowledge, and consequently also on the functions which e-book reader software require to assist them with this process. A well-known information systems usability theory, the task-technology fit (TTF) theory was used as a theoretical framework for the paper and individual interviews were performed to collect data from secondary school learners who have been using a specific e-textbook reader for at least six months.

The paper contributes to the literature on the utilization and usability of e-books, and more specifically e-textbooks in the field of digital learning, by providing a set of design guidelines which e-textbook reader developers could use to ensure the reader applications which they develop deliver a good fit to the task requirements of its users.

## 2 Literature Review

### 2.1 E-books and E-textbooks

E-books can be defined as electronic files which are roughly the length of a book, contain words and images, and are formatted to be viewed on electronic devices referred to as e-book readers [8].

Vassiliou and Rowley [9] suggested the following two-part definition for an e-book as many previous definitions had become outdated or were only focusing on a specific platform or technology:

1. “An e-book is a digital object with textual and/or other content, which arises because of integrating the familiar concept of a book with features that can be provided in an electronic environment. “
2. “E-books typically have in-use features such as search and cross reference functions, hypertext links, bookmarks, annotations, highlights, multimedia objects and interactive tools.”

E-textbooks are considered a variant of e-books [4] and are read in a different way than recreational e-books. The latter are read in a linear narrative structure, whereas e-textbooks typically follow a hierarchical structure [5, 10].

In order for e-textbooks to be utilized, it needs to have functions that assist readers with the construction of new knowledge and skills [7]. These functions are usually not embedded in the e-textbook itself, but rather in the e-textbook reader which is used to read the e-textbook.

### 2.2 The Task-Technology Fit (TTF) Theory

The TTF theory aims to provide a model that can be used to explain the utilization of a given computer system. To explain utilization, TTF finds the relationship between task requirements and technology characteristics. The model was introduced by Goodhue and Thompson [11] as a means to describe the impact of the relationship between tasks and technology on user performance.

The higher the TTF, the better performance by users [11, 12]. Similarly, the use of information systems will be high if the task fit for that system is high [11]. The need for TTF arose out of the lack of a theoretical basis in traditional user evaluations [13].

TTF forms part of the technology-to-performance chain (TPC) [11] which investigates how individual performance is impacted by technology. In addition, the TPC builds upon earlier work by DeLone and McLean [14] on the Information Systems Success theory.

The TTF theory has been widely used by researchers in both Information Science and other disciplines [15] and TTF is also one of the most used theories in predicting individual performance in Information Systems research. It has in this regard been used as the framework of choice for this research and by various other authors [12, 16-19].

### 2.3 TTF and E-reader Fit

The TTF model focuses on the ability of a system (e-reader) to match the tasks users (learners) need to perform using that system [11]. A high TTF will result in a greater performance impact and greater usage of the system.

D’Amra, Wilson and Akter [18] used the TTF model to evaluate the adoption of e-books by academics and to determine how it is influenced by its fit and performance.

They consequently provided an e-book TTF construct which could be used to evaluate academic task fit and confirm the hypothesis that task, technology and individual characteristics influence the use and performance of e-books in an academic setting.

As educational applications are tools that individuals (learners) use to complete certain tasks (studying, assessment etc.) it can be evaluated using TTF. This will require the authors to present a set of scales of measures designed for this specific audience. TTF has also been used by other authors to evaluate e-learning systems. In one such an example, the TTF was measured for two user types (instructors and students) in a tertiary learning environment by using a questionnaire [20]. Another study investigated the relationship between perceived fit and the continued utilization of an e-learning system in a blended learning environment [21].

### 2.4 Educational Tasks

Although this research is not focused on the educational outcomes (performance impacts) of e-books but rather on the utilization thereof, it is worth mentioning two categories of educational tasks namely cognitive and metacognitive activities. The tasks learners execute while using the e-book reader, fit into one of these two categories and, as discussed below, can have a direct or indirect impact on learning. The categorization of tasks in the educational environment is important when identifying the task characteristics to ensure non-educational tasks do not form part of the evaluation. For the sake of consistency with the TTF theoretical framework, activities will be referred to as tasks.

### 2.5 Cognitive Tasks

Cognitive processing tasks are the tasks learners execute that lead directly to learning and understanding [22]. These tasks assist learners in becoming more skillful or knowledgeable in a subject or topic. Examples of such tasks include thinking of examples that match a piece of theory; or establishing relationships between entities in the subject.

### 2.6 Metacognitive Tasks

Metacognitive regulation tasks regulate the cognitive learning tasks which in turn indirectly lead to learning results [22]. Metacognitive tasks can include identifying difficulties while studying for a subject by doing self-assessments; or by having greater control over the learning environment. Learners who have a greater control over their learning environment have been found more able to easily execute their cognitive tasks [23]. Metacognitive tasks were found to be an influencer of the perceived usability (utility) and satisfaction of e-learning platforms [24].

## 3 Research Design

The research was operationalized through an interpretive exploratory case study. The use of a single e-textbook reader, the EduReader[1], was investigated at three different schools. The EduReader is an interactive e-reader that was developed specifically for educational use. The e-reader was developed by EduCorp[2], a company based in Pretoria, South Africa. EduReader can be used to read the two most popular e-book formats, EPUB and PDF. The app is downloadable for free on Windows Store, Google Play Store and the Apple App store. The EduReader application is currently used by more than 80 000 users from a variety of primary, secondary, tertiary and corporate education environments.

To understand the functionalities offered by the EduReader, one of the researchers downloaded the EduReader for iOS and purchased a couple of textbooks in both EPUB and PDF format. He consequently played the role of an expert evaluator while identifying the technological characteristics contained within the EduReader e-book application. Furthermore, the technological characteristics of e-readers as reported on in existing literature, was also investigated.

In addition, to determine the task characteristics required by the user of the EduReader, qualitative data was collected by means of semi-structured individual interviews as it allows the interviewer to focus on the topics while still having an open conversation [25]. Participants were presented primarily with open-ended questions which assisted in identifying their attitudes and preferences when using e-textbooks [26]. This method was chosen as it allows the interviewer to rephrase or clarify questions to enable a better understanding by the interviewee [27].

In order to prevent the introduction of bias, the interviewer asked the respondents to describe the daily tasks they perform within the e-reader application rather than validating predetermined assumptions on what they used the e-textbook application for. Due to the exploratory nature of this research, no predefined tasks were mentioned to the participants during the interviews. This is different from quantitative studies reported on in literature where statistical data was collected on a predefined set of tasks identified by the researchers in each case [13, 28, 29].

During the interviews, the researcher maintained a neutral stance to all responses provided by the interviewees. The script was followed as closely as possible but, in some cases, where the researcher felt more details could be provided the script was adapted real-time to explore certain topics more deeply. Interviewees were given

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[1] The name of the e-textbook reader has been pseudonymized to protect the identity of the company that developed it.

[2] The name the company who implemented the e-book reader software has been pseudonymized to protect the company's identity.

sufficient time to provide responses, and when they misunderstood a question the researcher provided further explanations in a non-guiding way, in most cases avoiding the need to provide examples.

The data collected by the interviews appear to be of sufficient quality to draw conclusions from. Tests for construct validity [30] by comparing interview data to previous studies provided positive results. Tasks identified by interviewees matched those identified by previous research done on the subject [31-35]. The data saturation point can be described as the point in the interview process where no new themes, concepts or problems are identified in the data [36]. The number of interviews done proved sufficient as the saturation point appeared to be reached in the second last interview.

Kitchenham and Pfleeger [37] define the target population as individuals that are capable of answering the questions presented to them and individuals to whom the outcomes of the research are applicable. The target population for this research was South African secondary school learners, aged between 15 and 17 that have used the EduReader application in an educational environment for at least two school terms i.e. for more or less 6 months.

Due to the time and resources required to gather responses from the entire population, a sample that represents the population was determined. A small element of convenience sampling was also introduced as learners were only selected from schools in Gauteng, the researcher's geographic location. The geographic location should though not have a significant influence on the findings as all the learners who make use of the EduReader live in relatively similar socio-economic conditions in South Africa.

For ethical reasons the names of the schools where the learners were interviewed were also pseudonymized.

To match the population characteristics, learners were chosen from schools that match the following criteria:
using the EduReader reader for at least six months
in grade nine, ten or eleven (aged 15 – 17)
use the EduReader in class

Three schools were identified and contacted regarding the research. For each of these, the principal agreed that the researcher could interview five learners, thus a sample size of 15 was determined.

## 4 Data Analysis

The interviews were recorded with the permission of both the interviewee and the interviewee's parents. The recorded data was transcribed in MS Word documents - a single interview per document. The documents were then coded to identify themes across all the documents. Coding is the process of assigning labels symbolising some meaning to parts of the text [36]. First cycle coding is the first method of discovery

which the researcher uses to start assigning a deeper meaning to the data collected. Due to this discovery process, there was no pre-defined list of codes. As new themes had emerged from the data, new codes were added, and previous interviews were revisited and recoded using the new coding list.

Two coding processes were used as a form of hybrid coding. Process coding uses gerunds, or words ending in -ing as its labels, for example 'highlighting' or 'note taking'[38] and was used to identify all the actions in the interview data. These actions were the tasks which the learners performed on their e-book readers. The next coding process used was descriptive coding. Descriptive coding (also known as topic coding) labels sections of data as a short phrase or a single word [38]. The descriptive codes were assigned primarily to index the themes and the categories which arose from the data. All coding was done using the popular free application called QDA Miner lite.

# 5 Discussion

## 5.1 The Technology Characteristics of the EduReader E-book Reader Software

The functionalities available in the EduReader application will now be discussed. Unless specified, each function is available in both supported e-book formats (EPUB and PDF).

### Annotations and Highlights

Users can create notes, sketches and highlights in the EduReader reader. Different e-book formats have different ways to create these annotations though. Due to the reflowable nature of an EPUB, annotations cannot be created on the page, and are rather added to the right-hand margin of the book, attaching itself to an element within the EPUB to keep its location. A note is created by long-tapping a piece of text in the e-book and selecting 'Add note' from the pop-up menu. The notes created can only contain plain text, with no formatting such as colors, font-size or font-styles available. Once the note is created, the user can access it by swiping from right to left or clicking on the menu icon in the top right corner. Highlights are created by selecting the highlighting too from the toolbar on top of the book views. There are six predefined colour choices available for highlights as well as an eraser option to erase existing highlights. When making a highlight the user has the ability to undo the last couple of highlights.

The EduReader offers a drawing functionality to its users for both PDF and EPUB formats, albeit a difference between the two formats. For PDFs with static, non-reflowable content, users can draw directly on the PDF page. Due to the reflowable nature of the EPUB format, users are not able to draw directly on the e-book. The added

sketch is saved in the right-hand margin and keeps its vertical position even after the page is resized. The user cannot see the sketch and the page content at the same time.

**Additional Resources**
Content such as videos, images, URLs and assessments can be delivered to the EduReader application by educators through a push service. The educator uses a separate application to add content to parts of the e-book, similar to the way a learner will add a note. This content is then delivered to all learners in that educator's class and is also shown in the right-hand margin, alongside the learner's own content and annotations.

**Summaries**
The EduReader combines all annotations and additional resources into a digital summary. The summary allows users to show or hide notes, headings, and highlights based on colour. This summary can then be downloaded as a PDF to print and use for studying.

**Navigation**
The EduReader application offers several methods of navigating an e-book. All e-books offer a table of contents which contains a collection of hyperlinks, linking to the start of a section or page [39]. The table of contents is accessible from anywhere in the book by opening the left-hand drawer. This is done by clicking on the menu icon in the top right corner or swiping right with your finger or pointing device. The EduReader offers a table of contents search, which hides all options in the table of contents that does not match the search term entered.

Users can also search for a term throughout the book. While reading the book, a search icon in the top toolbar opens a search box. Terms entered in this search box are matching with content throughout the e-book. A list of each occurrence of the search term, including some context text and the page number is returned and displayed to the user.

If a user prefers to navigate directly to a page instead of a chapter or piece of text, the application has a page number selector within the book view. Users can navigate page numbers by clicking on the next or previous buttons in the bottom toolbar or by clicking on the page number itself. When clicking on the page number, a toolbox opens which allows the user to enter a page number manually. Unfortunately, page numbers do not always match the printed book, especially in the EPUB format, where reflowable content makes traditional navigation difficult. PDFs generally use the same page numbers as the printed book.

## 5.2 The Task Characteristics of the E-book Reader Software in an Educational Environment

From the interviews, it was apparent that learners use their devices for more than the e-book reader software and will tailor their usage to a unique style that fits them. The

same goes for the way in which they use e-books [35]. Throughout the responses, there was no clear pattern in the daily tasks they performed with the EduReader, with some interviewees making highlights, others making notes and others not making any annotations.

As discussed earlier, the EduReader allows educators to add additional resources to the learners' e-books. This functionality enables an enhanced version of the e-book, where relevant content such as videos and other documents are readily available within the application. Interviewees mentioned that educators add homework assignments to their e-books in the same way, instead of printing or delivering it via some other application.

A number of interviewees expected the e-textbooks to behave like a normal textbook, with a specific reference to navigation. They also expect the e-textbook should also contain all the content that the printed textbook does.

The interviewees also expected the EduReader to be stable. Printed books do not "crash", "glitch" or "freeze" and respondents expected the same stability from e-textbooks.

Highlighting is the functionality that the interviewees mentioned most and appears to have the largest positive impact on learning performance. This can be attributed to the aid highlighting provides in comprehending text [40].

An unexpected theme that emerged from the highlighting question was the temporary state of highlights and annotations in e-books, where learners can erase highlights from e-books unlike from printed books where once the highlight it made, it is permanent. This was not a common discussion in the literature studied on the subject.

Navigation in e-books can consist of browsing (paging), looking at the table of contents, searching and using the index [39]. It is important that e-books offer a variety of different navigation methods as learners will have different preferences and navigation should never intervene with the e-book's primary goal of studying.

Traditionally, e-books, especially those in the EPUB format offered no page numbers and this raised serious issues in studies done on e-books in the American K-12 education system [40]. A possible explanation for this was the technical difficulties attaching page numbers to reflowable content [39] as found in the EPUB format. The EduReader features page numbers in all of its e-books, even when the publisher did not create the e-book with page numbers. This feature drew positive responses from the interviewees, even though the page numbers do not always match the printed textbook.

As all e-book content and resources are backed up throughout the day by the EduReader application, an account is easily recoverable when a learner loses his/her device. Interviewees mentioned that this accessibility offered by the e-reader presents an advantage over printed textbooks, where if it was lost or damaged, you would need to recreate all your annotations.

Digital summaries, where the e-reader takes the collection of annotations created by the learner and automatically summarizes it into a single view, saves the learners' time when doing preparation for tests and exams. The annotations, resources and e-books are all shared across the learner's devices, which means that they can use a tablet or notebook at school to save space, and at home they can make use of a desktop PC with a larger screen and more ergonomic keyboard and mouse.

A number of e-textbook task characteristics were identified. These task characteristics were not listed in a single interview question and many of the characteristics came forward as part of discussions on other topics regarding the e-textbook reader. This is an advantage of having the task characteristics emerge from qualitative data, rather than quantitative data, where the number of tasks identified could have been limited.

The following task characteristics emerged from analyzing the interviews discussed above.

**Making Annotations**
Interviewees listed "looking over the notes" and making notes as some of the typical daily tasks they execute with the EduReader. The notes are then backed up and "allows you to keep your notes everywhere, so if your book is lost for whatever reason, you still have your notes". Interviewees expected the e-book reader software to "make it easier to make notes" and the functionality to be available at all times.

**Creating Highlights**
Interviewees mentioned highlighting as one of the major functionalities that e-books offer which improves their learning experience. One interviewee commented on the e-book highlighting functionality, which allows for multiple colors that "I love having color in my books. It helps me learn". Highlighting in e-books has its advantages over its printed counterparts, especially when a user "highlights something accidentally in the e-book", as "you can erase it".

**Reading Aloud**
The EduReader does not have any form of read-aloud support. One interviewee requested a read-aloud functionality as the feature she would want to be added to the EduReader as it would allow her to "make physical notes while listening to (my) textbooks". The lack of interest in the read-aloud functionality may be related to the lack of exposure to this functionality due to the feature not being implemented in the EduReader, and it being the only e-reader used by the majority of interviewees. The interviewee who requesting this feature is one of only a few interviewees that has some experience with other e-readers, and in this case with the Amazon Kindle application which has the reading aloud functionality.

**Additional Resources**
Interviewees identified the purpose of additional resources and mentioned that "teachers are also able to send you things that you need that is not in the book". The

additional resources assisted in filling the gaps in the learner's knowledge where educators "send us presentations and extra notes when we don't understand it".

The delivery of these additional resources can add strain to the institution's network infrastructure where a sudden increase in traffic can cause sluggishness and slow delivery times. Interviewees found it problematic when an educator "send us our tasks, our newspaper or answers for an activity and you cannot receive it" and when the e-book reader software "doesn't receive your resources the first time". It was not possible to determine the exact cause of the resource delivery problems from the interviews as further investigation will require technical expertise. It is problematic, however, that functionality intended to ease a burden on learners is causing issues for the learners.

**Navigation**

Navigating an e-book can be cumbersome to a user if the e-book does not offer the ability to browse content [39]. To make up for this lack of functionality, e-book reader software offers the user additional functionality to aid in navigation. A well-structured table of contents with working hyperlinks to the correct section in the book "allows you to go through all of the things in the textbook" and enables the user to "just click on the option and it takes you directly to what you want to do". An e-book usability study targeting medical academics in Australia stated that academics consider index and contents page browsing some of the most important functionalities of an e-book [41]. Interviewees did not mention any negative aspects towards the table of contents navigation of the EduReader and complimented "the chapters listed on the slide to the left of the tablet".

Page numbers have traditionally been a problem in e-books, especially reflowable EPUB e-books [39]. As discussed earlier in this paper, the EduReader attempts to solve this by linking page numbers to anchors within the e-book content. The functionality included by the EduReader makes navigating through the e-book using page numbers easy and interviewees commended the ability to just "type a number of the page". "You don't have to swipe through, or page through to find a page".

**Dictionary**

The EduReader offers two types of dictionary integration within the e-books. Firstly, it provides learners with the native platform dictionary. This was perceived as favorable by the interviewees as "you can also directly click on a definition of the word. It gives you direct access and it's quick."

**Searching**

At the time of the interviews, full-text search was a newly released feature of the EduReader, and only one interviewee had experience using it. The feature seemed to be well received with the interviewee stating that "there's a lovely little search function so if I'm looking for one specific thing in the book I don't have to flip through pages and pages looking for it".

**Assessments and Activities**

In the printed textbook environment, activities or assessments are normally completed in an additional workbook or notebook, as printed textbooks are owned by the school and given back at the end of the year. E-books offer students the ability to complete activities such as these in their books with no fear of damaging or losing the textbook. “Answering the questions using the textbook” was one of the common daily tasks mentioned by the interviewees.

Another advantage of e-books is the shorter feedback loop which reduces the time within which a learner gets feedback on his/her assessment. Except for essay type questions, most question types can be marked by the e-reader and feedback can be provided. Although the EduReader platform offers this functionality, interviewees still requested that if they could “do activities on the tablet and then it marks it for us, it would be very useful”.

**Making Summaries**

Creating electronic summaries from annotations in the e-book has not been discussed in previous literature. Generating summaries is a well-used studying tool exercised extensively while studying using both e-books and printed textbooks. While highlighting and note taking are tools offered by e-book reader software for educational use, these features are just as commonly used for non-educational purposes such as highlighting an inspirational quote in a biography or making a to-do list in a self-help book.

The electronic summary functionality of the EduReader summarises these highlights and annotations for educational use. Although summaries are not a common feature in e-book reader software, interviewees saw the value of it with one interviewee commenting that “the way that you can sum up all your work on one small thing… that makes everything easier.” It was not clear from the responses whether the interviewees would prefer to rather use another application such as a word processor to create the summaries, but being able to copy large parts of the textbook may have certain legal implications with one interviewee realizing “we are not allowed to because it's got copyright”.

**Referencing**

Internal referencing has not been given much attention by the EduReader application, with simple functionality such as bookmarks not present. This functionality is an important factor for the academic use of e-books [41], but the functionality was only mentioned by one or two interviewees, indicating that it might not be such an important feature for the school level use of e-books. One interviewee mentioned that the e-book “has a glossary so if I don't know a word, I can quickly go to the glossary and figure out stuff”.

External referencing was widely used by the interviewees and learners would “sometimes use the Internet because my e-book reader software would not have the complete information that I’m looking for. So, I'd usually just go onto the Internet and when I get the relevant information, I'd go back to my e-book to access the questions”.

The clear advantage e-books hold over printed textbooks is the time it takes to do external referencing. Google was the only service specifically mentioned by interviewees for referencing use and interviewees indicated that they frequently swapped between the e-book reader software and Google while working in their e-book.

**Recording Voice Notes**

To make up for the inability of electronic textbooks to be laid out across a table and seen as a big picture, interviewees use other features of the devices. Voice recordings offer learners an additional layer of note taking which can be played back while studying or revising for a test. “I memorize it and repeat what I learn. I record it, so when I'm at school, I listen to it on my earphones and then it just goes through my head”. Recording the notes, a learner repeats to herself is much quicker than typing the notes using a tablet and is not limiting in terms of physical space as another interviewee mentioned that “you can make voice notes and you can listen to them anywhere”.

### 5.3 Guidelines for E-textbook Reader Designers/Developers

On matching the EduReader’s functionalities with the task characteristics required by the EduReader users, it is possible to provide a set of guidelines for e-book reader software developers to ensure the app they are developing delivers a good fit to the task requirements of users. Table 1 presents a set of e-book reader software developers’ guidelines. The guidelines are formulated as a set of statements representing the characteristics of the educational tasks, which need to be supported by the technology (the e-book reader software/application) to achieve a good fit between the tasks and the technology. The task category describes the type of task as discussed in section 2.4 of this paper.

**Table 1.** A set of development guidelines for e-book reader software developers/designers.

| E-Book Reader Software Tasks | Task Category | True | False |
|---|---|---|---|
| **Making Annotations** | | | |
| Users can make textual annotations in their e-books. | Metacognitive | | |
| Users can make freehand (drawing) annotations in their e-books. | Metacognitive | | |
| Annotations are synced across all devices the user is signed in to. | Metacognitive | | |
| User annotations are visible while browsing the e-book. | Metacognitive | | |
| **Creating Highlights** | | | |
| Users can create highlights in their e-books. | Metacognitive | | |
| Users can create highlights in multiple colours in their e-books. | Metacognitive | | |

| | | | |
|---|---|---|---|
| Users can erase highlights made in their e-books. | Metacognitive | | |
| **Reading Aloud** | | | |
| The e-reader can read sections of the book aloud. | Metacognitive | | |
| **Additional Resources** | | | |
| Educators can share additional content with users in a specific location of the e-book. | Metacognitive | | |
| Users are notified when new content has been shared with them by the educator. | Metacognitive | | |
| Users can copy text and images from the textbook to use in other applications such as word processors. | Metacognitive | | |
| **Navigation** | | | |
| The e-reader offers TOC navigation. | Metacognitive | | |
| The e-reader supports page numbers and users can navigate using page numbers. | Metacognitive | | |
| **Dictionary** | | | |
| Users can look up the definition of a word without the need to use another application. | Metacognitive | | |
| Users can define a word quickly by selecting the word in text and tapping define. | Metacognitive | | |
| Definitions provided by the dictionary are context and region dependent. | Metacognitive | | |
| **Searching** | | | |
| The e-reader has an in-book search functionality that performs a full text search across all the pages of the book. | Metacognitive | | |
| Users can search within the TOC to filter sections within the e-book that does not match the search phrase. | Metacognitive | | |
| Users can search application wide within the e-reader to find books and content that matches the search phrase. | Metacognitive | | |
| **Assessments and Activities** | | | |
| The e-reader offers the ability for users to complete assessments within the application. | Cognitive | | |
| The assessments in the e-book have a self-marking functionality to provide real-time feedback on student answers. | Cognitive | | |
| The e-reader supports common learning object formats which allow e-book publishers to add their own in-line assessments to e-books. | Cognitive | | |
| Educators can provide assessment feedback to users and the feedback is delivered by the e-reader. | Cognitive | | |
| **Making Summaries** | | | |
| The e-book reader software can create summaries based on the user's annotations and highlights. | Cognitive | | |
| Users can edit these summaries after summary generation to add additional notes and content. | Cognitive | | |
| The summaries are correctly formatted and readable within the e-reader. | Cognitive | | |
| The summaries are printable by the user. | Cognitive | | |
| **Referencing** | | | |
| Users can use external search tools such as Google Scholar within the e-book reader software. | Metacognitive | | |

| | | | |
|---|---|---|---|
| Users can generate references from the e-book they are working with to use in assignments. | Metacognitive | | |
| **Recording Voice Notes** | | | |
| Voice notes can be created by the user and added to sections of the e-book. | Cognitive | | |

## 6 Conclusion

The purpose of this paper was to identify the task requirements of e-book reader software in the South African secondary education environment. For fit to be determined between a technology such as an e-book reader and the actions users want to perform with it, an accurate representation of these actions, namely the task requirements, should exist. The TTF theory was used as a methodological framework to provide a model that can be used to explain the utilization of a given computer system.

As the TTF model can be employed to explain utilization, the use of these task requirements as a component of the task-technology fit model can help researchers and developers determine the fit of the e-book reader software to the task requirements.

The task requirements presented in this paper can be reused by researchers to determine the task-technology fit of other e-book reader software in South African secondary schools. These requirements can also be validated in other countries by determining the task requirements for those schools and comparing it to this set. Opportunities for research exist in determining the evolution of task requirements for learners throughout their educational career by comparing primary school learners to secondary and tertiary learners.

As a practical contribution, this paper presents a set of task-technology fit task requirements that e-book developers/designers can consider when developing e-book reader software for the South African secondary school market sector.

In conclusion, for e-book reader software to be utilized in South African secondary schools, it needs to fit the task requirements of the learners. This paper identified those task requirements and presented them here. E-book reader software developers/designers who wish to achieve high levels of utilization should keep these task requirements in mind when developing an e-book reader application. Future research could contribute to the confirmation and or enhancement of these guidelines and could be done exploring a different e-book reader application used for educational purposes.

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# Innovation for Computing Students Matters, of Course!

**Full Paper**

**SACLA 2019**



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**Abstract.** Literature identifies enablers promoting Innovative Behavior (IB) among employees. Modelling motivation, metacognition and affective aspects of learning towards developing IB among Information Systems (IS) and Information Technology (IT) Higher Education Institution (HEI) students is, however, not well-understood. The study objectives included addressing this literature gap by examining how motivation, metacognition and affective aspects of Self-Directed Learning (SDL) act as antecedents of IB via Knowledge Sharing Behavior (KSB). A quantitative cross-sectional survey was employed with 268 students enrolled in IS and IT programs, from seven Kenyan public HEIs. Data collected using a questionnaire, with a 2,000-bootstrap sample generated direct and indirect effects. Findings are summated in a structural equation model for students in an educational context, largely supporting all hypotheses. Findings also revealed that SDL acted as a driver of KSB and IB among IS and IT students. Implications for HEI managers include leveraging attributes of IB antecedents in learning con- texts.

**Keywords:** Self-Directed Learning, Innovation, Motivation, Metacognition, Affective Aspects.

## 1 Introduction

With Schuh, Zhang, Morgeson, Tian and Van Dick [1] pointing out that organizations are increasingly depending on employees' efforts towards innovation, research has identified several individual and contextual level factors that promote Innovative Behavior (IB) among employees. However, the effect of Self-Directed Learning (SDL), Course Design Characteristics (CDC) and Knowledge Sharing Behavior (KSB) in facilitating the development of innovative behavior among Information Technology (IT) students at Higher Education Institutions (HEIs) is not well understood. Most of the existing literature, correlating knowledge-sharing behavior with innovative

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behavior, however, focus on employee innovation and has limited applicability to students [2].

In terms of the determinants of students' innovation in higher education, Martín, Potočnik and Fras [3] view university education in the changing environment of computer technologies [4] as engines driving countries' growth and development, as innovation is being nurtured, and university students as the employees of tomorrow; as such, they are a major source of future innovation in organizational settings. Consequently, it is of interest to society to establish what happens within the confines of university education, as it plays a crucial role in molding and shaping students' innovative behavior.

Based on the aforementioned, the purpose of the study reported on in this paper was to develop a Structural Equation Model (SEM) of the individual and contextual drivers of innovative behavior among Information Systems and Information Technology students.

## 2 Innovative Behaviour

In terms of the research context represented by the study reported on in this paper, Foster and Heeks [5] analyzed the policy for inclusive innovation with regard to the mobile sector and base-of-the-pyramid markets in Kenya. Other on-going initiatives reported on by Kinyanjui and Spooner [6] included young innovators in Africa, who have formed technology incubators and co-working spaces, such as the iHub in Kenya.

In a qualitative study, drawing from social cognition perspectives within a constructivist paradigm, Schuh, et al. [1] shared the inter-active effects of employee Innovative Work Behavior (IWB) and leader-member exchange on performance rating, and found that these "may affect the recognition that employees receive for their innovative work behaviors." In the context of team performance management, Agarwal [7] examined the role of work engagement, together with the impact of social exchange relationships, on innovative work behavior.

In a related context, Bysted [8] investigated the moderating effects of mental involvement and job satisfaction on contextual variables related to innovative employee behavior, while Liu, Hodgson and Lord [9] explored the role of culture in e-learning against the background of innovation in construction education. Finally, Duff [10] observed multiple effects related to innovative behavior in a multi-source field study, whereas, in terms of design methods, Kumar [11], followed a structured approach to driving innovation in an organization.

# 3 Self-Directed Learning

Boekaerts, Pintrich, and Zeidner [12] pointed out that self-regulation involves affective, behavioral, cognitive and motivational components, which provide individuals with capacities towards adjusting their goals and actions towards achieving desired results in terms of changing environmental conditions. In their introductory review on the psychology of self-regulation, Forgas, Baumeister and Tice [13] also referred to affective, cognitive and motivational processes.

The contextual environment of Information Technology students provides them with high levels of autonomy and self-directed activities in the design of new technological solutions, during their project work. This autonomy requires the technology student to exercise a level of self-control in managing their project work and their work environment. Consequently, and similar to some aspects of that of O'Shea [14], this study places the focus on how undergraduate Information Systems and Information Technology students, as early-stage entrepreneurs, engage with and integrate their cognitive, emotional and motivational self-regulatory processes to continually aid, enhance, promote and support the success of" their ventures or innovative behavior [15, p. 118].

While Zimmerman, Boekaerts, Pintrich and Zeidner [16] provided a social cognitive perspective in their handbook of self-regulation, Zimmerman and Schunk [17] looked at the roles of theory, research and practice in self-regulated learning and academic achievement.

In an open and distance education context, Idrus [18] studied technological innovation towards adult self-directed learning in the off-campus academic program at the Universiti Sains Malaysia, whereas Fink [19] provided a self-directed guide to designing courses for significant learning.

## 3.1 Self-Directed Learning and Innovative Behavior

This paper further extends on modelling motivation, metacognition and affective aspects of learning towards smart innovation for IS and IT students [20].

In the context of management education and challenges for staff development, according to Broos [21], an important part of learning to learn is the ability to self-direct learning. Piskurich [22] looked at fostering self-directed learning in the context of a medical school, when curricular innovation was not enough. In terms of innovation in dental education, Hendricson, et al. [23] probed educational strategies associated with development of problem-solving, critical thinking and self-directed learning. Gabrielle, Guglielmino and Guglielmino [24] developed the self-directed learning readiness of future leaders in a military college through instructional innovation.

Chang [25] examined the organizational innovation environment, self-directed learning, course design strategies, technology factors and the performance of Web-based training, while Jen-Obrom [26] explored self-directed learning in the context of innovation for teaching and learning. In the context of teacher education and, more specifically, the Bologna Process, Kazlauskiene, Masiliauskiene, Gaucaite and Poceviciene [27] considered the organization of self-directed learning as educational innovation.

In the keynote presentation at the Asia-Pacific Educational Research Association conference, Mok [28] therefore interrogated self-directed learning-oriented assessment in terms of evolution and innovation, towards assessing to what extent students can engage with relevant possibilities in this regard [29].

In a book chapter on situated, self-directed knowing and learning in the Vocational Education and Training system, Falk and Surata [30] scrutinized the borderlands, where innovation and future directions meet the performativity of vocational learning.

For introducing self-directed learning in an innovation-friendly institutional context, the setting of the experiment conducted by Bailly and Carette [31] was that of the "French Department for Foreign Students" (DEFLE), which "is an old department of the University of Nancy, originally designed for the training of foreign students to prepare them to study a wide range of subjects.

In a synthesis of biology, innovation and education, Gadapati, Zhou and Huang [32] facilitated self-directed learning by providing first and second year students with an early research experience.

The purpose of the study by Sassiru [33] was the development of effective web-based learning/online lessons for Fundamental Marketing courses. To study the self-directed learning achievement of undergraduate students of the College of Social Communication Innovation, Srinakharinwirot University evaluated how efficient and congruent the courses were, with the 80/80 basic marketing curriculum (on which these were based).

## 4 Course Design Characteristics

The construct of course design characteristics was inspired by literature drawn from the field of Human Resource Management (HRM). The course design characteristics was an adaptation of the Work Design Questionnaire (WDQ), formulated by Hackman and Oldham [34]. The WDQ was developed and validated as a comprehensive measure for assessing job design and the nature of work, and later improved by Morgeson and Humphrey [35].

The WDQ scale has been used extensively in literature, and consists of four (4) subscales, namely task and knowledge characteristics, as well as aspects relating to social and work contexts. According to Morgeson and Humphrey [35, p. 1324], the social characteristics included "social support, interdependence, interaction outside the

organization, and feedback from others", while "ergonomics, physical demands and equipment use" constituted the contextual characteristics.

In their more recent article, Parker, Morgeson and Johns [36] a bigger picture perspective was taken on one hundred years of work design research, while Morgeson, Brannick and Levine [37] investigated methods, research, and applications for human resource management in the context of work and job analysis. According to Morgeson, Spitzmuller, Garza and Campion [38], making job analysis judgments had a pivotal role in just about every aspect of Human Resources and was one of several high performance work practices, which were thought to underlie firms' performance. Finally, Battistelli, Montani and Odoardi [39] looked at the impact of feedback from job design and task autonomy in the relationship between dispositional resistance to change and innovative work behavior.

Strategy formulation is critical in guiding the process of course design, including aspects relating to the pedagogy underlying a particular course, as well as how such a course can be adapted [40] towards the end product and learning outcomes already in sight before the course commences. A good teaching strategy helps to organize the sequence of learning activities, with the aim of finding the sequence and combination of learning activities, which work together best towards building high levels of student energy, which could be applied towards the task of learning [30].

In addition, effective course design leads to intended learning having greater meaning, resulting in students being provided with an increased range of technologies towards creating this learning [19]. Further, students get opportunities towards working closely with other students to promote each other's learning. This concept correlates with knowledge sharing as used in this study.

In terms of rethinking teaching and learning in the 21st century, course design characteristics can be implemented towards innovative behavior [41], like when Scott and Cong [42] evaluated course design principles for multimedia learning materials.

When computer lecturers use their institutional learning management system for Information Systems and Information Technology education in the cyber world [43], researchers such as Tabata and Johnsrud [44] can correlate the impact of faculty attitudes toward technology, distance education, and innovative behavior, in the context of research into university education, with course design.

## 5 Knowledge Sharing Behavior

According to Erasmus, Seale and Venter [45, p. 147], champions "engage in knowledge sharing within triad service learning partnerships. However, the" effect of knowledge sharing on the development of such champions needs further exploration. There is, however, ample evidence in literature of studies that have investigated the determinants

of knowledge sharing behavior, including Amayah [46] in a public sector organization, as well as Papadopoulos, Stamati and Nopparuch [47] via employee weblogs. Kamasak and Bulutlar [48] identified knowledge-sharing behavior enablers and analyzed the influence of knowledge-sharing behavior processes on innovation performance on Spanish innovative firms. Studies having used Harman's single-factor test with knowledge-sharing behavior include Akram, Lei, Haider, Hussain and Puig [49], who provided empirical evidence from the Chinese telecommunication sector on the effect of organizational justice on knowledge sharing.

Literature like the study by Choi, Kim, Ullah and Kang [50] provided evidence that knowledge sharing significantly mediated how workers' transformational leadership facilitated the dependent variable of innovative behavior in Korean manufacturing firms. Camelo-Ordaz, García-Cruz, Sousa-Ginel and Valle-Cabrera [51] explored the mediating role of affective commitment and the influence of human resource management on the two independent variables of knowledge-sharing behavior and innovative behavior in Spain.

Previous studies like Afsar and Badir [52] also provided empirical evidence on the impacts of person-organisation fit and perceived organisational support, to suggest that knowledge-sharing behavior has mediating effects on innovative work behaviour. In terms of impact, Afsar [2] found that a nurse's person-organization fit was positively correlated with self and doctor ratings of innovative work behaviors, and knowledge-sharing behavior acted as a partial mediator between person-organization fit and innovative work behavior.

Previous studies also found that knowledge-sharing behavior mediated the relationship of various constructs to Individual Innovative Behavior (IIB). For example, Schuh, et al. [1, p. 397] found evidence to suggest that knowledge-sharing behavior moderated the relationship between employee innovative work behavior, perceived organizational support and the related constructs of leader–member exchange and performance ratings. Finally, computer lecturers can use emerging technologies in their course design to promote knowledge-sharing behavior and innovative behavior [53].

# 6 Research Design and Methodology

## 6.1 Population and Sampling

In this study, a population sample of 2000 was created and a 95% confidence interval for the population indirect effect was used to determine statistical significance. Considering the sample size of 249 participants, the moderate sample size problem was eliminated, like Hu and Wang [54], through the use of bootstrapping using Analysis of Moment Structures (AMOS) software.

### 6.2 Instruments Used in the Study

**Measurement of Self-Directed Learning:** The original Motivated Strategies for Learning Questionnaire (MSLQ) scale has two broad components: the motivation and learning strategies subscales, respectively. Usually, the motivation subscale is shown as having three subcomponents, namely value, expectancy, and affective components.

In formed by the manual for the use of the MSLQ from Pintrich, Smith, Garcia and McKeachie [55, p. v], the resource management strategies assumed the following four (4) subscales, namely:

(1) Time and study environment (8 items),
(2) Effort regulation (4 items),
(3) Peer learning (3 items), and
(4) Help seeking (4 items).

This study, however, adopted the remaining part of the cognitive and metacognitive learning strategies subscale of the MSLQ.

Measurement of self-directed learning was with the aid of a revised version of the Pintrich [56] 31-item, motivated strategies for learning questionnaire, which involved multiple goals and pathways, in terms of the role of goal orientation in learning and achievement.

Pintrich et al. [55] provided the reliability coefficients for the motivation scales as 0.68 and for the learning strategies scale as 0.62. For the present study, the reliability scores for the sub-constructs were as indicated in Table 1.

The scales had high reliability scores, which also closely compared to the original 0.62 value provided by Pintrich et al. [55].

**Table 2.** Comparison of reliability coefficients reported in the MSLQ manual and pilot study.

| Scale | No. of Items | α in pilot study | α from MSLQ Manual |
|---|---|---|---|
| Rehearsal | 4 | .695 | .69 |
| Elaboration | 6 | .580 | .76 |
| Organization | 4 | .645 | .64 |
| Critical thinking | 5 | .787 | .80 |
| Metacognitive self-regulation | 12 | . 881 | .79 |

**Measurement of Course Design Characteristics:** For the purpose of measuring course design characteristics, an adaptation of the motivational work characteristics developed by Morgeson and Humphrey [35] was used.

**Measurement of Knowledge Sharing Behavior**: The scale developed and validated by Yi [57] as a measure of knowledge sharing behavior was used in this study.

**Measurement of Innovative Behavior**: The instrument for the measurement of innovative behavior was described in Goosen and Ngugi [41].

In Goosen and Ngugi [58], further details will be provided with regard to especially the pilot study conducted, and how some of the data collection instruments were reduced. In this regard, Fan and Yan [59] provided a systematic review of factors affecting response rates for web surveys, while Morgeson, et al. [38] looked at the liabilities of the respondent experience.

### 6.3 Bootstrapping

Bootstrapping was employed, as it was the most appropriate analytic strategy to test the mediation effect of knowledge sharing. Further, bootstrapping, helps overcome the problem of underestimation of the significance of the mediation effect if the variables have measurement errors. In addition, it allows researchers to assess the stability of parameter estimates and can be applied to overcome the challenges posed by not having a large sample and problems in fulfilling the multivariate normality assumptions. Authors like Açıkgöz and Günsel [60] had applied the bootstrapping method in studies related to the mediating role of team decision processes on individual creativity and team climate in software development projects, with regard to the management of innovation behavior.

### 6.4 Missing Data Analysis

Byrne [61] argued that issues of missing data must be resolved irrespective of the cause of the data being missing. Following the latter author's suggestions with regard to the basic concepts, applications and programming related to structural equation modeling with AMOS software, this research investigated the amount and the pattern of missing data in terms of randomness, in order to find suitable techniques to overcome the problem of missing data.

### 6.5 Ethical Considerations

Since this study involved research into real people, key ethical considerations included privacy issues with regard to anonymity and confidentiality, as suggested by Daymon and Holloway [62] with regard to especially qualitative research methods in public relations and marketing communications.

# 7 Results

As indicated by Goosen and Pieterse [63], courses that speak to and inform students' perceptions of their learning Information Systems and Information Technology in that particular context are more likely to stimulate innovative tendencies than courses that have limited Information Systems and Information Technology feedback. This finding is well corroborated by the available literature [39]. Similarly, the path linking self-directed learning and knowledge-sharing behavior, though significant ($\beta$=.287, $p<.01$), was not very strong, in comparison to the path linking course design characteristics and knowledge-sharing behavior.

As also discussed by Alsaeed [64] in terms of the association between firm-specific characteristics and disclosure for the case of Saudi Arabia, and illustrated in Table 2, Variance Inflation Factors (VIF) values for an explanatory variable greater than 10 posed a problem of multicollinearity with other explanatory variables.

**Table 3.** Collinearity statistics of the driver variables with self-regulated learning as the dependent variable.

| | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|
| | $\beta$ | Std. Error | Beta | | | Tolerance | VIF |
| (Constant) | 2.011 | .433 | | 4.646 | .000 | | |
| Course design characteristics | .528 | .161 | .219 | 3.274 | .001 | .731 | 1.368 |
| Knowledge sharing | .249 | .105 | .190 | 2.362 | .019 | .507 | 1.973 |
| Innovative behavior | .142 | .094 | .118 | 1.520 | .130 | .547 | 1.827 |

By providing for theoretical sagacity, SEM generated indices of error modification, and the resultant suggestion of possible covariation. The resultant measurement model for learning strategies was as indicated in Fig. 1 and the corresponding fit indices in Table 3.

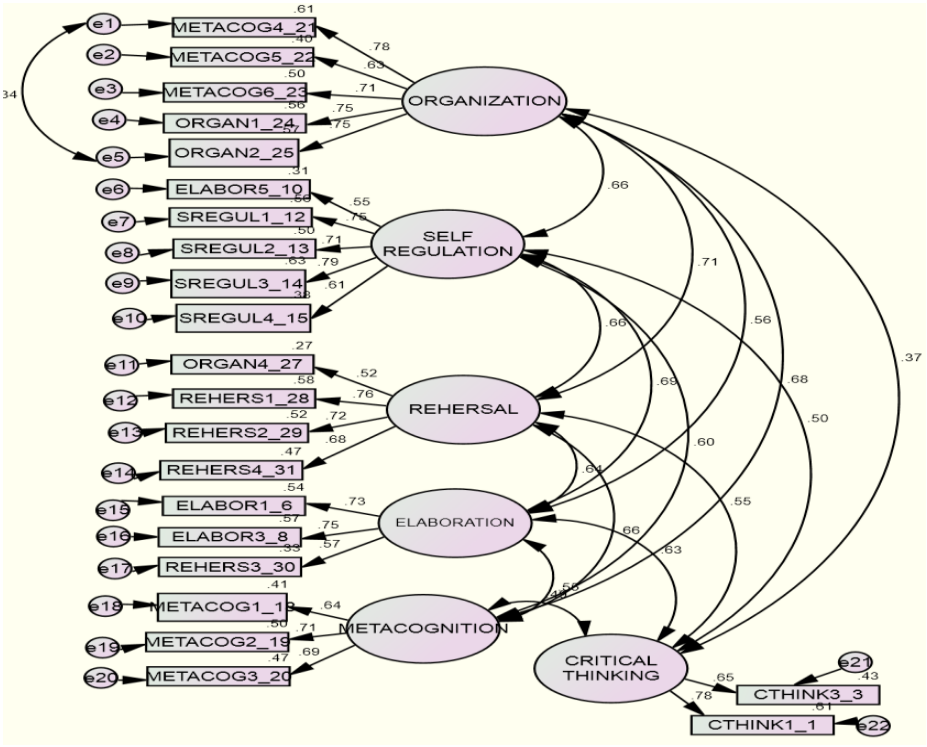


**Fig. 1.** Measurement model and fit indices for self-regulated learning factor solution.

With regard to the Chi-square ($\chi 2$) statistic, the measurement model for the **self-directed learning** construct, as illustrated in Table 3, did not produce acceptable fit, as the $\chi 2$ statistic was significant ($\chi 2$ =362.576, df=193, $p<0.05$). According to Hair, Wolfinbarger, Money, Samouel and Page [65], with regard to the essentials of business research methods, this suggested that the measurement model did not sufficiently explain for the observed covariation among the variables. All the other fit indices supported a good fit with the Tucker-Lewis Index (TLI) above the desired cut-off of 0.90. However, the Comparative Fit Index (CFI), Normed Fit Index (NFI), Goodness-of-Fit Index (GFI), and Adjusted Goodness-of-Fit Index (AGFI) were just below the border line and above 0.85. On the other hand, the Root Mean Square Error of Approximation (RMSEA) and Root Mean Square Residual (RMR) did not meet the recommended levels of 0.08 and 0.10 respectively, as suggested by Kline [66] regarding the principles and practice of structural equation modeling.

With regard to the Chi-square ($\chi 2$) statistic, the measurement model for the **knowledge-sharing behavior** construct, as illustrated in Table 4, did not produce acceptable fit, as the $\chi 2$ statistic was significant ($\chi 2$ =140.381, df=86, $p<0.05$), suggesting that the measurement model did not sufficiently explain the observed

covariation among the variables [65]. All the other fit indices lent credence to a good fit, with GFI, AGFI, TLI, CFI, and NFI surpassing the recommended cut-off point of 0.90. However,

**Table 3.** Measurement model and fit indices for self-regulated learning six (6) factor solution.

| Fit Index | Value |
|---|---|
| Chi-Square Value | 362.576 |
| Degrees of Freedom | 193 |
| P value | .001 |
| CMIN/DF | 1.879 |
| GFI* | .886 |
| AGFI* | .850 |
| RMR* | .148 |
| TLI* | .901 |
| CFI* | .917 |
| NFI* | .841 |
| RMSEA* | .060 |

**Table 4.** Fit indices for knowledge sharing six (6) factor solution.

| Fit Index | Value |
|---|---|
| Chi-Square Value | 140.381 |
| Degrees of Freedom | 86 |
| P value | 0.00 |
| CMIN/DF | 1.632 |
| GFI* | .928 |
| AGFI* | .899 |
| RMR* | .954 |

| | |
|---|---|
| TLI* | .963 |
| CFI* | .910 |
| NFI* | .057 |
| RMSEA* | 0.51 |

the RMSEA and RMR were above the recommended levels of 0.08 and 0.10 respectively as suggested by Kline [66]. Further, the factor loading t-values were all significant. In addition, all reliability and variance extracted measures surpassed the recommended levels of 0.5 [65]. The low value for the item KS.C4 'Share success stories which may benefit the class' resulted in its removal from the model. This may suggest that such sharing of success stories is not a common day-to-day activity among Information Technology students.

With regard to the Chi-square ($\chi 2$) statistic, the measurement model for the innovative behavior construct, as illustrated in Table 5, did not produce acceptable fit, as the $\chi 2$ statistic was significant ($\chi 2$ =52.568, df=18, $p<0.00$), suggesting that the measurement model did not sufficiently explain the observed covariation among the variables [65]. All the other fit indices lent credence to a good fit with GFI, TLI, CFI, and NFI surpassing the recommended cut-off point of 0.90. On the other hand, the RMR was below the recommended levels of 0.10 as suggested by Kline [66]. However, the RMSEA was slightly above the recommended value of 0.08. Further, the factor loadings t-values were all significant. In addition, all reliability and variance measures extracted surpassed the level of 0.5 [65] – these were as had been recommended by Bagozzi, Yi and Nassen [67] in their review of approaches and extension to three-facet designs, as these relate to the representation of measurement error in marketing variables, as well as Fornell and Larcker [68] for evaluating structural equation models with unobservable variables and/or measurement errors.

**Table 5.** Fit indices for innovative behavior scale solution.

| Fit Index | Value |
|---|---|
| Chi-Square Value | 52.568 |
| Degrees of Freedom | 18 |
| P value | .000 |
| CMIN/DF | 2.920 |
| GFI* | .945 |
| AGFI* | .891 |

| | |
|---|---|
| RMR* | .922 |
| TLI* | .950 |
| CFI* | .926 |
| NFI* | .060 |
| RMSEA* | .089 |

Please note that the measurement model and fit indices for the 4-factor solution of the course design characteristics scale is provided as Table 2, together with other pertinent details, in Goosen and Ngugi [41].

## 8 Conclusions and Recommendations

This paper should have relevance for not only attendees of this Southern African Computer Lecturers' Association (SACLA) 2019 conference, but also for their students' learning levels and interest. The paper forms part of a series of publications from a thesis, and as such, additional information about the larger study can be obtained from Ngugi and Goosen [69] and [70] on:

- the effects of course design characteristics, self-regulated learning and knowledge sharing behaviour in facilitating the development of innovative behaviour among Information Technology students at universities, and
- modelling course-design characteristics, self-regulated learning and the mediating effect of knowledge-sharing behaviour as drivers of individual innovative behaviour.

Given the standard, depth and originality of the research, Ngugi and Goosen [70] are convinced that this represents a contribution to the field of expertise and scholarly debate in the field, with something new and original, which fills the knowledge gap identified in literature.

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# e-Tutors' Perspectives on the Collaborative Learning Approach as a Means to Support Students of Computing Matters of Course!

**Full Paper**

**SACLA 2019**



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**Abstract.** Open Distance e-Learning (ODeL) institutions support e-tutors, providing them with digital tools, to select what they feel comfortable using to facilitate e-learning. Management systems further enable e-tutors to collaborate with students of Computing modules. This paper explores the collaborative learning approach employed in 'Computer Integration in the Classroom' offered at an ODeL institution. The Collaborative Learning Environment (CLE) was studied based on Vygotsky's social constructivist theory. The research approach was qualitative, with a case study design. The population was seven purposively sampled e-tutors. Data was gathered using unstructured interviews, non-participant observation and document analysis. Findings revealed limited interaction be- tween e-tutors and students in the CLE. Participants indicated a need for training in how to motivate and engage students in a CLE. We recommended that e-tutors receive training, ensuring that they do not focus solely on how to interact with students using a particular platform, but also develop scholarly approaches to- wards involving students.

**Keywords:** e-Tutors, Collaborative Learning Environment, Students, Open and Distance e-Learning, Learning Management System.

## 1 Introduction

Teaching and learning in the 21st century is no longer confined to the four walls of the classroom [1], [2], [3]. Garrison [4] states that distance is no longer a barrier to learning,

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as the use of educational technologies makes it possible for all students to interact and learn remotely, and particularly those studying Computing modules. The use of educational technologies at Open and Distance e-Learning (ODeL) institutions has evolved significantly in recent years [5]. These technologies provide new opportunities for students to interact with their lecturers and peers in acquiring knowledge and skills related to their studies [6]. Students engaged in ODeL need learning environments that will motivate them to focus on their learning, and they gain a great deal from interactions both with other students and with their lecturers [1]. These interactions encourage the important skill of collaboration, in order to share information, as more and more enterprises are digitizing, enabled through communication and collaboration [7].

Use of the internet makes it possible to apply various digital technologies and techniques that sustain ODeL practices and maximise independent learning [4]. As also pointed out by Goosen and Breedt [8], the changing environments of digital technologies and computer applications are key drivers in the presentation of collaborative learning experiences in this new transformed education system [6].

A collaborative learning approach encourages students to view the environment from a different perspective and provides them with an opportunity to practise social and leadership skills [6]. Students in a collaborative learning context assume a more active role than in a traditional instruction setting. Moreover, in the 21st century, students are better informed as a result of their learning experiences when education is supported by technology [5]. García-Valcárcel., Basilotta and López [6] attest that 21st century presentation of content offers students greater freedom to expand their thinking potentiality, and collaborative virtual learning contexts generate learning environments that meet this **objective**. The use of technological devices and the internet offers a considerable advantage for the presentation of a collaborative learning experience.

Collaborative learning environments are evolving, as ODeL institutions have begun to take advantage of unique features offered in virtual world spaces that make it possible to record and map the flow of ideas [9]. Groups of students will potentially benefit from collaborative thinking as they learn to mobilise energy and actions for the achievement of common goals [10]. Specifically, they will rely on an accumulative intelligence that is greater than the sum of their individual talents [6].

The advancement of new digital technologies does not limit students and e-tutors to a particular platform for sharing information and skills. A variety of technological devices that offer a broad choice that could work well for both students and e-tutors is available on the internet. At the beginning of each semester, students interact by exchanging cell phone numbers in order to form WhatsApp groups. This behaviour prompted the study under discussion, to establish whether students benefit from interactions with one another and e-tutors. Limited research has been conducted into how e-tutors interact with students in a collaborative learning environment.

The University of South Africa (UNISA), as an ODeL institution, relies on the collaborative learning context, as students have the opportunity to further their studies in different places and at different times [11]. The institution is pursuing a shift from

open distance learning to open distance e-learning and has extended student support through the appointment of e-tutors.

Since Johnson and Johnson [12] consider cooperative learning to be the foundation for active learning, and with similarities to the article by Pitsoane, Mahlo and Lethole [13], this paper will provide access to some of the UNISA e-tutors' perceptions, experiences and views of such active learning.

## 2 Background

Open and distance e-learning can be a lonely experience for students, who may feel isolated and unsupported. The use of technology has bridged this gap and made it possible to extend support to students in the form of collaborative learning environments.

In 2013, UNISA implemented an e-tutoring model for the provision of student support [14]. The institution uses the *my*UNISA learning management system as a platform for collaboration between lecturers, e-tutors and students by means of a range of digital technologies. The digital tools on this platform facilitate communication between students, e-tutors, lecturers and administrative staff. *my*UNISA can be accessed by students [15] from any remote location at any time when the need arises [14].

As of 2013, UNISA has appointed e-tutors to drive the e-learning process [14]. E-tutors are required to communicate with students via *my*UNISA, and they are expected to monitor students' self-paced learning [13]. They guide, advise, provide clarity regarding difficult concepts, and generally enrich students' UNISA experience [11].

The following digital tools that facilitate interaction between e-tutors and students are available on the *my*UNISA platform:

- **Announcements**: Lecturers and e-tutors use this tool to inform students about important matters related to modules
- **Discussion Forums**: This tool is used mainly for student–student and lecturer–student interactions
- **Additional Resources**: Lecturers and e-tutors can upload additional resources for students, and students can access these by means of this tool
- **Schedule**: The Schedule tool is used to make students aware of important dates such as examination dates and the due dates for assignments
- **Statistics**: This tool provides information about how many times users visit different tools and sites on *my*UNISA.

E-tutors are not restricted to these *my*UNISA tools; they are allowed to activate more, which are available by means of the Site Info facility.

At UNISA, two hundred students are assigned to one e-tutor [16]. All e-tutors are linked to their respective module sites, as are the students, who are provided with access to the sites that enable them to interact with lecturers, e-tutors and UNISA teaching and learning materials [17]. UNISA also employs Administrative Student Coordinators (ASCs), whose job it is to monitor e-tutors' group sites to ensure that e-tutors attend to students' questions timeously and that the responses are in line with UNISA's quality standards [13]. In addition, ASCs are responsible for tracking students' involvement in the collaborative learning environment.

### 2.1 The Role of e-Tutors

Morillas and Fandos [18] consider tutoring at higher education institutions to be part of the teaching and learning process, the basic purpose of which is to improve students' academic success and help them attain their professional goals. E-tutors contribute to students' academic success through their interaction with students in a collaborative learning setting in which they guide students and help them understand any parts of the learning content with which they may have difficulties. The presence of an e-tutor encourages students to ask questions and reflect on their online learning [19].

The main e-tutor roles identified by Berge [20] were pedagogical, social, managerial and technical. These are discussed next.

The pedagogical role includes tasks such as guiding and maintaining students' involvement in online discussions. This role draws on the methods used to create a collaborative learning experience. An e-tutor is expected to respond promptly and to ensure that students participate actively in online discussions. The Educational Broadcasting Corporation [21] emphasises the following techniques as essential pedagogical practices for a collaborative learning environment:

- prompt students to formulate their own questions (inquiry)
- allow multiple interpretations and expressions of learning (multiple intelligences)
- encourage group work and the use of peers as resources (collaborative learning)

The social role involves the creation of friendly and attractive social environments for students. As also pointed out by Vorster and Goosen [22], in essence, it promotes the continued support of human relationships, maintaining a group as a unit and helping participants collaborate. Excellent communication skills on the part of e-tutors are of the utmost importance in this regard.

The managerial role involves organising learning activities and tasks, clarifying procedural rules and decision-making. An e-tutor needs to display strong leadership and direction in presenting content to students.

The technical role entails becoming conversant with the digital devices and software that is to be used in a collaborative learning environment. Students must receive technical support online. The technical role is the most important, because online technologies are used as platform for teaching, supporting, managing and assessing students.

The Educational Broadcasting Corporation [21] contends that as the collaborative learning process unfolds, an e-tutor is expected to coach and suggest, while at the same time leaving room for students to conduct their own hands-on experiments, ask questions, engage in trial and error and succeed on their own. Collaborative learning activities must be structured in such a way that students participate fully. Students should also be provided with the opportunity to reflect on what they have learnt.

The above-mentioned roles are promoted through e-mails and online tutoring. E-tutors need to exercise patience as they interact with students, and to accommodate diversity. For students, this new educational teaching and learning method promotes collaborative learning in groups, while at the same time allowing e-tutors to prompt students to answer or comment and monitor the pace at which students' progress, from an educational perspective [23]. Interaction in a collaborative learning experience is key to the success of an e-learning environment.

## 2.2 Collaborative Learning

Collaborative learning involves two or more people learning or attempting to learn something together. This could involve, for example, teachers' information communication technology competencies in classroom practices [24] related to knowledge, skills and competencies [9], [25]. Khalil and Ebner [26] and Westbrook [27] further define collaborative learning as a set of processes, which help people to share knowledge or information in order to achieve a specific goal that is usually content specific. Sansivero [28] offers a slightly different perspective, defining collaborative learning as a methodology that transforms the traditional lecture or lecturer-centred approach into a student-centred one. Students work as a group to help one another understand content, solve problems or create projects, with the lecturer facilitating their virtual learning.

Interaction in a collaborative learning environment involves students working in pairs or in small groups, deliberating on learning activities or finding solutions to problems. Unlike in individual learning, collaborative learning participants rely on one another's resources and skills to achieve the end results. They shed light on the learning activities provided, asks questions for clarity, synthesise and share information to arrive at a desired goal [9].

During collaborative learning, it is expected that a particular form of interaction among the participants will take place that prompts a collective learning mechanism [25]. The sharing of knowledge and skills among two or more people is better than individual learning; many computer lecturers, like Goosen and Pieterse [29], believe that the lows related to misunderstandings and misconceptions can be turned into the highs of understanding through interaction between students [9].

Collaborative learning can take a variety of forms, such as quick online forums, chat rooms, collaborative writing, group projects, joint problem-solving, debates, study teams, and other activities [30]. All the participants are engaged in a common learning activity and are both dependent on, and responsible for, the outcomes [9].

Educational experiences of collaborative learning are designed based on the premise that **interactivity and sharing of information in small groups produces stronger solutions** than would have been arrived at individually [28]. In addition, García-Valcárcel et al. [6] attest that collaborative learning encourages students to understand learning from a different perspective: the environment creates a learning experience that allows students to practise social and leadership skills and provides a satisfactory learning experience that significantly reduces anxiety.

In the 21st century, collaborative learning is increasingly finding its way into the virtual world and has given rise to a new educational scenario that merges the notion of group-based learning and the potential offered by new digital technologies [26].

### 2.3 How Collaborative Learning is Implemented

Key to a successful collaborative learning experience is the evaluation and selection of the appropriate digital technology suited to the lecturer's pedagogy, students' needs and the specific outcomes of a course [26]. Thomson [1] emphasises that for collaborative learning to be a success, the appropriate strategies for learning activities need to be put in place, otherwise it is possible that students studying at a distance may experience a sense of isolation and feel neglected or even disengaged. The proper strategies would give rise to easy collaboration, and students would quickly become acclimatised within a new learning environment. This would sustain their interest and improve focus, and they would be able to contribute in the best possible way and achieve quality results.

A well-planned collaborative learning experience with broadening technological tools will enable students to learn how to learn, giving them the opportunity to learn not only individually, but also from their peers, as they are able to pick up learning strategies and methods from one another [21].

The e-tutor or lecturer should constantly think of ways to introduce a collaborative learning experience to the students. Time should be allocated for interaction and navigating digital technologies, and the e-tutor needs to think about how to support students and probe as the collaborative learning experience unfolds [31]. An e-tutor should demonstrate empathy, putting herself or himself in the students' shoes, as a large number of learning activities are undertaken collaboratively online.

The lecturer should consider students' prior knowledge as a connection to new content knowledge [21]. Familiarity with the selected technology is paramount, and so students need to be provided with the opportunity to navigate or familiarise themselves with the selected digital technology [31]. When students are comfortable with the selected technology, the lecturer can proceed to more challenging activities, prompting students as learning flows and asking them to reflect on what they have learnt. The role

of an e-tutor during this process would entail offering guidance and ensuring that students are on the correct path.

According to McWhaw, Schnackenberg, Sclater and Abrami [32], in order to help students to become collaborative learners, and move from co-operation towards collaboration, the social and intellectual outcomes of learning in groups need to be considered. For a collaborative learning experience to be a success, the following five basic elements identified by Johnson and Johnson [33] should be borne in mind:

1. positive interdependence to ensure that individual students believe that they 'sink or swim together'
2. promotive interaction to ensure that group members assist, encourage, help, praise and support each other's efforts
3. individual accountability to ensure that, as emphasized by Goosen and Mentz [34, p. 55], "each collaborator must be individually accountable" to do their reasonable share of the work
4. interpersonal and social skills to work effectively with others
5. group members process how well they achieve their goals and maintain effective working relationships.

Thomson [1] suggests six online collaboration strategies, which are discussed below:

1. Provide a clear definition of expectations and purpose: Students should be made to understand what is expected of them, for example, why they have to work together as a group, clarification of their syllabus, how interaction should take place, and the specific platform for collaboration.
2. Provide clear instructions to students in a group: Clear and proper instructions need to be formulated, and every activity should have a purpose so that students understand the route to take. Due dates should also be provided.
3. Keep groups small: Small groups enable the lecturer to provide all students with enough attention, and all students have the opportunity to respond and contribute actively to the activity.
4. Provide close monitoring and support: The lecturer is expected to be readily available when the need arises.
5. Set etiquette guidelines for proper participation: Guidelines are essential to familiarise students with navigation rules; this will enable them to work towards the achievement of a common specific outcome.
6. Devise activities relevant to the topic: As pointed out by Goosen and Van der Merwe [35], the e-tutor needs to be knowledgeable about content, and be able to select from various possibilities those activities that will keep the Information and Communication Technology (ICT) in education content relevant to the theme. Exploration activities encourage greater interaction, especially when they are linked to a real-life situation.

As collaborative learning experiences unfold, students will ask questions, obtain clarity, respond to questions, navigate, and help each other to reach the desired goal [26].

The advancement of new digital technologies supports collaborative learning experiences in higher education. These tools need to have the appropriate functionality and be user-friendly [1]. They should also allow for stronger and more powerful engagement with collaborative learning environments [9]. Only then can students feel confident and interact to complete their tasks.

Thomson [1] emphasises the importance of choosing the 'best' digital technology [36], as this will contribute to the collaborative learning environment. The activities could be carried out quickly.

Table 1 sets out examples of collaborative tools and how they are being integrated in teaching and learning [1]. The online collaboration digital tools mentioned in Table 1 highlight how collaborative learning experiences could bridge the gap between distantly located students and lecturers, and how students in the 21st century is able to learn and gain more from one another. The various digital platforms, along with the proper implementation of online strategies by lecturers, could lead to the enhancement of students' content knowledge and the honing of their skills.

## 3 Social Constructivist Theory

The social constructivist theory of Vygotsky [37] was the lens through which the collaborative learning experiences of students enrolled for the module 'Computer Integration in the Classroom' (FDEME3L) at UNISA was viewed – this module obviously focuses on computer integration into teaching and learning, which happens in a classroom [38]. Social constructivist theory was considered suitable for the study, because it emphasises the sharing of knowledge and the assistance rendered by knowledge experts. Social constructivism considers the construction of knowledge through learning as a group and being provided with the chance to reflect on what has been learnt [21].

Vygotsky [37] favoured having students work as a group to share different ideas, after which they can concur and arrive at a deeper understanding of an activity [39]. Wikipedia [9] states that collaborative learning is rooted in notion of the zone of proximal development, from Vygotsky [37], which emphasises that knowledge is developed through interaction with other people. The idea of the zone of proximal development emphasises learning through interaction with other students, rather than as an individual [39]. As students interact, they construct knowledge for themselves as learning unfolds. In addition, since students cannot be expected to master activities on their own, mastery can be realised only with the assistance of a person who is more knowledgeable. This person can be, for example, a lecturer or an e-tutor.

**Table 4.** Examples of collaborative tools and how they are integrated in teaching and learning.

| Collaborative learning digital resources | Operation |
|---|---|
| ProofHub | This software not only enhances collaborative learning experiences, but also significantly improves communication among distantly located participants. A group interacts through a chat room; questions that are asked are answered quite quickly. |
| MindMeister | This collaborative platform enables participants to plan or brainstorm on a single mind map document in preparation for group work. Besides mind maps, this software features direct live chat and fast communication. |
| Google Docs | This online collaborative device facilitates the creation and sharing of documents. Documents can be edited and accessed from any remote location at any time and from any digital device. Formatting can be done by users and changes to a document are saved automatically as typing is done. |
| BigMarker | Participants communicate through webinars so as to share information from different locations in real time. The slide presentations, videos, chats and webcams can be recorded and stored for later viewing and sharing. Participants who miss live events are provided with the opportunity to view the recorded version at a later stage. |
| Skype | The lecturer video conferences with a group of students. This platform enables members of the group to interact conveniently and support one another. Skype also offers a video chat facility that boosts online group learning. |
| Collaborative learning using Wikipedia | Wikipedia as a collaborative learning experience platform is extremely beneficial for students engaging in online discussion, as it enables a group of students to share information and exchange ideas. |
| Blog | The lecturers can use this platform as a collaborative learning log to support students. The students are allowed to reflect and share their collaborative learning experiences. They can also post queries pertaining to assessment and receive prompt feedback [40], [41]. |

For the Educational Broadcasting Corporation [21], constructivism does not dismiss the responsibility of lecturers to assist students by imparting expert knowledge. A lecturer is expected to constantly help students to construct knowledge, rather than simply to reproduce information. Construction of knowledge assists in transforming students from passive recipients of information to active participants in the learning process. In the context of the study under discussion, the expertise of e-tutors and how they probe interaction was taken into consideration.

## 4 Methodology

FDEME3L is a module for which roughly 3300 students register per semester. The study involved seven e-tutors who tutored FDEME3L students in the 2017 academic year. As also described by Goosen and Naidoo [42], these e-tutors as 'computer lecturers' used the ICTs on the institutional *my*UNISA Learning Management System (LMS) to facilitate teaching and learning [43] in the cyber world, as well as e-mails, to collaborate or interact with students.

The study sought to explore how e-tutors supported FDEME3L students by means of the collaborative approach towards facilitating the module. The qualitative research approach was considered appropriate for the study, because it was possible to directly explore the perceptions of e-tutors in a natural setting; in this instance, the *my*UNISA learning management system. The foci were the experiences of the e-tutors in terms of collaborative module activities, their roles as e-tutors and how they used different digital technologies to interact with students. A case study research design was used, and data collection strategies included unstructured interviews, non-participant observation and document analysis. The targeted sample comprised the seven e-tutors for the module FDEME3L, who shared their lived experiences of collaborating with students from the beginning of a semester until students sat for their final examination for the 2017 academic year. The intention was to observe various digital technologies available on the *my*UNISA learning management system being used as a means to support students. Digital tools such as Announcements, Schedule, Additional Resources, Discussion Forums and e-mail were investigated.

The data used were collected over both semesters in the 2017 academic year. Seven e-tutors for the module FDEME3L shed light on their e-tutoring experiences during unstructured interviews, which used a set of open-ended questions to gather data.

The primary computer lecturer for the module was able to observe the e-tutors' interaction with students by means of group sites on *my*UNISA. The participants' experience in supporting students by means of a collaborative learning environment was also observed. The *my*UNISA learning management system was used to access e-tutors' group sites for the purposes of non-participant observation in terms of data collected. All e-tutors were linked to *my*UNISA, and each had her or his own site to use as a collaborative learning environment.

In all data gathering, ethics protocol was observed through informed consent, voluntary participation, anonymity and confidentiality. The participants were informed about their role in the study, that their participation was voluntarily, and that they could withdraw at any time if they so wished. The participants were reassured that their contributions would be treated confidentially and that letters of the alphabet would be used, instead of their real names, when reporting was done: to maintain anonymity, the participants were referred to as participants A to G. Assurance was also provided that their shared collaborative experiences would not be linked to their names. Approval for

the study was sought and obtained from the UNISA College of Education ethics committee.

The data were analysed using the data analysis procedure suggested by Creswell [44], including observation data analysis conducted on each e-tutor's group site.

The data gathered by means of the three data collection strategies were reduced to manageable and understandable information. Similar patterns were put together and coded, and this resulted in the establishment of themes.

## 5 Discussion of Findings

The findings are based on content analysis of the unstructured interviews, non-participant observation and document analysis. A representative sample of the lived e-tutoring experiences of e-tutors for the module FDEME3L was highlighted.

All seven the participants were teachers.

According to the findings, the female participants seemed more prepared to face technological challenges than their male counterparts.

With regard to the participants' age, four were below the age of 50, suggesting that the majority were digital natives.

Of the seven participants, five had sound experience and the potential to work as e-tutors, as compared to the other two.

The results revealed that most of the participants were technologically capable and had the necessary skills to facilitate a collaborative learning experience.

UNISA provided all the participants with training in e-tutoring before they were allocated students. In addition to receiving training, all had good qualifications in educational technology, the minimum qualification being a BEd honours in computer-integrated education or computer-based education. Four e-tutors had a BEd honours in computer-integrated education, two had master's degrees in computer-based education and one had a doctoral degree in the field of educational technology. The technology content knowledge and skills they had acquired enhanced their ability to overcome difficulties associated with the collaborative learning environment.

Of all the available digital tools on the *my*UNISA platform, the participants indicated a preference for **Discussion Forums**, because this tool enabled them to motivate, guide and actively engage students. In terms of interacting with students, all the participants used the Discussion Forums tool as a means of student support. The Discussion Forums site was used mainly for discussions of the learning material and responding to students' questions. Evidence of the support provided to students is revealed in the following excerpt:

*Participant F: "In the discussion forum, generally I used (the) Gilly Salmons 5 stage model on online learning. I began by setting the scene. The first discussion was to*

*welcome them and have the members introduce themselves. Thereafter, we discussed the learning material that they have to use."*

Another tool used by all the participants was the **Announcements**. The participants indicated that they used this tool to notify students about the learning activities. The participants were highly skilled in the use of this technology.

Limited use was made of **e-mail**, with only two participants using it to interact with their students.

The **Site Info** tool on the *my*UNISA platform provides access to other digital tools that *my*UNISA users can activate and use. Users are therefore not confined to the readily activated tools on *my*UNISA, but are afforded the opportunity to try other tools, such as blogs, podcasts and wikis. Participants required support in the form of readily available information and a broad choice of user-friendly digital tools. One of the participants indicated a need for training on motivating students to participate actively and use the Site Info tool:

*Participant E: "I need support on how to encourage students to actively participate in discussions about the subject content and how to use the Site Info Tool."*

The participants were unanimous that collaboration as an e-learning method enables students to help one another by sharing information. Students gain knowledge by interacting with other students, lecturers and e-tutors, and are able to achieve goals that they were unable to attain while learning as individuals.

The participants also indicated that most students do not participate actively in collaborative learning experiences and seemed not to favour working in groups. The participants found the poor engagement of students in the collaborative learning experience and how to motivate them to participate actively, to be challenging.

The tutorial letters sent to e-tutors were also taken into account as a means to further collect data. The tutorial letter stated that e-tutors were expected to:

- familiarise themselves with the prescribed book, study guide and tutorial letters for the module
- access the myUNISA learning management system and become acquainted with their group site
- cover all the study material within a stipulated time frame
- go through materials and prepare for tutor sessions
- motivate students to participate actively in collaborative learning platforms
- help students understand materials and assignment questions without giving them the answers
- liaise between the lecturer and students.

The e-tutors were also reminded to work closely with ASCs and the module lecturers, so as to ensure that they all had the same point of departure.

In addition to tutoring training, e-tutors also received such tutorial letters, which included the timetable, clearly setting out how to tutor students and all the activities that e-tutors are required to carry out. This timetable was a suggestion from lectures as to what to do; as technology experts, the e-tutors were expected to be innovative and use their technological expertise to make a collaborative learning experience interesting

and beneficial to students. This became evident during the interview sessions, when it was revealed that one of the participants elected to choose a platform that was not included on *my*UNISA. As revealed in the excerpt below, one of the e-tutors created other platform accounts and used these to interact with students:

*Participant A: "As an e-tutor, I also have an account on quizlet. I created multimedia interactive tutorials and linked them with my students through myUNISA."*

Each e-tutor's group site includes a Report Activity on *my*UNISA, and this was used to establish how e-tutors collaborated with students. As a non-participant observer, the researchers chose to present the analysed information graphically. Fig. 1 presents information illustrating e-tutors' interactions with students using the four digital tools.

The results in Fig. 1 reveal that the Discussion Forums tool was used by all e-tutors to interact with students. This tallies with information provided by participants as they shared their lived collaboration experiences in interviews sessions. They indicated that they used this tool to engage students in discussions about the module.

The second most preferred tool used by e-tutors on their group sites was Additional Resources. Most of the participants uploaded more resources for students, for further

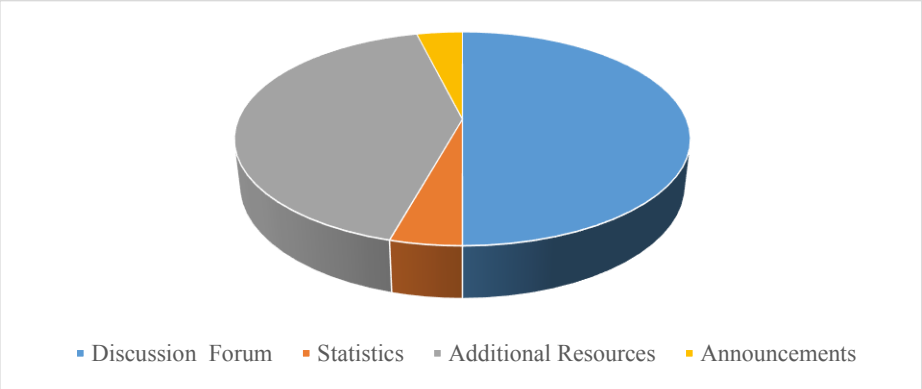


**Fig. 2.** Information relating to the use of four digital tools, illustrating e-tutors' interactions with students.

reference in their interactions. The uploaded materials provided students with more opportunities for discussion, and to overcome problems.

The Statistics tool provides information about how often other tools within a group site are visited and allows an e-tutor to view the most active tool and most active user. All e-tutors were identified as the most active users, and the Discussion Forums tool was identified as the tool that they used most frequently.

Use of the Announcements tool was shown to be limited, with only three e-tutors using it to any significant degree. This implies a lack of knowledge on the part of e-tutors regarding how to use this tool.

All in all, the results show less commitment to interaction on the part of students, while the equipment of e-tutors with the skills required to present a collaborative learning experience using appropriate digital tools needs more attention.

## 6 Recommendations

So as to ensure that e-tutors do not focus on how to interact using one particular platform only, but instead develop a scholarly approach with regard to involving students, they should be trained in how to support students in terms of the following:

- knowledge of various platforms that can be used in a collaborative learning experience
- ability to select the appropriate digital tool to ensure the achievement of module-specific outcomes
- how to motivate and engage students in a collaborative learning environment
- how to make appropriate use of the *my*UNISA learning management system.

## 7 Conclusion

Especially for students of Computing modules, which are often described as "frustrating" and "difficult" to learn [45, p. 169], the use of technology in teaching and learning has a significant impact on the presentation of modules by higher education institutions. Although this paper highlighted the fact that e-tutors still have more to learn about collaborative learning environments, Goosen and Gouws [46, p. 99], referring to Goosen [47], also pointed out that the collaborative learning environment "provided a structure through which computer lecturers, students and their" e-tutors could collaborate. The latter approach is not only innovative in terms of providing students with the opportunity to explore new ideas about learning as a group, but also, aimed at the teachers or lecturers of Computing modules, as it provides them with e-tutor guidelines, to assist in dealing with the huge classes that most of us have to contend with these days.

The principles of collaborative learning are increasingly influencing the way in which learning is conducted online and signal the need for higher education institutions to transform the presentation of modules, such that students are able to learn from one another and to close the gap in distance learning. There is a need to reflect on practice, so as to enhance the collaborative learning experience.

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# A Decision Making Approach to Evaluation of Learning Components in Adaptive Educational Systems

**Full Paper**

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**Abstract.** Personalized learning models are developed to cater for the differentiation in learner styles and needs. Tutors determine the most appropriate learning components for each student. The learning units (LUs) are adapted to learners based on their contexts. However, there are no methods that adapt learning objects to learners based on their personalized learning styles. There also does not exist appropriate techniques that employ decision making approaches to evaluate the LUs. This study presents a model that uses learning styles to determine the appropriate learning information by employing learning analytics. Its proposed evaluation model facilitates evaluation of how suitable, acceptable and useful- ness of personalized learning in the LUs. To test the model, varying evaluation criteria weights are employed. It is proposed that the model can be used by tutors to assist learners in creating and applying LUs that are most suitable for their needs thereby improving the quality of learning.

**Keywords:** Educational Data Mining, Adaptive Educational System, Suitability Evaluation, Personalized Learning.

## 1 Introduction

### 1.1 Overview

One of the key objectives for educational systems is to enhance students' learning performance and satisfaction. Trainers are required to carry out accurate evaluations of learners' varying competencies to enable them tailor the teaching process to personalized learner requirements. Learners can differ based on their knowledge level,

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interests, how they are socialized, and the motivation level [1, 2]. To create personalized learning systems, designers and developers should consider artificial intelligence (AI) techniques that have been extensively used in creating near human like applications. While AI is the broad science of mimicking human abilities, machine learning is a specific subset of AI that trains a machine how to learn. Its applicability in educational settings is also gaining prominence with growing volumes of available learning data [3].

Machine learning skills are necessary for developers of predictive applications. Current practices show that machine learning skills are taught primarily via a teacher-centered approach [4] limiting the ability of trainers being able to identify problems faced by individual trainees. This calls for innovative ways of training learners to solve their own problems during learning. Learners should be assisted to be able to identify their learning styles. Training modules should be evaluated by domain experts for appropriateness to particular learners according to their learning styles.

There is utmost need for methodologies for evaluating how suitable, acceptable and useful personalized learning units (LUs) are for each student in addition to methods for evaluating the learning objects (LOs). LOs can be defined as a series of learning components, learning tasks, and learning settings. An acceptable LO should entail learning components which are appropriate for certain learners depending on their learning styles.

Emphasis on the individual learner differentiation while modelling ideal online setting is a major component in adaptive educational systems (AES). Successful provision of adaptive learning models depends on the identification and ability to meet learners' needs. Enabling these features is key if AESs are to provide methods and content that are suitable for their users [5]. Importantly, accurate learner profiles and models should be created after analyzing learner affective states, knowledge type, skills and personality traits. This information should then be employed in the creation of adaptive learning settings [5].

E-learning courses can be delivered using several existing learning management systems (LMS) like Sakai and Moodle and learning portals like Dream-box and massive open online courses [6]. Being online and hosted in large database systems, the platforms store massive data. The continuation of the learning process by student is based on his/her individual learning style and the results of his/ her performance evaluation [6]. In literature, educational data mining (EDM) and learner analytics (LA) fields of research have specialized in the analysis of online learning systems' stored data to create personalized profiles that can be used by interested parties to develop personalized adaptive educational systems [6]. Formal definitions and applications of EDM and LA are found in [7].

### 1.2 The Problem

Lack of knowledge and limited awareness by majority of educators in the application LA and EDM methods [6] has been a great impediment to the successful learning. Educators are handicapped in the correct analysis of the results and correct inference deciphering. In dealing with these challenges, a key point is the creation of a positive

environment for cultivating a data centered approach in the educational sector [8, 9]. In this regard, the environment should facilitate learner analytics for personalized recommendation of learning objects based on learners' learning styles.

According to Kurilovas [10], the concept of personalized learning styles became popular in the 1970s. Since then, the concept has had great influence in education sector despite some researchers criticizing it. However, its proponents have suggested that trainers should evaluate their learners' learning styles and make their teaching methods adapt to each learner's preference. Notably, evidence exist suggesting that individual learners have preferences on how they would like to receive information. However, seldom works have tried to validate use of learning styles to adapt course materials. Possible reason for this could be the lack of evidence of learners' learning outcomes improvement when learning styles is the basis of developing learning activities [11].

In the authors' assessment, the criticism by these researchers has nothing to do with the validation of the construction of learning objects based on learning styles. It is the opinion of the authors that the application of learning styles constructs for efficient learning personalization, could be the genesis of the criticism. This can be attributed to existing varied learning styles, impracticality of having enough trainers to personalize learning materials based on possible numerous learning paths that are dependent on learning styles. Moreover, some researchers have stated that personalization of learning when based on learner's learning styles can be effective when intelligent technologies are properly applied to develop optimal personalized learning paths.

In this study, learners fill the psychological questionnaire to identify their learning style. Thereafter, employment of learning analytics techniques to identify and correct the discrepancies in the outcome is done (sometimes the outcome of filling the questionnaire differ from the existing defined learning styles). This results in better identification of individual learning styles. In this work, personalized LUs encompass learning components with the highest probabilistic suitability indices (PSI) to particular learners based on the Felder-Silverman Learning Styles Model (FSLSM) [12].

This study also proposes to evaluate suitability, acceptance and use of personalized LUs by using a multi-criteria decision making (DM) method. The method employs DM criteria proposed in Educational Technology Acceptance and Satisfaction Model (ETAS-M) [13] that is based on the Unified Theory on Acceptance and Use of Technology (UTAUT) model [14]. This study defines LU as a sequence of learning objects (LOs), learning tasks (LTs) and learning settings (LSs) which according to some authors, has been frequently referred to as either virtual learning settings (VLSs) or virtual learning environments (VLEs). This study adopts the former reference.

# 2 Previous Works

## 2.1 Employment of Artificial Intelligence Methodologies in Adaptive Educational Systems

The success of any adaptive educational systems (AES) is dependent on how the systems are able to cater for each learner's needs [15]. This becomes possible when learners' profiles and learner objects are created accurately after considering their affective states, knowledge level, personality attributes and skills. All these information is utilized in creating the adaptive learning setting [15]. AI being the approach that is most applied in creating decision making processes that have largely been adopted by people [16], is also seen as a valuable tool for developing AES.

Use of AI approaches in AES has been in examining and assessing learner attributes for generation of their profiles. Using the personalized profiles, the overall knowledge level is determined which is used as basis for prescribed software pedagogy [17]. Similarly, diagnostic process completion is facilitated by using these approaches. Adjustment of course content to cater for individual learner needs is done. Analytics of learner behavior is carried out and the prescribed software pedagogy [18] is adjusted accordingly.

It can be considered time consuming or costly to rely on designer or expert knowledge to guide the pedagogy of the AES. Furthermore, because of incomplete knowledge on what entails effective teaching, dealing with varied characteristics of students is sometimes not possible. It can be more convenient and effective for adaptive e-learning system designers or experts if they consider learner behaviors for automatic learning. It may save their time and effort in the design of suitable pedagogy according to the learner needs. In the design, learning models which can be continuously edited and modified without difficulties can be generated. Therefore, AES can be developed based on how learners define their styles of learning and the experts' evaluation of the learning units. Experts' evaluations are inherently uncertain.

The AI techniques, such as fuzzy logic, decision trees and neural networks can manage the uncertainty that is inherent in human decision making. These techniques have been touted as being able to deal with imprecision and uncertainty and thus can be used to build and automate accurate teaching-learning models [19].

## 2.2 Learning Units' Personalization

Research works in recent times have shown personalization of learning attracting a lot of attention from researchers [20, 21]. Popular topics in this domain have been (or include), creation of LUs [22], learning objects (LOs) [23], LTs [24] and LSs [25] that should be most appropriate for individual learners. Seemingly high demand of these techniques have seen a lot of proposals coming forward from researchers.

In [24], it is stated that going into the future, educational systems will have to adopt both personalization and intelligence. Personalized learning refers to learner ability to receive learning materials based on their personal learning needs. This is achieved by creation and implementation of personalized LUs. In other words, the adaptive system

should recommend the most suitable learning components to learners. Intelligent technologies, the likes of resource description framework (RDF) can be applied in AES to improve learning quality and efficiency in personalized learning.

The steps for implementing personalized learning include, 1) implementation of learner profiles (models) based for instance, on FSLSM where a dedicated psychological questionnaire like Soloman and Felder's Index of Learning Styles Questionnaire (SFILSQ) [26] is applied, and 2) integration of other features like knowledge, goals, learning behavioral types, interests and cognitive traits in the learner profile. In [27], it is stated that FSLSM learning styles model is suitable for technology-based related learners. Hence its adoption in this study.

Literature reveals that FSLSM, uses number scales to categorize learners according to how they receive and process information. For instance, in [10], the categories are by: a) Information type, b) Sensory channel, c) Information processing, and d) Understanding. Descriptions of sub categories for each category can be found in [10].

Explanations given in [28] on the steps of implementing personalized learning indicates that step three (3), entails filling the SFILSQ, to obtain a learning style that is currently stored in (or represents) learner's profile. The outcome of this step is checked against the results described in Table 1 and appropriately modified using the correct learner's information as determined in this personalized learning implementation step by application of LA methods. The application of the process to create suitable LUs for individual learners should be carried out as per the descriptions given in [29]. Ultimately, implementation of integrated learner profiles is done. Further, creation of ontologies-based recommender systems that adapts appropriate learner components according to individual learner's FSLSM-based profiles is also carried out.

**Table 1.** An instance of learner's learning style stored in his/her profile (as provided in [10]) that should be modified.

| Styles of Learning | | | | | | | |
|---|---|---|---|---|---|---|---|
| Information type | | Sensory channel | | Information processing | | Understanding | |
| Sensory | Intuitive | Visual | Verbal | Active | Reflective | Sequential | Global |
| 0.639 | 0.361 | 0.821 | 0.179 | 0.731 | 0.269 | 0.449 | 0.551 |

From the preceding steps, each learner should have a personalized LU for each learning task/activity he /she engages in. The personalized LU should be created using existing AI technologies. These intelligent technologies can be useful in evaluating quality and suitability of the learning components. Among these technologies are ontologies and recommender systems which should work by linking learner profiles (LP) to learning components (LCo). There exists established interlinks between LP and LCo that can be exploited in these cases even as experienced experts participate in creating appropriate learning environment to facilitate proper guidance to learners or creation of appropriate learning components / objects.

### 2.3 Evaluation Approach: UTAUT Model Application in Learning

There are a number of decision making techniques (evaluation approach adopted in this work) in literature. As highlighted in [30], they include 1) Analytical Hierarchy Process (AHP), 2) VIsekriterijumska optimizacija I KOmpromisnoResenje (VIKOR), 3) Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) among others. Any of these can be employed in the design and development of models suitable for use in evaluating the quality of learning components as per defined criteria. However, only a few research works have investigated the application of these techniques in AES.

One of the consistent concept in decision making, has to do with identification of decision / evaluation criteria. These criteria are usually relatively precise but can be conflicting at times. Each criterion is evaluated by comparing it against another criterion with respect to a given objective, where weight of importance is assigned based on a defined crisp or fuzzy scale. These criteria are also referred to as alternatives.

The identification of criteria in the decision making techniques, as stated by Kurilovas and Zilinskiene [22], should be based on among others the following principles: 1) Relevance of value; 2) Comprehensibility; 3) Ability to be measured; 4) Not redundant; 5) Independent of any judgment; and 6) Operational aspect. All these principles are relevant to a number of multiple criteria decision making (MCDM) models.

In [22], Kurilovas and Zilinskiene present the measure of performance model for LU quality that is based on the preceding principles of MCDM identification criteria. LU is Educational Modelling Language and IMS LD [31] based technology consisting of learning objects, learning tasks and learning settings.

Authors state that the same criteria-based evaluation can be applied by educators in the virtual learning settings. The basis of this evaluation is the Unified Theory on Acceptance and Use of Technology (UTAUT) model [14]. The focus on UTAUT model has been on its application in education as regards to the acceptance and use of information technology (IT) in the design and creation of personalized learning applications. While examining UTAUT as applied in IT acceptance research, it is glaringly shown that there exist several models (that are competing). Each of them have acceptance determinants of varying sets.

In the examination alluded to in the preceding section, a review of the following models among others was done, the theory of reasoned action, the technology acceptance model, the motivational model, the theory of planned behavior, a model combining the technology acceptance model and the theory of planned behavior, the innovation diffusion theory, and the social cognitive theory. The results of the review of the models as relates to UTAUT, were converging to a few constructs that were appearing like they were significantly determining the usage in at least one of the models. Researchers in this study have determined that four of the constructs are critical and as a result have employed them as direct determinants of user acceptance and usage behavior. They are adapted from Venkatesh et al. [14] and include: a) Performance

expectancy (PE), b) Effort expectancy (EE), c) Social influence, and d) Facilitating conditions (FC) as presented in Fig. 1.

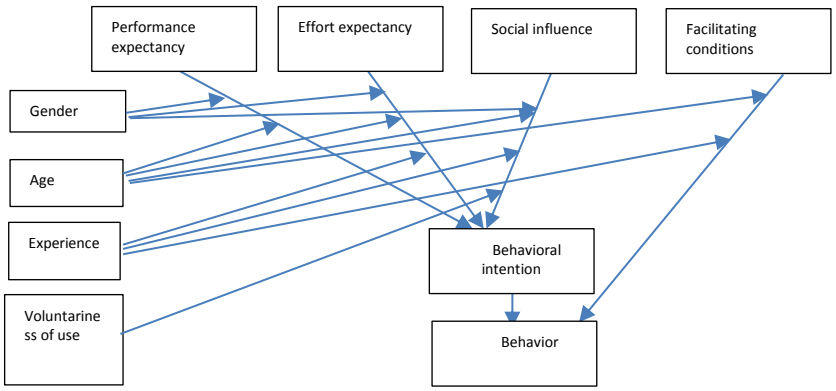


**Fig.1**. UTAUT model (Adapted from Venkatesh et al. [14]).

### 2.4 Learning Personalization by Use of Learner Analytics Methods

A selected review of recent works in [32, 33, 34], on learning analytics reveals the following issues. The list is non-exhaustive. The application entails: 1) Learners categorization in predefined set of learners group; 2) Course materials clustering for provision to particular learners based on their profiles; 3) Discovery of interesting relations between course elements used by specific learners; 4) Adaptation of learner profiles to personalized learning objects affecting the eventual learning outcomes; and 5) Creation of decision tree based on learners' actions. Decision trees are widely applied in data mining as they are easy to comprehend and use. The proposed method resembles decision tree where the branches represent correct responses to questions sought. A response can also be a state. The study divides datasets into branches at the initial steps progressively leading into a homogeneous state. The states assist in the identification of the data used to base the final decision.

## 3 Methodology

### 3.1 Using Learning Analytics in Learning Personalization

Use of learning analytics for personalized learning in education sector has been successful from what literature reviewed has shown. Literature has also shown that there are large volumes of data depicting learner behaviors which can be used in creating individual learner profiles. Appropriate learning objects can be designed to be adapted to the correct profiles in real-time, enabling successful learning activities thus improving performance in knowledge and skills acquisition.

When data analytics methods are employed in learner data in a learning institution, using the data obtained from students depicting their real behaviors, learner profiles as shown in Table 1 can be corrected based on this obtained data. This profile's correction can be achieved using a developed learning analytics (LA) software agent. It corrects the learner profile based on the learner behavior in the learning environment essentially implementing the recommended LUs.

In a learning institution or learning setting like multi-agent system or virtual learning setting (VLS), as learning takes place, learning objects and tasks can be associated with particular learners before identifying appropriate PSIs and recommending suitable LUs. Authors perceive that due to the foregoing discussion, it seems that learners' preference is to employ particular learning activities or use appropriate learning objects for their specific learning needs. Hence, usage of suitable LA methods, could facilitate easy analysis of learning activities and objects particularly used by the learners in the learning setting, and also determining the extent of usage.

Step one of using learning analytics in personalizing learning, authors propose the use of FSLSM-based approach and expert evaluation method [24]. FSLSM is widely used in higher learning institutions, as the appropriate learning style model. Furthermore, in [22], analysis of expert evaluation methods for learning components is presented. Secondly, SFILSQ is filled by learners and analyzed to determine their personalized learning styles. In the third step, it is proposed that the use of experts' evaluation methods should be employed to determine the suitability interlinks between learning styles and VLS learning activities. Thereafter, computation of PSIs [28] is carried out for each learner behavior analyzed. Additionally, the same process is applied to each VLS-based learning activity so that appropriate learning activities for particular students are identified. It is stated that when suitability index is high, the learning activity is presumably better. The same applies to learning objects used by learners. The higher the index, the better or more appropriate, the learning object is considered.

Fourthly, after the learners have been through a learning process, use of appropriate learning technique is recommended for analyzing the exact learning objet and tasks by students. Essentially, the information on the exact nature on how the learner used VLS-based learning tasks is then compared to their PSIs that resulted in the second step as discussed earlier. Discrepancies could have resulted during the comparison, in which case, the analyst (the teacher for the purposes of this study), is required to correct the learners' personal LUs in VLS based on the obtained information as a result of the process. This new information is attributable to the discovery of the differences in students' learning styles in their profiles as per their PSIs identified from the evaluation.

If there are still any glaring discrepancies that results when learning units are created based on the identified learners' learning styles from the filled questionnaire and when their real historical behavior is identified based on learner analytics, the analyst can either request the learners to refill the questionnaire or in the case that the results of historical behavior are good, learner analytics approach is employed to create optimal LUs. In the latter case, students learning quality and effectiveness can be enhanced.

### 3.2 Evaluation Approach Adopted for Suitability, Acceptance and Personalized Learning Units' Usage

Previous related works have employed MCDA based evaluation models to identify criteria for analysis. They base their arguments on the principles proposed in [22]. Authors borrow from this precedence and propose to use the same approach to evaluate LU model in the current work. This study uses the ETAS-M (as shown in Fig. 2), and PSIs to identify learning components' suitability to particular students' needs according to their learning styles [28].

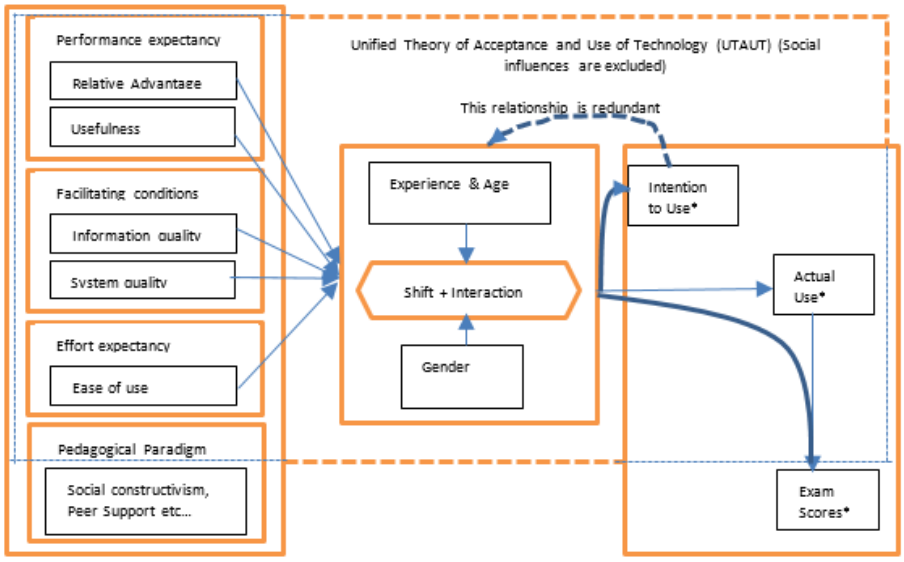


**Fig. 2.** ETAS-M (Adapted from Poelmans et al. [13]).

The proposed model is both component- and ETAS-M-based. Evaluation criteria for the model include, PE, EE, FC and pedagogical paradigm influence (PPI). In ETAS-M, PPI criteria replaces social influence used in UTAUT. When PPI in ETAS-M is compared with component based model mode in [22], it is shown that the operation convenience is enhanced. It is believed that the enhanced convenience level manifested in the comparison is attained because the described comparison is solely based on the evaluation of acceptance in addition to the use of LU the participants have developed or prepared, which fully reflects the participants' needs and perspectives.

# 4 Study Results

## 4.1 Application of the Proposed Learner Analytics Technique

To demonstrate the applicability and validity of the proposed learning analytics technique, an analysis of a sophomore class of 42 students enrolled in the Bachelor of Science in Computer Science at Dedan Kimathi University of Technology in Kenya was carried out. As much as this was a moderate class size suitable for such experiments, the focus was not so much on the class size but rather the sufficient differentiation in terms of their learning styles. The learners were put in six categories of seven members each, labeled as A, B, C, D, E and F (see Table 2). The university offers a number of its courses in the moodle-based e-learning platform[1] which is integrated with the now well-known and used big blue button platform[2] which is offered to all universities in Kenya by Kenya Education Network (KENET)[3] . The department of computer science has a number of select courses offered by either face to face or online.

The experimental class participated in the VLS-based digital image processing course for one semester during the August- December 2018 semester. It took fourteen weeks with each session lasting three hours per week. Researchers used this class having identified the differences in the learning styles for illustration purposes though the sample size is acceptable as it is the whole class which represent 25% of the students of the entire program which is studied in four academic years, hence a quarter of the entire population for the programme in the department. It should be noted that these results can be different in other universities but they can be generalized. Generalization is possible because in Kenya, students in majority of universities are government sponsored and are therefore allocated through Kenya Universities and Colleges Placement Services (KUCCPS) which is a state agency. The characteristics of students across most universities are majorly similar if not the same due to similar origins and backgrounds. Similarly, generalization is possible because the study has sufficiently analyzed different learning styles.

After determining the students to participate in the evaluation process, learners responded to the forty-four (44), two answer questions in the SFILSQ. It is shown from the analysis of the responses that 28 students preferred active information processing while the remaining 14 preferred the reflective mode; Similarly, 28 learners were mostly Sensory, with only 14 of them being intuitive learners; Finally, 28 learners were mostly Visuals versus 14 that were Verbal learners by sensorial channel; and 7 were either Sequential or Global learners by understanding (Table 2).

1 Moodle-based e-learning platform at Dedan Kimathi University of Technology. Available at: https://elearning.dkut.ac.ke

2 Big blue button platform. Available at: https://bigbluebutton.org

3 Kenya Educational Networks. Available at: https://www.kenet.or.ke

**Table 2.** Ratios of learner' learning styles for each category.

| | | Information processing | | Information type | | Sensorial channel | | Understanding | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Learners' Identification | ACT | REF | SEN | INT | VIS | VER | SEQ | GLO |
| A | 1,9,15,16,30, 32,34 | 0.724 | 0.276 | 0.544 | 0.456 | 0.728 | 0.272 | 0.544 | 0.456 |
| B | 5,12,20,22,26,39,40 | 0.456 | 0.544 | 0.272 | 0.728 | 1.000 | 0.000 | 0.184 | 0.816 |
| C | 4,6,17,21,27,35,38 | 0.728 | 0.272 | 0.365 | 0.635 | 0.365 | 0.635 | 0.454 | 0.546 |
| D | 2,10,23,24,33,37,42 | 0.728 | 0.272 | 0.635 | 0.365 | 0.272 | 0.728 | 0.456 | 0.544 |
| E | 8,11,14,18,19,28,36 | 0.635 | 0.365 | 0.728 | 0.272 | 0.544 | 0.456 | 0.456 | 0.544 |
| F | 3,7,13,25,29,31,41 | 0.272 | 0.728 | 0.728 | 0.272 | 0.908 | 0.092 | 0.728 | 0.272 |

NB: ACT-Active, REF-Reflective, SEN-Sensing, INT-Intuitive, VIS-Visual, VER-Verbal, SEQ-Sequential, GLO-Global

After the identification of learner styles from analyzing the responses in the questionnaires, expert evaluation methods are used to help determine the activities in VLS Moodle appropriate for FSLSM-based learning styles. This is shown in the third column of Table 3. In Table 3, column 4, it is shown the outcome of using learning analytics methods to identify the particular learning tasks that each member of the experimental class exhibited. Decision tree technique was used to analyze the data using the learner identification (in clusters) as the target. In decision trees, different learners are shown using colored blocks where the records appropriate for each learner is represented by length of the line.

**Table 3**. Appropriate learning styles for learners' participation in moodle-based tasks (Adapted from Kurilovas [12]).

| Moodle-based tasks | Description | Appropriate learning style | Number of learners |
|---|---|---|---|
| Assignments | Enable teachers to grade and give comments on uploaded files and assignments created on and off line | Reflective | I(35) |
| Chat | Allows participants to have a real-time synchronous discussion | Active | J(35) |
| Forum | Allows participants to have asynchronous discussions | Active | K(21) |
| Lesson | For delivering content in flexible way | Sensory, Sequential | L(21) |
| Quiz | Allows the teacher to design and set quiz tests, which may be automatically marked and feedback and/or to correct answers shown | Reflective, Sensory, Sequential | M(35) |

From additional observations from Table 3, it can be noted that J is identified as the elements of the modules with the most active students, which is the target group with the highest averages scores. Similarly, students' participation in chat rooms characterizes their activities. To know the worst state of the learners' average values with the highest activity, one looks at the tasks and test course elements.

From the analysis, it could be deduced that there was a direct relationship of the learners' grade scores on the study module with their activities. It was then important that during the study process, more attention was paid to the learners' behavior in addition to their style of learning while at the same time facilitating active involvement in the course. The Moodle-based activities like chats and fora registered majority of the activities confirming learners learning in correspondence with their styles of learning.

### 4.2 Application of the Proposed Evaluation (Decision making) Technique

Fig. 3 shows the proposed evaluation model for suitability, acceptance and use of LU.

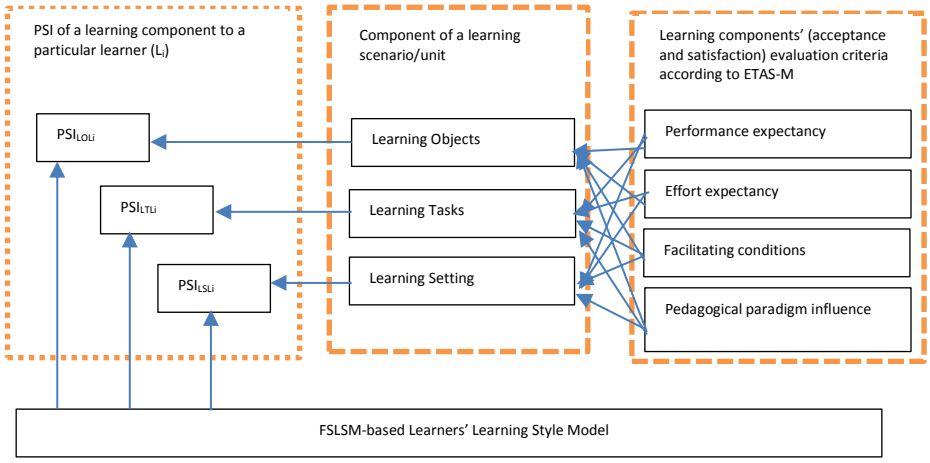


**Fig. 3.** A proposed evaluation model for suitability, acceptance and use of LU.

The evaluation model is used to evaluate a particular LU. Equation 1 is used to express the evaluation model:

$$f(x) = \left(\frac{\sum_{l=1}^{c} PSI_l}{c}\right)\left(\sum_{s=1}^{p} \alpha_s f_s(x)\right) \quad (1)$$

Where, $l$ is the learning component (LO, LT or LS), c =3, $PSI_l$ is the probability suitability index of corresponding learning component $l$ to particular learner, $\alpha_s$ is a weight of criterion s, and $f_s(x)$ is a value of criterion $s$, p= 4 (PE, EE, FC and PPI).

To compute the LU evaluation function numerical value, first, get the product of all ETAS-M-based evaluation criteria and their weights. Secondly, get the sum of the results from the first step. Thirdly, the product of these sums with their corresponding learning components' probability suitability indices is done and the final step is the computation of the overall sum. For LU of a particular learner to be considered appropriate, then its numerical overall weight, should be higher than the weights of other LUs.

In equation 1, the weights $\alpha_s$ of evaluation criteria *s, s = 1,2,3,4* might have been either equal or not, depending on how each evaluator views the criteria in terms of their importance in relation to each other. As pointed out by Kurilovas and Zilinskiene [34], when according to the evaluators', the criteria are of equal importance, i.e., $\sum_{l=1}^{p} a_l = 1, a_l > 0$, the weight of evaluation criteria $\alpha_S \cong 0.249$. Computing f(x) in equation 1, then becomes simple.

For demonstration purposes, the following section use a particular learner $L_i$, whose profile is shown in Table 1. It is imagined that a recommender system had recommended that its suitable learning units are $LU_1$ and $LU_2$ with the aggregated learning components (*LO, LT and LS*) $l$ = 1, 2, 3 having the highest suitability indices for the learner $L_i$. Also, it is imagined that the values of $f_s(x)$ of evaluation criteria s = 1, 2, 3, 4 (PE, EE, FC and PPI) using trapezoidal fuzzy numbers [24], respectively are:

$LU_1$*: (0.999 0.799 0.799 0.499)*

$LU_2$*: (0.899 0.899 0.699 0.599)*

Computation results when all the weights have equal values becomes:

$LU_1(\sum_{s=1}^{p} \alpha_s f_s(x)) = 0.249*0.999 + 0.249*0.799 + 0.249*0.799 + 0.249*0.499$

$\cong 0.775$

$LU_2(\sum_{s=1}^{p} \alpha_s f_s(x)) = 0.249*0.899 + 0.249*0.899 + 0.249*0.6999 + 0.249*0.599$

$\cong 0.775$

The following are the computation results when weights have different values (for instance, the weights of PE = PPI = 0.20; EE = FC = 0.25):

$LU_1(\sum_{s=1}^{p} \alpha_s f_s(x)) = 0.200*0.999 + 0.250*0.799 + 0.250*0.799 + 0.200*0.499$

$\cong 0.700$

$LU_2(\sum_{s=1}^{p} \alpha_s f_s(x)) = 0.200*0.899 + 0.250*0.899 + 0.250*0.699 + 0.200*0.599$

$\cong 0.700$

To identify learning components' probability suitability indices, trapezoidal fuzzy numbers can be applied on a select simple and convenient expert evaluation method and used to identify the learning components suitable for particular learners' FSLSM-base styles of learning.

A reference was made to an adaptive e-learning model (AeLModel) developed in [35]. The model allows social interactions such as content annotation, blogs, and tagging. Noting the use of the AeLmodel by learners (as described in the preceding section), twenty (20) expert evaluators were asked to give their opinions on how they rated the suitability level of learning activities based on the application of remodeled/enhanced (augmented) reality and social networks to Felder-Silverman learning styles. They filled in the questionnaire by selecting one of the following linguistic variables as proposed in [10]: excellent, good, fair, poor, or bad. Table 4 shows results of expert evaluation method

**Table 4.** Results of application of decision tree method.

| | Students identification by category and their ratio values for each task | | | | | | |
|---|---|---|---|---|---|---|---|
| | No. of records | A | B | C | D | E | F |
| Activity | 2827 | 0.3033 | 0.1113 | 0.1953 | 0.1205 | 0.1200 | 0.0441 |
| Lesson | 99 | 0.2800 | 0.0900 | 0.0100 | 0.1201 | 0.0000 | 0.4002 |
| Test | 667 | 0.1592 | 0.1802 | 0.1907 | 0.1412 | 0.1425 | 0.0588 |
| Assignments | 375 | 0.2371 | 0.1122 | 0.1527 | 0.1414 | 0.2424 | 0.0113 |
| References | 330 | 0.2315 | 0.0875 | 0.2165 | 0.1267 | 0.1867 | 0.0000 |
| Chats | 129 | 0.4908 | 0.1746 | 0.0955 | 0.0322 | 0.1348 | 0.0000 |
| Other activities | 1228 | 0.4035 | 0.0755 | 0.2294 | 0.1102 | 0.0608 | 0.0337 |

on the suitability indices of using social networks and augmented reality as media for learning. This is as determined by learning activities in learners' FSLSM-based learning styles (see Table 5).

**Table 5.** Results of expert evaluation method.

| Learner Style | Sensory | Intuitive | Visual | Verbal | Active | Reflective | Sequential | Global |
|---|---|---|---|---|---|---|---|---|
| Value | 0.740 | 0.750 | 0.910 | 0.600 | 0.870 | 0.450 | 0.670 | 0.780 |

As shown in Table 5, use of social networks and augmented reality as learning media is most suitable for Visual and Active learners with numerical values of 0.91 and 0.87 respectively. However, the suitability indices of Verbal and Reflective learners are 0.60 and 0.45 respectively. Computing the product of probabilistic values (PV) of learners' learning style from Table 1 and suitability values (SV) of learning styles & learning tasks from Table 5, results in probabilistic suitability values PSI, of suitability of certain learning tasks to certain learners (see equation 2 for active learning style).

$$PSI_{Active} = PV_{Active} * SV_{Active} \quad (2)$$

Computation of probabilistic suitability indices of other learning styles of a certain learner is carried out in the same way. Using Tables 1 and 5, these computations are done for a particular learner *Li*, as shown in the following section.

$PSI_{SEN} = 0.639 * 0.740 = 0.4736;$ $PSI_{VIS} = 0.821 * 0.910 = 0.7462;$ $PSI_{ACT} = 0.731 * 0.870 = 0.6351;$
$PSI_{INT} = 0.361 * 0.750 = 0.2700;$ $PSI_{VER} = 0.179 * 0.600 = 0.1080;$ $PSI_{REF} = 0.269 * 0.450 = 0.1215;$
$PSI_{SEQ} = 0.449 * 0.670 = 0.3015;$
$PSI_{GLO} = 0.551 * 0.780 = 0.4290.$

*The mean weight of this particular learner,* $PSI_{Li} = 0.3856.$

Similarly, computation of suitability indices for LOs and LSs is done in the same way. For instance, $PSI_{Li}$ for LOs in $LU_1$ could be equal to 0.499, and $PSI_{Li}$ for LSs in $LU_1$ could be equal to 0.599.

Therefore, *$PSI_{Li}$ for LOs in $LU_1$ = 0.499; $PSI_{Li}$ for LTs in $LU_1$ =0.3856; and $PSI_{Li}$ for LSs in $LU_1$ = 0.599. The average $PSI_{Li}$ for $LU_1$ = 0.4951.* Thus, $f(x) = (\frac{\sum_{l=0}^{c} SI_l}{c})(\sum_{m=1}^{p} \alpha_m f_m(x))$ = 0.4951 * 0.775 = 0.3837

## 5 Conclusion

It has been demonstrated that there is the possibility of applying learning analytics techniques to learning personalization. A methodology is presented for enhancing the quality and effectiveness of learning by learners. It is proposed that the use of FSLSM and appropriate learning styles questionnaire can be used for identifying learning styles of certain learners. Establishment of suitability indices of learning tasks for certain learners is done through evaluation by experts.

Additionally, learning analytics are employed to establish the exact LOs and activities carried out by the learners in the VLS and the extent of use. If it is noted that personal learning styles of learners and optimal LUs show some mismatch, appropriate adjustments are done. Practically in the learning institutions, the level of application of personalized LUs in the pedagogy determines the level of competences exhibited by learners in terms of knowledge, skills and attitudes.

The study has proposed a model based on MCDM criteria identification principles for personalized LUs' suitability, acceptance and use. Also proposed are: an evaluation model based on learning components and an UTAUT model based on ETAS-M. Authors argue that to personalize LU's components and the whole LU, correct identification of corresponding probabilistic suitability indices should be carried out. At the same time, learning analytics should be applied in a proper manner. The model in this study is both component- and ETAS-M-based. The model is more convenient when compared to purely components based ones. It is believed that the enhanced convenience level manifested in the comparison is attained because the described comparison is solely based on the evaluation of acceptance in addition to the use of LU developed / made / prepared by the participants, which fully reflects the participants' needs and perspectives. Even better is the fact that high-level technological expertise is not required for this kind of model.

Tutors of all cadre can use their specific domain knowledge to create optimal LUs by establishing learners' profiles based on FSLSM. Tutors can create learning styles by letting learners fill Soloman-Felder questionnaire with immediate output for analysis. Computation of learning styles' suitability indices can be easily done using mathematical formulae in an excel workbook.

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# An Investigation into Best Practice Approaches for Computing Research Programmes in South Africa

**Full Paper**

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**Abstract.** The purpose of this paper is to identify best practice approaches to teaching research in the field of Computing in South Africa. The methods used included a systematic literature review and a preliminary investigation of seven South African higher education institutions. The findings revealed a set of outcomes and best practice approaches to address these outcomes. The most popular research methods used in Computing in the seven largest higher education institutions in South Africa were identified as literature reviews, data analysis and case studies. The primary challenges reported related to over dependence on supervisors, writing skills, critical reflection and confusion regarding the wide array of research methodologies. The findings provide a high-level understanding of postgraduate research in Computing disciplines in South Africa and indicate a need for more research on curriculum design for teaching Computing research in South Africa using best practice approaches such as integration, reflection and a common research culture.

**Keywords:** Computing Research Methods, Research Methodology Education, Research Outcomes, Best Practice Teaching Approaches.

## 1 Introduction

The provision of relevant and high quality education on research methodology in postgraduate (Honours, Masters and Doctoral) curricula in higher education institutions (HEIs) is of increasing interest to researchers and educators globally [1, 2]. One of the reasons for this interest is the increase in the volumes of data in our society and the emphasis of a knowledge-intensive economy resulting in a higher demand for a postgraduate education [1]. Involving students in research improves their employability

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since it provides them with increased critical thinking and analysis skills; development of intellectual independence and self-confidence; and the ability to think like a scientist [2]. Teaching research skills at a postgraduate level, however, requires considerable effort, and includes a significant body of knowledge in research methodologies [1]. Postgraduate students struggle with many challenges related to understanding and applying the various research methods. An acknowledgement of the realities of the contemporary doctorate and also the increasing complexity associated with the supervisor role has been highlighted [3]. Another challenge is that the relationship between theory and practice is often not considered [4].

Understanding research methodology is critical to undertaking high-quality research [1]; however, it is one of the most challenging competencies to teach [1,5]. A research methodology is defined as 'the strategy, plan of action, process or design lying behind the choice and use of particular methods and linking the selection and use of methods to the desired outcomes' [25, p. 3]. The terms "research methods" and "research methodology" are often used interchangeably. However, they differ theoretically in scope, form and function. Research methods are defined as a selection of approaches that can be used to gather/collect data in order to interpret the data and make inferences [7].

The benefits of teaching research methodologies to Computing postgraduate students are to recruit and retain more students; improve efficiency and staff utilisation; and to empower the teaching faculty [8]. However, several studies [2, 3, 9, 10] have identified the challenges with teaching research skills to Computing students in postgraduate programmes in HEIs. According to [11], the field of Computing can be broken down into the disciplines of Computer Science (CS), Software Engineering (SE) and Information Systems (IS). In addition we have as a related field, the discipline of Information Technology (IT) or Information Communication Technology (ICT). For purposes of this paper, Computing will refer to all of these disciplines. Computing is a diverse and often interdisciplinary field, which has led to researchers borrowing methodologies from other disciplines such as business, psychology or mathematics [12]. Research methodologies for Computing therefore remain relatively premature and finding the appropriate experts and material in the diverse range of methodologies used by students in Computing postgraduate programmes is very difficult [8, 13].

Globally there are limited studies on teaching research to Computing students and actual experience reports are rare [2]. There is also limited advice with regards to how the forms of learning approaches can be integrated into a curriculum [14]. Healthy dialogue among the various stakeholders of Computing research is needed, which can support the development of a mature research culture [12]. In Africa high quality and important research is taking place but the continent produces only 1.1% of global scientific research [15]. Africa and its HEIs need to make far greater contributions to world knowledge and the need for high quality research education is critical. There is an urgent need for investment in research and development particularly in science and technology and the implementation of the outcomes of scientific and developmental work.

This paper aims to reduce this gap and to address the following research questions:

RQ1. What challenges are encountered when designing a curriculum to teach research methodologies to Computing postgraduate students?

RQ2. What are best practice teaching approaches (outcomes considered, methodologies/methods adopted and activities) used in Masters and PhD programmes at HEIs globally and locally (in South Africa), specifically for Computing programmes?

In our literature review on approaches to teaching research in Computing in global and South African HEIs, the studies that were identified were mostly literature review papers with few empirical evidence papers or reports on actual curricula or research methodologies adopted in postgraduate programmes in HEIs. Only a few studies of South African programmes were found, and even fewer of those were published in the last five years. From our literature review of global and local studies, best practice approaches are proposed. These approaches support a rich set of alternatives for imparting knowledge of research methods and design in Computing.

The structure of this paper is as follows: Section 2 describes the research design used in this study. Section 3 reports on the findings of the literature review, which resulted in a set of desired outcomes for Computing research programmes and common challenges faced. In Section 4 best practice approaches to teaching research are identified from the literature. Section 5 explores the South African higher education context and reports on the findings of an analysis of seven South African HEIs. The paper concludes with a discussion on the implications and relevance of the research in Section 6 and the conclusions and recommendations in Section 7.

## 2 Research Design

This study started with a systematic literature review as recommended by [16] to determine best practice approaches for teaching research in Masters and PhD programmes at HEIs globally and in South Africa. This review followed the three stages of literature review recommended by [16]: 1) inputs (literature gathering and screening), 2) processing (using Bloom's Taxonomy), and 3) outputs (writing the review). The findings highlighted several common outcomes, challenges faced and approaches adopted (including methods/methodologies and activities) that should be considered when designing postgraduate Computing research programmes. A preliminary, exploratory and qualitative investigation was conducted into seven HEIs offering postgraduate Computing qualifications. The nine participants who volunteered to be part of this investigation were all leading researchers involved in postgraduate programmes in Computing in South Africa. Each participant was emailed a short questionnaire, which related to their experiences regarding research outcomes, teaching

approaches adopted and challenges faced in their postgraduate Computing programmes.

# 3 Literature Review

## 3.1 Outcomes of Computing Research Programmes

Holtz et al. [8] identified 22 outcomes/skills for Computing research curricula, which can be classified into core/generic skills and research specific skills. These outcomes were confirmed by [2] in the field of SE, and two additional outcomes were cited, namely writing a research paper and conducting peer reviews. Writing a research paper could be considered to form part of the Presentation category of outcomes, whilst conducting peer reviews can be considered as forming part of the Literature review category. The study of [2] was in the field of SE and only recommended statistical analysis for data collection. For the field of Computing, this is extended to include qualitative data collection. The outcomes in [2] as well as the phases of research proposed by Steenkamp [10] were used as categories to classify the outcomes as shown in Table 1.

**Table 5.** Outcomes for Computing Research Programmes.

| CATEGORY | OUTCOME/SKILL |
|---|---|
| **SPECIFIC RESEARCH OUTCOMES/SKILLS** | |
| Planning | Proposal development [8, 17] |
| | Problem identification [17] |
| Literature Review | Search literature [8, 16] |
| | Critical reading and evaluation of scientific literature [18] |
| | Scan and select relevant papers [8, 16] |
| | Analyse and critique literature [8, 16] |
| | Synthesise knowledge from a number of sources [18] |
| | Conduct a conceptual analysis/propose a conceptual solution [10, 19] |
| Methodology | Formulate research questions/hypotheses [8] |
| | Identify ethical concerns [8] |
| | Choose and motivate methodology [10] |
| | Select research methods, data collection methods and research instruments [17] |
| Data Analysis | Collect, verify and analyse data [8] |
| | Conduct statistical analysis and/or experiments [10] |
| | Evaluate results [8] |
| Critical Thinking | Critical thinking [9] |
| | Ability to make logical arguments [18] |

| | |
|---|---|
| | Draw conclusions and identify limitations [8] |
| | Link research to body of knowledge [8] |
| | Connect theory to practice [8] |
| **CORE/GENERIC SKILLS** | |
| Presentation | Present results: oral [8, 18] |
| | Present results in dissertation or thesis [8] |
| | Present results: other (for example publications) [2] |
| Project Management | Competencies related to executing a research project (for example, engaging with stakeholders and teams) [10] |

An additional category of Planning was identified with problem identification and proposal development as outcomes [17]. Within Planning, an analysis of problems in the research domain should be performed and a proposal developed [10]. The proposal outlines the problem to be investigated, the scope of the project, the research approach to be followed, a literature review, the method of investigation and estimated project schedule. The importance of a thorough literature review in IS research has been noted, but has been lacking [17]. As part of a literature review students must be able to define the concepts, principles and methods in the various related fields of Computing [10]. This review forms the basis for conceptualising a solution to the research questions under consideration and includes the ability to find literature in libraries, online databases and on the WWW as well as appropriate search strategies [18]. Conceptual analysis involves conceptualisation of a solution, whereby the researcher formulates a theoretical conjecture that represents a possible conceptual solution to the research question or hypothesis [10]. The conceptualisation could be a graphical model of an empirical generalisation, a mathematical formula representing the conceptual solution, or a description of a grounded theory.

In the Methodology category, the SIGCSE-CSRM [13] clearly highlights the need for a rich pedagogy to teach research methods in the field of Computing. Students must be aware of the many possible research strategies in Computing [20] and should be able to select appropriate methods based on the nature of their research problem [17]. They must also have a knowledge of best practice in applying a research methodology in the field of Computing. Identifying the type of research (theoretical or experimental) is a key question used to determine an appropriate research methodology problem [17].

In CS and SE, researchers usually produce technical artefacts (for example, methods, algorithms or systems), whilst IS studies predominantly explore things such as theories, techniques and projects. In CS and SE the products are mostly based on the rules and practices of mathematics, and not on theories from other disciplines. IS research projects are usually undertaken in an organisational context and are usually behavioural and theory-based. In addition to using IS-based theories, IS researchers often adopt

theories from other disciplines [17, 20]. A taxonomy of research methods for Computing published in [11] has 19 categories: action research; conceptual analysis; conceptual analysis/mathematical; concept implementation (proof of concept); case study; data analysis; descriptive/exploratory survey; ethnography; field experiment; field study; grounded theory; hermeneutics; instrument development; laboratory experiment – human subjects; laboratory experiment – software; literature review/analysis; mathematical proof; protocol analysis; and simulation. The ability to conduct experiments whereby the conceptual model is demonstrated and the proposition(s)/hypothesis(es) validated is important [10]. The nature of applied research in the field of IT/IS management (which concerns people, processes, policies, software, hardware and infrastructure) necessitates that a flexible research process model be adopted which allows iteration among processes and accommodates theoretical and empirical research. Both quantitative and qualitative methods have been used. The research onion [21] is commonly used to help researchers in discussions and design of a methodology and provides a logical progression through which a research methodology can be designed, moving from the research philosophy, approach and strategy to time horizons and data collection methods. However, the main focus of the research onion is on the business disciplines and it does not consider more recent, popular methodologies used in the field of Computing (specifically IS and IT) such as the Design Science Research (DSR) methodology [22]. DSR allows a problem to be solved by building an artefact and evaluating it iteratively until a suitable solution is derived. Several other methods, strategies and methodologies have been reported as used within the Computing field and its sub-disciplines [10]. For example, case studies [10, 23], action research and grounded theory are all methods used within the fields of both IS and IT [24].

Data collection and analysis skills are core for research programmes [8, 10]. Students also need to develop critical thinking skills early on in the research process [9]. Critical thinking includes, amongst others, the ability to make logical arguments, draw conclusions and connect theory to practice. In addition to research specific skills, students also need generic skills such as presentation skills and project management skills. Presentation skills are very important for PhD students, since research is of no use if it is not communicated [18]. They also need to have general skill-sets related to competencies in initiating, planning and executing IT research projects [25].

### 3.2 Challenges with Research Programmes

There are many diverse approaches to conducting research and it is virtually impossible to design a single course or module that encompasses the entire spectrum of research methodology [1, 5]. It is not realistic to expect students to acquire all the competencies required to carry out the theoretical and practical aspects to conduct different research methods, all in one course. Lecturers therefore face the problem of what to teach. Lecturers also struggle with guidance relating to how to teach research, since there are

opposing views on how to do this [1]. Traditional researchers believe that there should not be a formal way of learning research and that it should be learned "along the way". With this view, you would have only 'learned' research at the end of your postgraduate degree. This method is supervisor-intensive as students who struggle to understand the concepts will depend more on their supervisor for assistance and will take up more time from the supervisor. Others argue that there should be compulsory courses, lectures or workshops/colloquia on how research should be conducted where students gain exposure to various methodologies. In these courses, lecturers tend to use a traditional lecture format rather than providing practical examples for theoretical concepts and do not encourage discussions and critical thinking [1, 14]. Furthermore, textbooks are typically too prescriptive and present research designs as being essentially linear, which is not always an accurate reflection of the true process of research [5]. The time it takes to select appropriate materials to fulfil the course objectives is extensive [9]. In addition, giving students regular assessments and feedback is time consuming.

Researchers [1, 5, 9] have reported psychological challenges faced by students such as learning shock, frustration, anxiety and confusion. Students often do not understand how to conduct and report on a critical literature review so as to ensure coverage of the breadth and depth of the research topic [1]. There is also unfamiliarity with the research "jargon" describing fundamental concepts. Novice researchers could be resistant to working with literature for several reasons [26]. Firstly they may not have much experience in working with literature. Secondly, theories are an unknown terrain and choosing one is difficult. Thirdly, integrating the theory into their own research can be challenging. Students struggle to motivate the selection of the methods adopted and to implement them, especially with regards to quantitative and statistical methods [1]. They also struggle to compile well worded research questions and to align these questions with the methods and analysis of data. The selected methodology/methods are often not well motivated and do not meet the research objectives or questions. One of the reasons could be that the selection of a methodology to adopt in students' projects is often dependent on criteria such as familiarity with a particular method, general level of comfort using the method, domain of what is being studied, and the nature of questions being asked, as well as the supervisor's influence and expertise. Other problems relate to deciding on a suitable sampling strategy and dealing with low response rates in surveys.

Whilst the challenges related to teaching research are common to many disciplines, there are several that are unique to Computing [12]. One of the main challenges is the diversity of sub-disciplines within Computing and the fact that relative to other disciplines it is considered a new discipline. Comprehensive expert knowledge related to using a particular research method is lacking. There is a lack of clarity regarding what material should be taught and a lack of resources from which to build a course

particularly relating to Computing research projects [9, 13]. This leads to the need to tailor some of these research methods specifically for Computing.

## 4 Best Practice Teaching Approaches for Research Programmes

Conventional approaches to teaching research methodology emphasise the method and techniques instead of the methodology [4]. To overcome this an active and integrated learning approach was adopted in a PhD Programme in Iran where the methods are driven from methodological theories and students work together on a continuum paradigmatic approach from a methodological to a practical tradition. The approach was integrated since it allowed students the opportunity to equilibrate between the underpinning theory and the research methods selected. The students reacted positively to this approach, which included running pilot interviews and using NVIVO to analyse the interview data. NVIVO is a software program for analysing unstructured qualitative data. A similar integrated approach was successfully adopted for teaching research methodology using active engagement by students [14]. Two PhD programmes in the United States also implemented successful active learning and hands-on approaches to their PhD programmes [18, 28], which were found to be very rewarding for the students. Students got their hands dirty and learned first-hand about the constraints that bind the research process. Both instructors and students can benefit from this teaching strategy. It gives the instructor an opportunity to integrate research with teaching, and to inject students directly into an active research agenda. Specific activities recommended in these approaches were: group work activities related to data analysis and data collection techniques; comparisons of papers and testing hypotheses.

These active and integrated approaches for teaching research are in line with Merrill's [29, p. 44-45] five first principles of instruction, which are that learning is promoted when:

- Learners are engaged in solving real-world problems;
- Existing knowledge is activated as a foundation for new knowledge;
- New knowledge is demonstrated to the learner;
- New knowledge is applied by the learner; and
- New knowledge is integrated into the learner's world.

Another approach to teaching research methodology is one of reflective practice in a design studio environment that emphasises the need for the researcher to use methods and techniques in a way that allows them to select and respond in suitable ways to specific and often complex changing events [5]. This approach is similar to that of a design studio and the focus of a research methodology course is shifted away from the methods and approaches to the research design. A good design is one where the elements work harmoniously together to promote successful and efficient functioning. A good design also fits its use and its environment, whereas a design that is flawed can lead to failure or poor operation. Research design should be conducted not as a linear,

one size fits all process, but rather as a reflective practice. Multiple lenses should be used to view phenomena and to acquire adequate knowledge thereof. With this approach, continuous critical-constructive reflection is undertaken on how to align and adjust methods and techniques to the research purpose, problems and options available.

A Masters' programme in the department of CS at the University of Sheffield in the United Kingdom was accredited with a best practice award by the British Computer Society [2]. Important elements of this curriculum are an approach that: a) promotes a stimulating research climate, which is important and b) integrates the taught part with research. In terms of creating a stimulating research climate the following should be included: develop a sense of collegiality, research culture, collective responsibility and strong emotional support and guidance.

An early study of an Honours programme in South Africa [9] recommended that re research skills be acquired through a series of small, guided exercises and readings that deal with issues ranging from philosophical questions of the nature of research to nitty-gritty issues like how to cite papers. Another South African study of an IT research methodology course in a PhD programme [10, 17] used an active and reflective learning approach where students and faculty were encouraged to reflect, compare, challenge, restate, summarise, integrate, and apply their ideas, thereby enhancing their skills to define, design and conduct research projects. Various research seminars/colloquia took place throughout the course, some conducted by faculty members and others by students. Seminar assignments were designed by the teaching team to reinforce the topics addressed in the respective seminars, and were intended to inform students about how to conduct the research processes and select methods and tools to perform their own research project. In this way students and faculty members share a "common research language" that promotes information exchange and dialogue among students and faculty members. Students responded positively to the approach with appreciation for the wide exposure to the field of research methodology. The pedagogical assumption [10] was that there is no one "correct" approach to designing a research project, although inappropriate approaches to a given problem are analysed during the course.

## 5 Computing Research in the South African Context

In 2001, the National Plan on Higher Education in South Africa [29] sought to give effect to the following priorities:

- increase the graduate output, especially doctoral gradates;
- increase research outputs;
- sustain existing research capacity and create new centres of excellence;
- facilitate partnerships and collaboration in research postgraduate training; and
- promote articulation between the different elements of the research system.

According to a recent report by the South African Department of Higher Education and Training (DHET) [29], over the past decade research productivity in South Africa has been on a steady rise across all institutions, particularly publications in journals. This increase could be attributed to a number of factors including an increase in the number of researchers with doctorates as highest qualifications; the publication subsidies instituted by the DHET; the ability of institutions and researchers to attract research funding from various sources locally and abroad; improved infrastructure and institutional strategies and policies. The distribution of journal publications by broad academic fields has been consistent in the past few years, with over half of the journal publication units accrued to the Science, Engineering and Technology (SET) field (58%). From 2015 to 2016, the South African Classification of Educational Subject Matter (CESM) category 06 (Computer and Information Sciences) showed an increase in the number of output units for all types of publications. This is commendable under the many challenges researchers face within South Africa. The Centre for Research on Science and Technology (CREST) report [30] outlines some of these challenges as:

- the 'pile up' of students caused by increasing enrolments at Master's and PhD level;
- the increasing 'burden of supervision' on South African academics;
- the unavailability of young lecturers to supervise immediately and the ageing of the more senior supervisory cohort who may not be taking on new students.

The CREST report states that *"for any supervisor in South Africa the focus is on simply keeping their heads above water with notions of excellence probably far from their minds"*. This highlights the importance of providing mechanisms to support supervisors in the supervision of quality research outputs as stated in the definition of Master's and Doctoral (PhD) Degrees provided by the South African Government Gazette [31].

In order to answer the research questions of this paper and determine outcomes, methods/methodologies taught and approaches undertaken for Masters and PhDs in Computing in South Africa (CS, IS and IT), a preliminary investigation was conducted. In South Africa there are 25 HEIs [29] that are publishing research. In our investigation, seven of the large HEIs with high research publications in South Africa were contacted and asked to give input related to the proposed outcomes listed in Table 1. The original list of 24 outcomes was reduced to a shortened list of 17 outcomes by combining several related outcomes. Participants were asked to share any challenges they have encountered regarding postgraduate studies. Nine participants respondents with five from IS, two from CS, one from both CS and IS, and one from IT.

The results for the research outcomes were analysed and sorted according to their calculated rankings ($Rk$). These rankings were based on the participants' ratings

according to the importance of each outcome for postgraduate studies, where a score of 0 was assigned to those outcomes of "no importance"; "1" for those of "limited importance"; 2 for those deemed "important"; 3 for those of "relative importance" and 4 for those considered to be "very important". This score was multiplied by the frequency of occurrence to determine a final ranking *(Rk)* for each outcome.

From Fig. 1 it is evident that the ability to "analyse and critique literature" *(Rk = 36)* as well as "scan and select relevant papers" *(Rk = 36)* had the highest rankings. This was closely followed by the ability to "link research to body of knowledge" *(Rk = 35),* "draw conclusions and identify limitations" *(Rk = 35),* "evaluate results" *(Rk = 35)* and "search literature" *(Rk = 35).* The ability to present written results *(Rk = 34)* and "collect, verify and analyse data" *(Rk = 33)* followed, with "choose methodology" *(Rk = 32)* close behind. It was interesting to note that "Writing research proposals" *(Rk = 24),* "project management" *(Rk = 22)* and "engaging with stakeholders and teams" *(Rk = 22)* were considered relatively unimportant. One of the participants mentioned that "citations" and "similarity count checking" were further outcomes required of their postgraduate students. This refers to the ability of students to reference and cite literature sources correctly and to ensure that they avoid plagiarising the work of others.

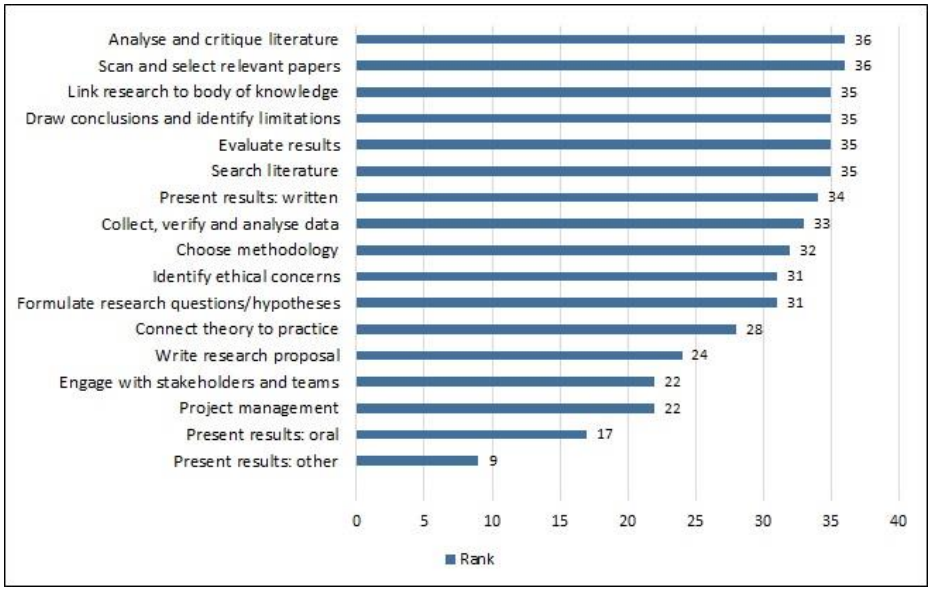


**Fig. 3.** Research Programme Outcomes.

The results for the research methodologies/methods were analysed and sorted according to their calculated rankings. These rankings were based on the participants' ratings according to the extent to which each research methodology/method was considered to be used within the postgraduate Computing research programme at each university. The taxonomy of research methods for Computing published in [11] as mentioned in Section 3.1 were used in the investigation. A score of 0 was assigned to those methodologies/methods "never" used; 1 for those used "rarely"; 2 for those "sometimes" used and 3 for those used "often". This score was multiplied by the frequency of occurrence to determine a final ranking *(Rk)* for each methodology/method used. From Fig. 2 it is evident that "literature reviews" *(Rk = 26)* and "data analysis" *(Rk = 26)* are most utilised, followed by "case studies" *(Rk = 23);* "descriptive/exploratory surveys" *(Rk = 22);* and "conceptual analysis" *(Rk = 22).* Close behind with the same ranking are "DSR" *(Rk = 20)* and "proof of concept" *(Rk = 20).* It is interesting to note that "ethnography" *(Rk = 7),* "grounded theory" *(Rk = 7)* and "mathematical proofs" *(Rk = 10)* are not often used. One reason for the low frequency of mathematical proofs could be the low response with regards to CS departments.

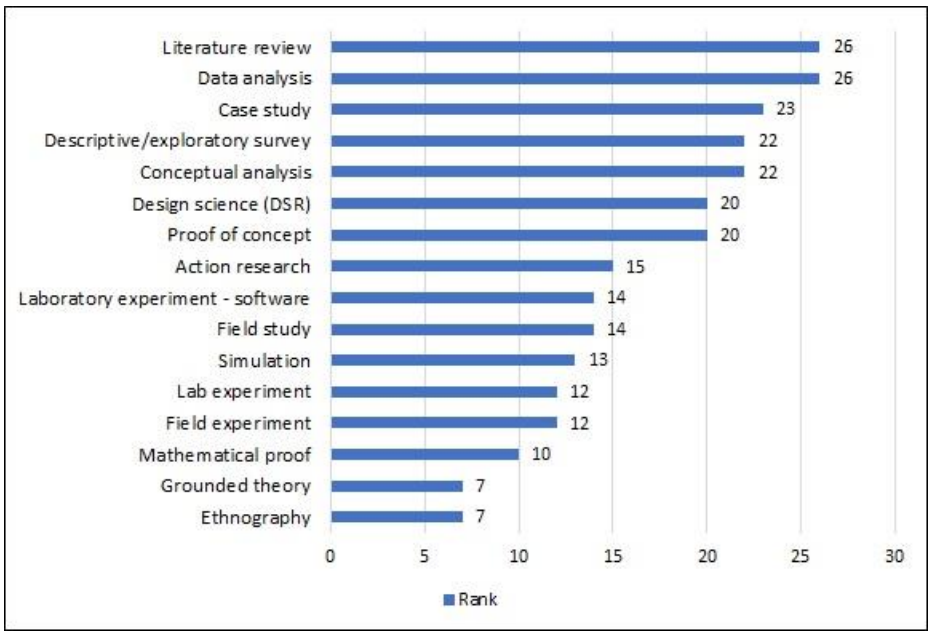


**Fig. 4.** Research Methodologies/Methods Adopted.

Participants were asked to rank each of a list of teaching approaches in order of frequency used with 1 indicating "most frequent" and 6 indicating "least frequent". However, not all participants ranked each approach accordingly, with some approaches

being given the same ranking as others. Despite this, it is evident from the results that many of the participating HEIs still rely on the knowledge of the supervisor/promoter and self-study or learning "along the way" by the student (as described by [1] and [3]), followed by research methodology workshops, regular research colloquia and research methodology lectures. The heavy reliance on the knowledge of the supervisor/promoter is a great concern, confirming the study of [1] and [30]. This indicates a need for best practice approaches for Computing research programmes.

Participants were also asked an open-ended question that required them to specify the challenges they faced. The main challenges identified related to the following three themes: 1) writing skills, literature review and critical reflection 2) the confusion regarding the plethora of research methodologies and 3) project management and culture.

The challenges identified by participants regarding writing, literature and critical reflection confirm the studies of [1, 26]. Comments provided related to these challenges included:

- *"Writing skills of students – we now offer lectures on academic writing to the M and PhD students".*
- *"Many postgraduate students battle with technical writing skills. We have recently employed an intern to assist students in this regard."*
- *"In Open-distance learning, we have students from different backgrounds with varied levels of preparedness. Academic writing and critical reflection and argumentation skills are difficult to teach".*
- *"Lack of ability by students to complete appropriate literature searches, and getting entrenched in popular media resources."*
- *"Critical thinking is sometimes a problem. The students seem to want to follow a "template" in order to complete their manuscript. Sometimes writing is not at the standard it should be. Ethical approval is sometimes laborious and restrictive. The students often find a job and start working halfway through their studies and this hinders them".*
- *"Lack of ability by students to identify research questions and the core points from literature".*

Statements related to challenges with methodologies confirm the study of [10] and included the following:

- *"There is a very different focus on the role of research methodologies (and the interpretation of what is meant by "methodology") between CS and IS. It all comes down to the field of the examiner. Discussions that would appear superficial and pointless to one examiner would be considered essential by another examiner".*
- *"Getting expertise on the diverse range of methodologies is a struggle".*

- *"Research methodologies within Computer Science can vary drastically from sub-discipline to sub-discipline. It is important for students (and lecturers) to realise this"*
- *"Research methodologies are varied in applicability amongst research topics. Not all stakeholders (supervisors) are enthusiastic about looking into and get more knowledge on different research methodologies and tend to stick to what they know. With the course work masters, we have 2 modules in research methods and communication. With the full masters we will be using a workshop approach to incorporate these topics".*

Challenges regarding project management and culture confirmed those reported by [10]. These challenges were stated as*:*

- *"Time management skills of students – lack of adequate milestone planning and underestimation of data collection and analysis."*
- *"Lack of ownership of projects (student expectation of hand holding and thinking there is a simple 'template' for research), which impacts on the creativity in their research process."*
- *"Data collection problems, especially if students identify a population, but can then not gain access due to 'red tape' at the given site."*
- *"Getting students to attend lectures and workshops is always difficult."*

An interesting comment related to the use of weekly colloquia, which was not really a challenge, stated that *"In the past we have found that weekly colloquia sessions are effective. Each session would address a specific research topic and students were encouraged to interact during these sessions".*

## 6 Discussion, Recommendations and Conclusion

Curriculum design must firstly consider the outcomes of the programme as well as the teaching approaches and activities. In this paper, a set of outcomes for Computing research programmes was identified from the literature review (Table 1). These outcomes should be considered when designing teaching approaches and activities. Best practice should also be considered. From a review of a best practice programme in the United Kingdom [2] and other empirical research studies [4, 5, 10, 14], two main elements were identified as key to a Computing research programme curricula, namely: integration and stimulating research culture. The term integration refers to integrating both formal teaching and active learning approaches. An active learning approach should include hands-on practical activities and exercises that are designed based on getting a student's hands dirty and that address one or more of the outcomes, in some cases with related assessments and reflective practice. A stimulating research culture should incorporate approaches that provide strong emotional support and guidance; a sense of collegiality and corporate responsibility and ultimately a common research culture.

The findings revealed that several of the challenges identified by the seven HEIs confirmed those found in theory. These challenges related to writing skills, literature review, critical thinking; confusion regarding the vast array of research methodologies; project management and culture. The challenges encountered can be barriers to the success of adoption of any programme in an HEI, and therefore these also need to be considered when deciding on what teaching approaches to use. The findings revealed the most popular methodologies used in the seven largest higher education institutions in South Africa in Computing are literature reviews and data analysis followed by case studies, descriptive/exploratory surveys, conceptual analysis, DSR and proof of concept. With regards to popular teaching approaches and activities, participating HEIs mainly rely on supervisor knowledge and support and self-study or learning "along the way"; confirming the studies of [1] and [30]. Other approaches used were workshops/colloquia and lectures.

When comparing the results from the South African investigation with best practice in literature, initial indications reveal that additional research into improving approaches for teaching research could be beneficial. Whilst there are some successes, such as the increase in research publications, there are still several possible areas for improvement. Student success in South Africa seems to be highly dependent on supervisor support (the traditional approach) and needs to be addressed. Students should rather learn by doing in an active learning approach rather than learning along the way. South African programmes should consider offering a more integrated and reflective approach in order to offer more flexibility. More workshops/colloquia and group activities should be conducted since these have been shown to encourage a common research culture and improve the feeling of student support. These approaches can reduce the workload of supervisors.

The two research questions identified in this study were successfully answered using a systematic literature review and an analysis of existing curricula globally and in South African HEIs. In conclusion several contributions are made in this paper for both researchers and educators; these are a set of outcomes (Table 1), challenges and best practice teaching approaches (Sections 4 and 5) for Computing research postgraduate programmes that can be used in curriculum design. From the findings it can be deduced that further effort still needs to be made in terms of improving curriculum design for teaching CS research in South Africa. Two limitations of the preliminary investigation reported on in this paper were the small sample size and that only a qualitative analysis was done. Our larger study will conduct a far more extensive investigation and also address other issues related to curriculum design of Computing research programmes such as pedagogical aspects such as scaffolding and activity design. Other future research could consider undertaking a larger study that possibly includes all the universities and more CS departments. It would also be interesting to compare the South African results with a similar study of HEIs in other countries.

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# The Application of Teaching Interventions in a First-year Fundamental IT Course in Improving Throughput Using the PAC Framework: 2013 to 2018

**Full Paper**

**SACLA 2019**



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**Abstract.** South African students come to university with vastly different background and skills and are grouped together in general first year courses. All first-year students at university are introduced to an information technology and information literacy subject, called Academic Information Management (AIM), where they have to be able to pass the course as a prerequisite for their future courses and assessments. From 2013 to 2018, new teaching interventions were introduced annually and the success rates of the students were measured in terms of comparing the intervention with the pass rate. The Providers, Activities and Contexts (PAC) Framework is used as a structure to place the teaching interventions in context. It is concluded that technology as a teaching tool can assist universities to manage large groups of students, but also ensure an upward trend in throughput. A short comparison is drawn between other large university groups, mostly locally, but also internationally. Future research will expand the comparison of other courses with large numbers to AIM, both nationally and internationally.

**Keywords:** Teaching Interventions, Technology, PAC Framework, Blackboard, Learning Management System, Student Throughput.

## 1 Introduction

First-year university students in South Africa have vastly different information technology and information literacy skills, ranging from highly proficient to completely novice [1]. It is the university's responsibility to provide the necessary fundamental

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training to all their first-years, as the skills are required to successfully complete assignments and activities. Also, multilingualism, varying academic readiness and large class sizes [2] lead to a need for contextualized teaching approaches focusing on a variety of teaching methods and interventions. This paper illustrates by means of an example drawn from a large, residential university how student needs are met in applying different interventions in an Academic Information Management (AIM) course and how it affects student throughput over a period of six years, using the Providers, Activities and Contexts (PAC) Framework.

## 2 Background

In South Africa, the diverse demographical composition is evident, with eleven different official languages and a myriad of cultures [3]. The majority of the population is poor [4], with minimum exposure to technology in their secondary schooling. This means that many first-year students are only exposed to technology after enrolling at a university [5]. It is pivotal that first-year students are introduced to technology in an environment that caters for all students and provide them with enough opportunities to learn and excel using technology.

A major challenge remains multilingualism, where only a half percent of the African population speak English as their home language [6]. English by itself is difficult and is often only a student's third- or fourth language, but all subjects are presented in English. One also cannot move away from English as the language used in IT. It is therefore important to keep in mind that students might struggle with the IT jargon in order to master the AIM courses.

Another challenge is the fact that student numbers increase annually. In 2013, the number of students enrolled for AIM was 2 968 and in 2018 the number was 5013, an increase of 69%. From 2000 to 2012, the state subsidies universities received declined from 49% to 40% [7]. The universities often lacks the financial resources to build bigger IT laboratories to cater for the growing student numbers, leading to larger numbers of students in classes, with less personal help and guidance, if needed to follow the lecture. Also, in 2015/2016, the #FeesMustFall movement led to a fee-freeze in 2017 and the subsequent promise of free higher education for all by the governing party [8], placing further financial constraints on universities, as well as even larger class numbers. It is within this university context that the universities have to cater for all the students, but also ensure annual pass rates improve [8].

Students require more help to pass their subjects and universities have to cater for their needs by making available additional resources.

## 3 Technology as a Teaching Resource

Technology is known as one of the greatest resources used at educational institutes and provides a platform to enhance teaching, learning and assessment [9]. There are many learning styles, but one of the most used in today's tertiary environment is the blended learning approach [10], where technology is used together with traditional methods to assist students to perform better in their courses. Blended learning is also referred to as hybrid learning, with benefits such as improved large-group efficiency and acquisition of skills [11]. Blended learning assists students to gain more independence in their studies, have other tools than merely face-to-face learning, while also enforcing individual accountability [12]. A study in Malaysia explains why large groups of students have become the norm and highlights the usefulness of the blended learning classrooms [13].

In the AIM course, technology has proven to be very successful. The cloud based Learning Management System (LMS): Blackboard, provides the AIM courses with the advantage of increased availability to students and great communication, feedback and tracking. A study at the University of Limpopo, where 42% of students stated that Blackboard Learn has improved their computer skills performance, with a further 62% of students stating that Blackboard Learn had a positive influence on learning [14].

In the AIM courses these features are used extensively to communicate at any point in time on the students' progress. Assessments are set up as to provide immediate feedback on objectives not met and the course of action to take. The Grade Center in Blackboard Learn is also an invaluable tool used, the different technologies integrate with Blackboard to sync marks automatically for large numbers of students, thereby cutting out the administration of manually entering the marks. Technology assists to eliminate human error and saves hours of data capturing.

Textbooks used in the AIM course have moved from carrying big bulky textbooks to being available as an e-Book. The e-Book is always available to students when they require it. All the students' e-Books can exist on the same platform. It is described as carrying around your own library on you iPad, phone or digital device. E-Books are easily portably and because of how the e-Book is set up, it caters for many different learning styles [15]. In a white paper by Renner [16], the advantage of e-Books are outlined. Enhanced user access and book functionality is among the advantages that benefit the students at AIM. Cost saving and immediate availability is an extra benefit that students enjoy. In an article by Waller [17], it is explained that the customization of e-Books can enhance a student's learning experience and since this is the age where technology is driving education, e-Books should be implemented earlier rather than later. At AIM a custom e-Book is prescribed in the first semester of the first year. The custom e-Book is put together using the most popular series and titles that meet the objectives of the course.

Two major challenges with using technology are privacy and ethics. It is important to take cognizance of these issues and how it affects students in a blended learning environment [18], however, it is not the main aim of this paper.

## 4 The PAC Framework

The PAC Framework was introduced by Blosser and Kratcoski [19] as a useful tool in describing interventions with students suffering from hearing impairments. In this paper, the study is adapted to describe the different teaching interventions in the AIM course over a period of six years. The framework relies on the following three premises:

Premise one: Characteristics of good student performance [20]:

- Good teachers: For any intervention to ensure a positive outcome, one needs good teachers. By good teachers, it is implied that the teacher can engage with a group of students in such a way that the students are able to learn and apply new skills. In terms of the AIM course, the "teachers", or "Assistant Lecturers", as they are called, are graduate students.
- Efficacy: The AIM course, and how it is structured and presented, enable the efficient and effective every-day running.
- Continuity: The course must have a logical flow, also in how the course is presented.
- Student Participation: Students need to participate in class, but also participate in assignments and own study via the tools made available.

Premise two: A variety of teaching and learning methods [21]:

- The teaching and learning methods need to be flexible and up to date.
- Students should be able to link skills, apply it to the real world and be offered different perspectives.
- Not all learning is linear. Students do not have to start engaging in learning strategies at the beginning and end at the end of the course.

Premise three: The provider, activity and context must be clear. There are three interactive factors that need to be considered in learning [22]:

1. The task that needs to be completed.
2. The way in which it need to be completed.
3. The learner.

In terms of the PAC Framework, the factors are described as:

1. Providers: Providers have to have a meaningful impact.
2. Activities: Meeting the needs of students. These activities are further broken down:

- Planning
- Assessment
- Implementation Intervention
- Evaluation

3. Contexts: Situations, conditions and environments where interactions take place.

The PAC Framework will provide the structure in which the different teaching interventions will be placed in perspective.

## 5 Main Research Question

Taking into account the different challenges facing higher education in South Africa, there is an upward trend in the AIM students' pass rates over six years. In order to fully understand this phenomenon, students' marks were analyzed from 2013 to 2018, taking into account the implemented teaching interventions of that specific year, as well as interventions that build on one another. AIM is presented on three campuses over the course of a year, but in order to identify the effectiveness of every intervention, only the first-semester AIM course marks were analyzed of students studying on the main campus, as well as the marks of the three campuses combined. Subsequently, the two research questions asked in this paper are:

1. How effective was every intervention in terms of annual throughput of first-year students in their first semester on the main campus?
2. How effective was every intervention in terms of annual throughput of first-year students in their first semester on the three campuses combined?

## 6 Methodology

Table 1 below summarizes all the aspects involved in the AIM teaching interventions as outlined in the PAC Framework:

**Table 6.** The PAC Framework applied to the AIM teaching interventions. (Framework adopted and adapted from Blosser and Kratcoski [17]).

| **Providers: Bring about meaningful change.** | **Activities: Meeting the needs of students.** | |
|---|---|---|
| Assistant lecturer | Planning | Assessment |
| Tutor | Plan specific intervention | Evaluate efficacy |

| | | |
|---|---|---|
| Management of IT Labs<br>Technical support staff<br>Administrative support staff | Develop assessment<br>Create consistency<br>Buy-in from entire team | Test concept |

| **Activities: Meeting the needs of students (continued)** | | **Contexts: Situations, conditions and environments where interactions take place.** |
|---|---|---|
| Implementation intervention<br>Teach<br>Elicit feedback<br>Modify<br>Accommodate | Evaluating progress<br>Gather data<br>Monitor progress<br>Chart effectiveness of intervention | Class room<br>Tutor / consulting sessions<br>Assignments<br>Feedback<br>Reinforcement of concepts<br>Study environment |

# 7 Research Context

In support of the university's strategic goals, the AIM program offered views its mission as:

1. Creating an educational and intellectually stimulating environment.
2. Generating significant value for students through the quality of its courses, lecturers, and facilities.
3. Assisting students daily to achieve academic excellence, and to equip them with Business and Industry skills.
4. Remaining innovative and professional at all times.

This course history backs up its mission statement; in 1997 the management at the university communicated that all students that attend the university should not only be computer literate but also information literate before they graduate. The school of information technology was then tasked with the job to investigate and present a suitable solution to make sure all students will be digitally and information literate and carry this skill to the world of work. Many different departments and stakeholders were involved to come up with a suitable solution.

A number of constraints existed, infrastructure and resources was the biggest concern. This ultimately led to a three-year contract with an external company to present information and material developed by a department within the university. This introduced the compulsory course for all students at the university – Computer and Information Literacy (CIL). Despite a few technical and administrative difficulties, this worked well until the termination of the third party's contract in 2002. A further

committee was introduced to oversee the preparation of a new course that included information and computer literacy. All first year students had to then attend two courses offered at the IT labs of the university. These courses were structured to ensure that they were equipped with the right skills for their studies and future careers. By 2005 these courses were offered by other campuses because of the drastic increase in numbers of first year students.

An exemption exam was introduced for one of the courses, but the university also saw a drastic increase of students with no former experience to digital literacy. Many other challenges existed and the strain on the IT labs infrastructure was becoming a huge concern. One of the major challenges was the concept of a one-approach to service all students with different skills levels. This then led to a phased addition of infrastructure to cater for the growth and needs of students. By 2011 a major shift was implemented, this included a move from CIL towards a more academic approach leading to the new service courses called AIM. These courses were developed to emphasis the skills of information management concepts, in which now computer and software were view as supporting tools.

The AIM courses cover the following topics:

- Navigation Information Literacy
- Windows 10
- MS Word 2016
- MS PowerPoint 2016
- MS Excel 2016
- Browsers
- Office 2016 common features
- Blackboard
- In house Portal training
- Gmail and Google Drive training

### 7.1 The Learning and Teaching Environment

AIM is conducted in 18 computer laboratories across three campuses. AIM is offered for five session from a Monday to a Thursday. Each session has a two-hour duration. Seventeen computer laboratories are equipped with approximately 50 workstations and one laboratory with 32 workstations. All laboratories have a projector and screens for visibility. All computers are loaded with the software needed to run AIM. Each class comprises of learners from different faculties and different programs. Each learner books his/her own time slot in which to complete the AIM course according to their individualized timetable. Thousands of first-year students take AIM annually, requiring 190 laboratory sessions of 2-hours each.

Consultation sessions also exist from Monday to Friday 9.30 to 3.30 for any students that may require extra help. Apart from offering consultation, most of our classes have tutors to help the lecturers.

Each AIM courses comprises of a fully integrated LMS. The university subscribes to Blackboard. Housed in the Blackboard Classroom, are the e-Books available for students to download, compulsory assessments used for semester marks, integration building block for the digital system used, PowerPoint slides for each chapter as an enhanced resource and a very detailed breakdown of the schedule for the semester with test and exam dates. All marks for assignments and tests are uploaded or automatically synced with Blackboard. The students can determine at any time how they are doing in the course.

### 7.2 Teaching Interventions

The AIM courses are presented by Assistant Lecturers on all the campuses. All Assistant Lecturers are postgraduate students studying at the university. Novice classes have tutors present for all sessions. An intensive month of training occurs before Assistant Lecturers have to give their first class. Every Monday morning is also training to make sure the AL's understand the content and are fully prepared for the week.

2013 started off with the intervention of using hardcopies of the textbook and a very basic simulated testing environment. The students needed to carry their textbooks to class for every session and this sometimes did not work out to well, as the books were heavy and bulky. A simulated testing environment was used for exams and some assessments. Please refer to Fig. 1 on the next page.

2014 saw the introduction of a Skills Assessment Management (SAM) system. SAM is a web-based application that measures student proficiency in Microsoft Office software and technology-related topics. SAM iterates concepts of Microsoft Word, Excel, PowerPoint, Access, Outlook and Internet Explorer in addition to foundational computer concepts. "SAM uses skill-based assessments, interactive training, real-world projects and just-in-time remediation to help students learn essential computing skills" [23]. When SAM was introduced the full capability of SAM was not used, a subset of the capabilities was introduced. All assignments were based in SAM. The only function of SAM used was the assignment function.

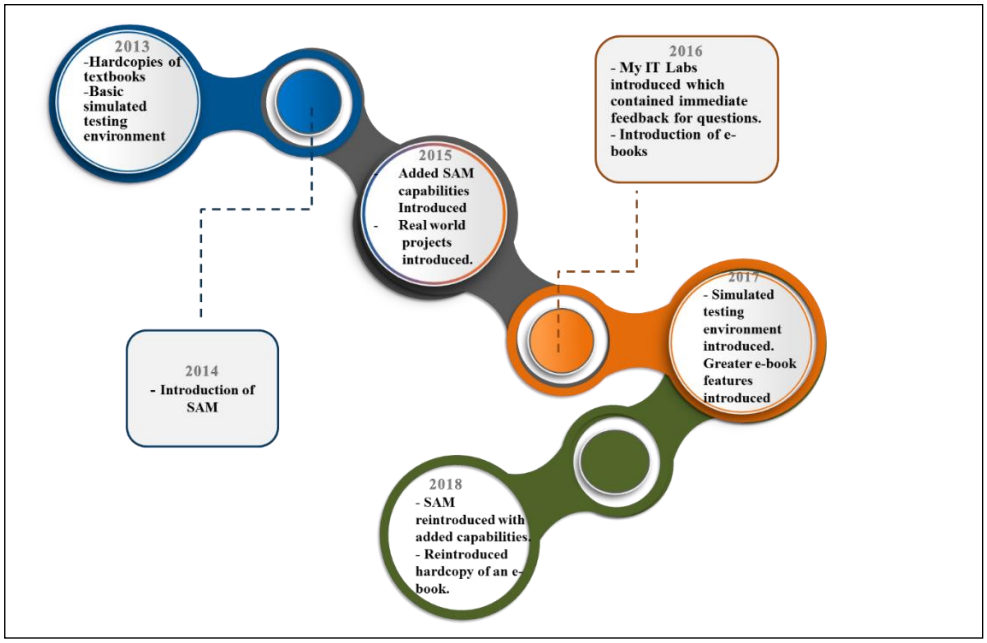


**Fig. 5.** The different interventions undertaken from 2013 to 2018 summarized.

In 2015, the extra features of SAM were introduced. Assignments and tests were now done using the capabilities of SAM. Real world projects were available on the platform which enhanced the objectives of the course. Students now had more practice in different areas of Microsoft office.

2016 saw a shift of systems due to system capabilities and budget constraints, an introduction of My Lab IT. In My Lab IT Students follow a predesigned path of activities, which can include simulations, Grader projects, and student resources, to support effective learning. Students have to master each activity before moving on to the next one. Customization of My Lab IT can be easy done for this. Students received immediate feedback when an activity is completed and can rectify errors and resubmit assignments. 2016 was also a year that e-Books were introduced and students needed to shift over from the normal tradition textbook system to an e-Book system. E-Books allowed for access across different devices and students were assured of always having access. The university's free Wi-Fi allowed students to download the e-Books and this would then be available on their devices without data charges being applied. This would allow students to study anywhere and at any given time.

In 2017 a simulated training and testing environment was used for teaching, learning and assessment. Many practice simulated tests were introduced and training was provided based on poorly answered questions or sections. The e-Book features introduced included highlights, summaries and a chance to simplify and customize learning according to one's own learning style. The e-Book platform was also more user-friendly and easy to navigate.

In 2018 the intervention were expanded from 2017 by moving back to SAM now with added capabilities. Students could now observe how a task should be done and then practice these tasks. A simulated environment was extensively used to re-iterate concepts covered in class. Novice students found the added observing capability very helpful. The observing capability also reduced the queries in class. SAM prepares the students for the real world. 2018 also saw the introduction of the hardcopy of the textbook should students prefer to learn via the hardcopy. Students now had a choice of which book to use for learning.

From 2013 to 2018, new interventions were introduced every year, this was to help students get ready for the work place and to understand basic computer concepts and computer software. The course's aim was to help students better understand the digital environment so that it will help them in all their other courses. If AIM became the golden thread that linked all courses, then the course will be considered a success.

All the interventions link to Table 1where the providers involved, the aims and outcomes of the activities are summarized and the specified contexts in order to determine the impact of every intervention. The results of the student performance follow.

## 8 Results

To determine the effectiveness of every year's teaching interventions, the data obtained from student pass rates are illustrated in Figures 2 to 5 below:

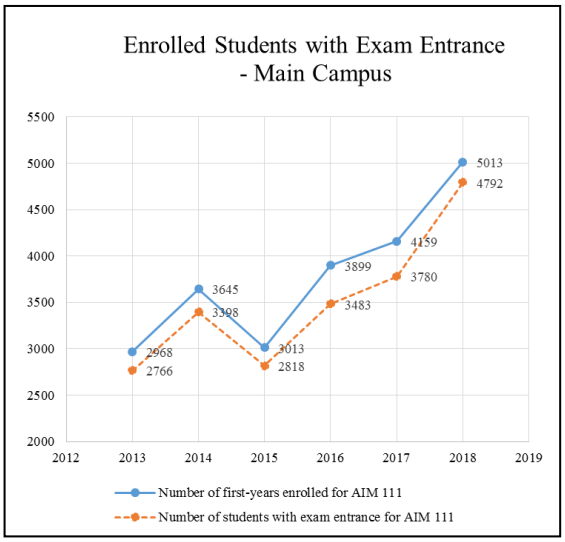


**Fig. 6.** The number of first year students enrolled for AIM on the main campus compared to the number of students with exam entrance.

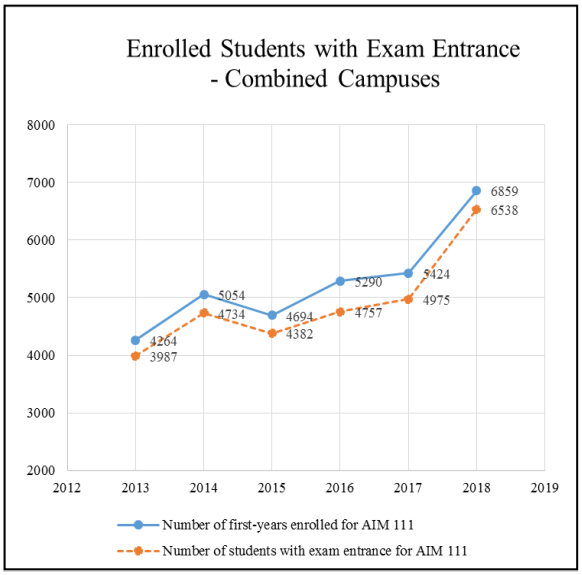

**Fig. 7.** The number of first year students enrolled for AIM on all three campuses compared to the number of students with exam entrance.

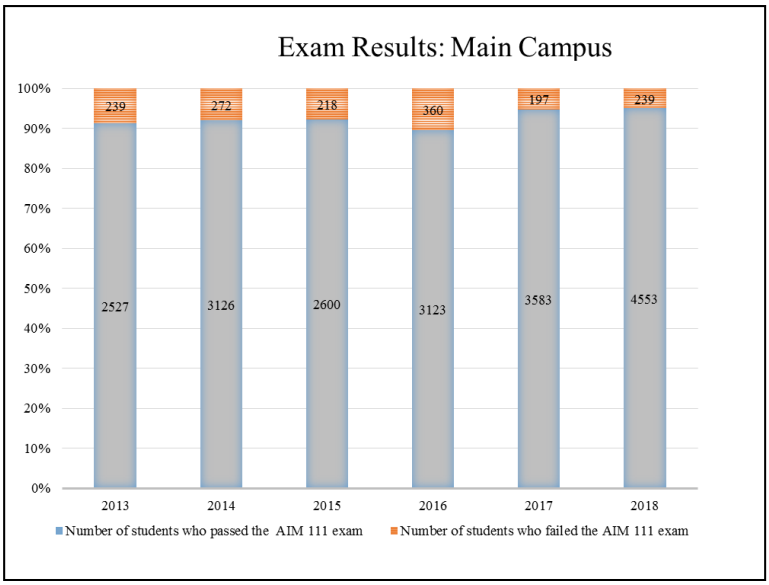


**Fig. 8.** The number of first year students with exam entrance who passed, or failed, the exam on the main campus.

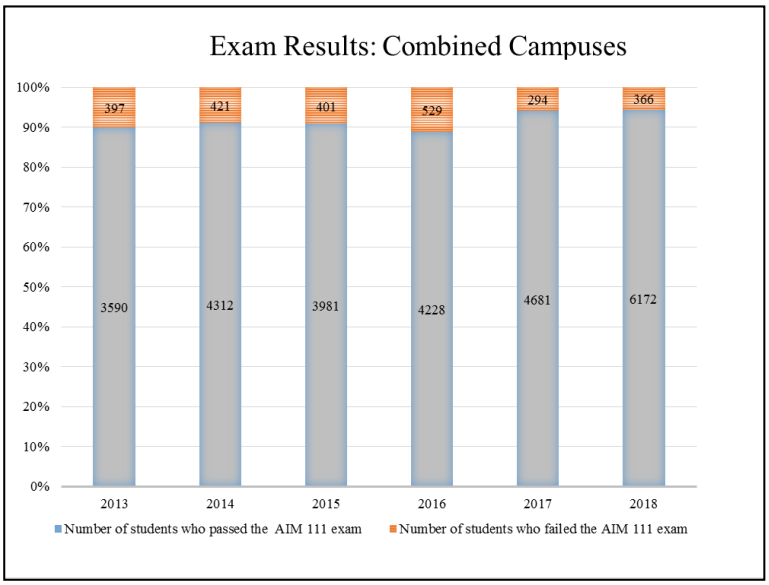


**Fig. 9.** The number of first year students with exam entrance who passed, or failed, the exam on the three campuses combined.

## 9 Discussion of Results

In 2013, 93,50% of all first-year students on all three campuses obtained exam entrance, with 93,20% on the main campus. The number of students with exam entrance are high, as it should be, seeing that the course is a pre-requisite for most of their further courses. The exam pass rate for all the students are 90,04% and 91,36% on the main campus. The fact that the main campus' overall pass percentage is slightly higher, can be ascribed to the fact that the other campuses have less sessions and are spread more remotely, thus there might not always be someone available to ask a question to if they struggle. At this stage, the hard copy textbooks were still used, with a simulated testing environment

In 2014, with the introduction of SAM, the number of students with exam entrance were 93,67% on all campuses and 93,22% on the main campus, with the pass rates 91,09% and 92% respectively. SAM made a positive impact, but it was only slightly.

2015 saw the introduction of additional SAM functionalities, leading to the number of students with exam entrance overall of 93,35% and on the main campus 93,53%. The students who passed the exam were 90,85% overall and 93,53% on the main campus. There is a small difference between all the campuses and only the main

campus, with the main campus achieving higher pass rates. Again, it might be because of accessibility. The extra SAM functionalities showed an upward trend on the main campus.

In 2016, there was a decline, the most significant change across all years. The main reason being the introduction of the e-Books. Some students struggled to get used to the electronic version, with other students still buying the hard copy additionally. The exam entrance rates dropped to 89,92% overall and 89,33%, with more than 10% of students enrolling failing to obtain exam entrance. The pass rates were 88,88% overall and 89,66% on the main campus. If one is to combine exam entrance and pass rates, almost 20% of all enrolled students failed AIM. During this time, the #FeesMustFall movement gained momentum, with certain contact sessions not taking place, leading to more self-study.

In 2017, the e-Book introduced extra functionality to bridge the gap. Students entering AIM were also more accustomed to e-Books than before and used it much more effectively. The exam entrance rates improved to 91,72% overall and 90,87% on the main campus. There was a sense of relief that the e-Book is a viable option. The exam pass rates were 94,1% overall and 94,79% on the main campus. The data showed that students engaged with the SAM functionalities and the e-Books much more during the exam time than in the previous year.

In 2018, with full SAM functionalities and an option of a hard-copy textbook, saw another increase in both exam entrance and pass rates, with exam entrance at 95, 32% overall and 95,59% on main campus and an exam pass rate of overall 94,4% and 95,01% respectively.

By making use of technology more and more, the positive impact on students are evident, as their engagement with the AIM e-Book can be downloaded from a dashboard and scrutinized. Only a few students opted for the hard-copy textbook, which might also have led to a higher success rate.

## 10 Lessons Learnt from Other Universities

Other universities, more specifically South African universities, have also encountered issues with large groups and LMSs such as Blackboard, or similar. The Durban University of Technology (DUT) has applied e-learning to nursing [24] and experienced the following challenges:

1. Students were not always psychologically ready and needed assistance in that regards.
2. Students struggled with the technologies themselves.
3. The IT equipment gave problems.

Another study done by Nash [25] looked at the effectiveness of blended learning on different ethnic groups and found that African students struggled more to pass than white students, who struggled the least.

The University of South Africa (UNISA) launched a blended learning course in 1999, with hands-on training on the library website, with an innovative way of tracking the student's performance [26] More courses followed, with varying degrees of success.

Internationally, a study of Ireland [27] found that it is very difficult to differentiate the meaning of a "large group" of students, as the meanings differ in every context. In the findings above, the large groups are split into different lecture groups, not one, very large class for the entire course.

The Northwest Missouri State University first introduced an IT course for first-year students, but it was removed shortly after its introduction, sparking heavy debate in 2001. It was recommended that the course be reintroduced [28].

Higher Education had to adapt to stay current with trends and had to make changes in the way courses are presented currently and in the future, as one simply cannot ignore the 4th Industrial Revolution. Students need the skills to manage life after university, implying that they need to be job-ready. Large groups of students also need to be managed in a cost-effective way to ensure the survival of the South African university system.

## 11 Conclusion and Future Research

It is concluded that the introduction of technology in how large groups of students are taught and assessed, leads to an increase in student pass rates, as is evident from 2013 to 2018. The role of the teacher remains important to convey knowledge and skills, but technology allows for anytime learning. The university also offers Wi-Fi on campus to download e-Books and to make use of the interactive LMS system. The shrinking number of students without a smart device is countered by the availability of hard-copy textbooks. The high percentage of annual pass rates further strengthens the belief that multiple teaching interventions lead to higher student pass rates.

Future research will include to compare other computer-literacy courses with thousands of students to AIM, whether the course is using any form of technology as a teaching intervention or not. Other universities' data can also be obtained with the introduction of e-Books and interactive technological capabilities and the trends can be compared to identify further areas of enhancing student throughput.

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# A Knowledge-based Service-learning Framework for Large-scale Community Projects in Higher Education

**Full paper**

**SACLA 2019**

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**Abstract.** Service-learning that combines academic study with community service by giving students volunteer projects in community organisations provides a richer, more practical experience for students, while delivering benefits to the community. To achieve faculty, student and community goals, service-learning engagement must be closely aligned with the students' faculty experience and must be built on a sustainable, trusting relationship between the faculty and the community partner. However, current research that focuses on factors that create a supportive environment for service-learning is scarce, and this study aims to contribute a holistic approach for service-learning by considering the role players, their interaction goals and the knowledge conversion processes in service-learning. In this study, we designed a knowledge-based service-learning framework for large-scale community projects in higher education. We applied the framework by mapping it to a service-learning module from a higher education institution (HEI) using the elements of the framework as a guide, as well as proposing a conceptual architecture for the service-based knowledge management system (KMS). By using the knowledge-based service-learning framework and KMS architecture for large-scale community projects in higher education, service-learning designers can ensure that the service-learning solution enables strong support to the community, while students' knowledge and skills are enhanced.

**Keywords:** Knowledge Management System, Service Learning, Knowledge Exchange.

## 1. Introduction

Academic service-learning combines academic study with community service by giving students volunteer projects in community organisations, focusing on achieving academic goals for students and fostering meaningful, beneficial outcomes for communities [1, 2]. In addition, service-learning is regarded as a high-impact practice that improves student engagement, pointing to interaction and commitment among the community service-learning parties [3]. Attention to the nature of such a service-

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learning partnership is indispensable as the intent is for service-learning to ultimately have a positive impact on communities [3, 4].

The aim of service-learning design in the context of large-scale community projects is to explicitly ensure that academic course content and experiential learning create knowledge that students can access and apply in new situations [5]. Researchers established that service-learning and community-based experiences provide a rich context for learning [6, 7] and that prior knowledge is reframed into new understanding through reflection and active experimentation [8, 9]. Therefore, service-learning solutions should enable abilities such as active engagement, problem analysis, action orientation and reflection on the entire service-learning experience [5].

However, scholars have identified several problems with regard to academic service-learning programmes such as the transfer of homogenous, university-based knowledge only, a lack of academic development measurement, a low adoption of deeper learning approaches such as project-based learning activities, and limited research that examines the impact of reflection in service-learning programmes [1, 2, 7, 10]. Current research that focuses on factors that create a supportive environment for service-learning is scarce, and there is a shortage of empirical research in the service-learning field for countries outside the United States of America (USA) [3, 11, 12]. This study aims to contribute a holistic approach for service-learning [11, 13] by asking who the role players are and what interrelationships must be considered for service-learning design. It also aims to investigate the knowledge conversion principles that inform knowledge-based flows in a service-learning module. Therefore, the purpose of this study is to present a knowledge-based service-learning framework and conceptual architecture for large-scale community projects in a higher education institution (HEI). The purpose of such a framework and conceptual architecture is to outline the guiding principles and key structural elements, highlight the role players and interrelationships, and identify knowledge conversion and knowledge-based flows in a service-learning module.

Section 2 of this paper provides the background to the study and presents the role players, engagement goals, knowledge transfer and reflection as part of service-learning. The approach to this study is discussed in Section 3, while Section 4 provides an overview of the knowledge-based service-learning framework. Section 5 maps a community-based academic module to the knowledge-based service-learning framework to establish the proposed framework's suitability for holistic service module design and application. Section 6 discusses the findings and concludes the paper.

## 2. Background

According to Gelmon, Holland and Spring [4 : i], the definition of service-learning is "an educational methodology that combines community-based experiences with explicit academic learning objectives and deliberate reflection". Service-learning addresses the theory and practical application of teaching and learning through mechanisms such as community and volunteer service projects, work-based learning, field studies and internship programmes [11, 14]. Students who embark on service-

learning as part of their academic studies encounter a rich, innovative form of experiential education, while simultaneously gaining academic knowledge and skills [4, 11].

The success of service-learning modules in HEIs depends on multiple factors and interrelationships as these institutions consider module design, implementation and assessment while engaging the community [4, 15]. Some of these factors include the HEI context, the student group involved, the community involved, and the desired learning outcomes [14]. It is also recognised that community engagement is a complex, multi-faceted process that involves relationships in, for and with communities [12, 14].

In the next sections, multiple factors, role players and particular interrelationships in service-learning are considered and an overview is provided of knowledge conversion in service-learning.

### 2.1 HEI Service-learning Role Players and Interrelationships

According to Bednarz et al. [14], three main parties are implied in service-learning in the community: the community group, the lecturer and the students. These three parties play different roles and arrange the structured interactions of service-learning [3, 15]. The HEI faculty and lecturer define the learning outcomes of the service-learning module, facilitate learning and provide structure and resources, such as a budget for transferring knowledge and skills, in which learning can take place [15]. The student spends time and effort towards service and reflection in order to learn through experience, obtain the required course credit, and achieve a sense of community responsibility [14, 16]. The community partner's role is to provide opportunities, mentorship and resources for students' learning over and above the service they receive from the students and faculty members [14, 17].

In the engagement between the lecturer and the community, some interaction goals include the fulfilment of service requirements and bridging the gap between the HEI and the community. The interrelationship goals between the community and the students point to developing solutions to solve real-word problems and facilitate skills transfer and experiential learning. The interaction goals between the students and the lecturer include bridging the gap between theory and real-world practice, curriculum guidance, evaluation and curriculum credits [14]. The oversight of engagement and exchange is facilitated through a service-learning plan and the realisation of strong relationships between parties [3, 15].

In the context of the different role players in service-learning, their interaction goals and their interrelationships, student learning is more meaningful, productive and enjoyable when the service-learning engagement is closely aligned with the students' faculty experience, and when there is a sustainable, trusting relationship between the lecturer and the community partner [18]. A key factor that reinforces the success of a service-learning initiative is the degree to which the needs and interests of all three role players in a service-learning context are considered and served [1, 18].

In this section, we reflected on the role players and interaction in a service-learning module, highlighting the impact on service-learning design and the interests of the

different parties. Hence, the next section presents the considerations related to service-learning and knowledge conversion in the context of service-learning project design in an HEI.

### 2.2 A Knowledge Based Solution for Service-learning

Service-learning through experience takes many forms in an HEI, with the aim to increase knowledge and provide a service to the wider community [19, 20]. The role of an HEI in this instance includes the development of cross-boundary knowledge and requires new approaches to knowledge generation and transmission as students must be able to apply knowledge in and outside academic structures [8, 21]. Knowledge can be categorised as either being explicit (has been articulated) or implicit (less tangible, deeply embedded knowledge) [22, 23]. Tacit knowledge, as a dimension of implicit knowledge, is personal and context-specific, and therefore hard to communicate and formalise [23-25].

In order to act on information, students should internalise it and achieve this by progressing through knowledge conversion processes namely socialisation, externalisation, combination and internalisation. *Socialisation* ensures that knowledge is acquired, after which *externalisation* enables students to express their tacit knowledge (mental models and know-how) [26, 27]. *Combination* is the process of integrating concepts, while *internalisation* is closely related to learning-by-doing, or experiential learning. This process of knowledge application ensures that knowledge is advanced through practice, guidance, imitation and observation [21, 26]. Reflection offers a means by which the students understand and generalise their experience before, during and after the service-learning module. If considered as part of an HEI service-learning module, reflection supports students to surface tacit knowledge, therefore adding to their work-based learning experience [8, 19]. Consequently, service-learning design should include clearly delineated processes of knowledge conversion, reflection and evaluation [3, 28].

Furthermore, the knowledge management system enabling such a service-learning design, should be based on an architectural framework of knowledge transfer [29]. Knowledge management systems (KMS) are information technology based infrastructure implemented to support and enhance knowledge creation, storage, retrieval, transfer, and application [29-31]. Knowledge *creation* includes activities such as knowledge acquisition and knowledge capturing, while *storage* refers to the effective archiving and codification of knowledge. Knowledge *retrieval and transfer* allow the integration of different representational and communicational media, and *application* denotes the dissemination and utilisation of knowledge [30].

In the next section, we consider the attributes of existing service-learning models and frameworks in order to inform the knowledge-based service-learning framework.

### 2.3 Existing Service-learning Models and Frameworks

Scholars have identified the need to develop a more systematic approach to understand better, improve and substantiate the theory, practice and value of service-learning [3, 11, 12, 15, 32].

Bennett [3] developed a relationship-based, service-learning framework based on the exchange as a social process of relationship building. This framework considers relationship, objectives, scope, interaction structure, and outcomes, and offers a way for lecturers and their campus-community partners to navigate the service-learning dialogue and develop meaningful relationships. Kiely [32] conducted a longitudinal research study that led to the development of a theoretical framework for explaining how students experience the process of transformational learning in service-learning. This service-learning model considered five conceptual categories that describe how students experienced transformational service-learning: contextual border crossing, dissonance, personalising, processing and connecting. These five learning processes enable lecturers to understand and foster learning processes that lead to transformative outcomes in service-learning. Konak, Clark and Nasereddin [33] illustrate how the stages of Kolb's experiential learning cycle of doing, feeling, watching and thinking may be applied as a framework to design hands-on activities. Molee et al. [34] evaluated a model of critical reflection for assessing student service-learning. This model comprises a three-step process: describing the service-learning experience, examining this experience in light of specified learning objectives for academic enhancement, personal growth and community engagement, and articulating their learning in their reflections.

Sudtho and Rajaphat [35] utilised a knowledge-based approach to encourage interactions between tacit and explicit knowledge for the creation of new knowledge. However, they focused on final-year students who were enrolled for language education. They implemented the knowledge-based approach in six steps: shared vision, free-writing, editing, sharing, talking to the expert and producing instructional innovation.

In order to establish how the service learning models and frameworks impact the knowledge-based service-learning framework, we mapped the elements of the service learning models and frameworks to the knowledge conversion processes as shown in Table 1.

**Table 1.** Knowledge conversion processes to service learning model and framework map.

| Knowledge conversion process | Service learning model and framework element | References |
|---|---|---|
| Socialisation | community engagement, engagement with expert, interaction structure, objectives, relationships, scope, shared vision, watching | [3, 34, 35] |
| Externalisation | doing, experience description, outcomes, processing, sharing | [32-35] |
| Combination | connecting, dissonance, learning objective, examination | [32, 35] |
| Internalisation | contextual border crossing, feeling, personal growth, personalising, reflection | [32-34] |

From the existing service-learning models and frameworks discussed in this section, it can be seen that many different variables and approaches are used to guide service-learning design. The approach of this paper is based on the notion of equally benefitting the faculty, students and the community, and ensuring that equal focus is given to the service being provided and the learning that occurs.

Before the knowledge-based service-learning framework for large-scale community projects in an HEI is presented, the research approach is discussed in the next section.

## 3. Reseach Approach

The objective of this paper was to design a knowledge-based service-learning framework for large-scale community projects in HEIs. The purpose of such a framework is to outline the guiding principles and key structural elements, highlight the role players and interrelationships, identify the knowledge-based flows and provide a conceptual enablement architecture.

In order to achieve this outcome, we followed an educational design research approach that can be defined as "a genre of research in which the iterative development of solutions to practical and complex educational problems also provides the context for empirical investigation, which yields theoretical understanding that can inform the work of others" [36 : 7]. Educational design research is predominantly concerned with developing practical knowledge that aims to improve educational practices [36, 37]. Educational practices are improved through iterative analysis, design, development, and implementation processes that are grounded in collaboration between researchers and practitioners in real-world settings [37]. Educational design research yields theories and practical educational interventions as its outcomes [38] and covers five characteristics [37]: theoretically orientated, interventionist, collaborative, responsively grounded and iterative [36]. Theoretically orientated refers to the application of scientific understanding to frame the research and shape the design of a solution to a real problem. The interventionist nature of educational design research strives to positively affect practice, bringing about transformation through the design and use of solutions to real problems. Educational design research requires collaboration among a range of role players who are connected to the problem being addressed. It also requires responsively grounded points to participant expertise, literature and field testing of the outcomes of educational design research that is structured to discover and explore the complex realities of teaching and learning contexts, and respond accordingly. The insights and interventions of educational design research evolve over time through multiple iterations of investigation, development, testing and refinement, illustrating the iterative nature of the approach [36].

With these characteristics guiding the research, prior literature about service-learning, optimal knowledge conversion and transfer, and education were used as the foundation for a knowledge-based service-learning framework for large-scale community projects in HEIs. The study was conducted at an HEI in South Africa that

offers a compulsory undergraduate community-based project module. In order to evaluate the knowledge-based service-learning framework designed for HEIs, the proposed framework was mapped to the large-scale community service module, corroborating the comprehensive nature of this study.

In the next section, the application of the knowledge-based service-learning framework for large-scale community projects in HEIs is discussed in detail.

## 4. Exploration of Service-learning through Reflection in Education

The purpose of this study is to present a knowledge-based service-learning framework for large-scale community projects in an HEI.

Based on the literature presented in this paper and depicted in Fig. 1., three role players are important in service-learning in an HEI: the faculty and the lecturer of the service-learning module, the student, and the campus-community partners. These three partners each have specific roles, as well as specific engagement and interrelationship goals. From a faculty and lecturer perspective, these roles include the definition of the learning outcomes for the service module, the number of credits allocated to the module and the structuring of the service-learning interaction (this may be a lecture, a briefing or a blended learning approach). The student needs to complete the service-learning module as part of their degree and learn new skills and competencies. The community partner provides service opportunities, mentorship and enables active participation with community life. The interaction goals between the lecturer and the student include teaching and learning engagement, curriculum guidance, the assessment of learning outcomes and bridging the gap between the theory and real-world practice. The interaction goals between the lecturer and HEI, and the community partner are built on partner engagement and bridging the gap between the HEI and the community. Through this partnership, service requirements are met and active community participation is achieved. The interaction goals between the community partner and the students focus on the student's actual service delivery, while the community partner and student develop solutions for real-life problems. During this experiential learning process, skills and knowledge are transferred to the student.

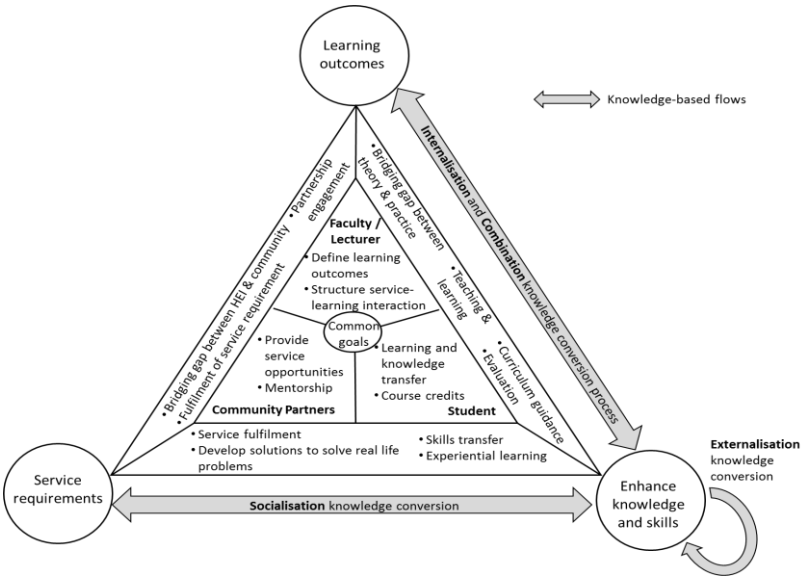


**Fig. 1.** A knowledge-based service-learning framework for large-scale community projects in higher education, adapted from Bennett [3, 14].

In Fig. 1, the triangle shows the role players, their roles and their engagement goals, each with their own objectives. In order to ensure that students' opportunities for learning and knowledge are enhanced, and personal and social skills are developed, Fig. 1. also shows that the knowledge conversion processes can guide the design of particular interventions and thinking about a service-learning module.

Between the lecturer, who is focused on the module's learning outcomes, and the student, the knowledge conversion process of *internalisation* is relevant. The student enters the service-learning module with prior knowledge. The internalisation knowledge conversion process ensures the extraction of knowledge from the service-learning module and enables the subsequent filtering of knowledge, ensuring greater relevance and appropriateness of knowledge to the student. At this stage, the enhanced knowledge is theory-based. With this theory, the student embarks on a service-learning community project, where the theoretical knowledge is converted to capability through the *socialisation* knowledge conversion process. Socialisation is enabled through the experiential nature of the service-learning community project and exposure to a real-world problem setting. Once the student has completed the service-learning community process and ultimately the service-learning module, the *externalisation* knowledge conversion process enables the student to reflect on the learning that took place and *combination* assists the student in creating new explicit knowledge based on the experience.

The inner triangle of Fig. 1 and subsequent description present the role players and interactions, and provide a view of the questions of who the role players are and what interrelationships must be considered for service-learning design. The outer arrows of Fig. 1, the knowledge conversion flows, offer a view of the question of which guiding principles of knowledge conversion inform knowledge-based flows in a service-learning module.

By considering the knowledge conversion processes to service learning model and framework map (Table 1), as well as the knowledge-based service-learning framework (Fig. 1), the final component of the proposed framework includes the enablement conceptual architecture as a KMS facilitates the knowledge-based processes. The proposed knowledge-based service-learning conceptual architecture is shown in Fig. 2.

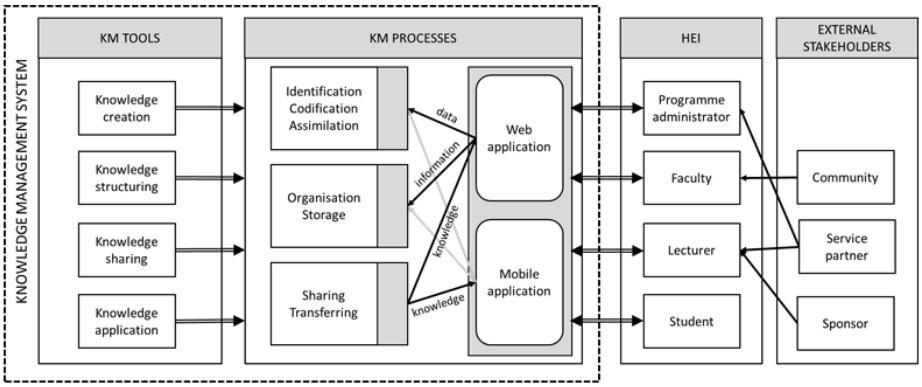


**Fig. 2.** Proposed knowledge-based service-learning conceptual architecture (adapted from [30]).

The KMS component of the conceptual architecture includes KM tools (technologies) and KM processes as presented in detail in section 2. The KM tools and processes enable the capturing, structuring, organisation, application and sharing of knowledge through a web or mobile user interface. Data, information and knowledge are captured into, and retrieved from, the KMS. In a service learning context, there are 2 role players: the HEI and then external stakeholders. Roles relevant from an HEI perspective are faculty, service module lecturers, students and service learning administrative support staff engaging directly with the KMS in the HEI. External stakeholders, including the service partners, community and sponsors, do not directly engage with the KMS in this instance, but have indirect access through the service learning administrator. This is a requirement as potential service learning projects, service partner details, community requirements, etc. must be captured.

Through an understanding of the role players, the interaction goals among role players and the knowledge conversion processes that are relevant in a service-learning module in an HEI, the knowledge-based service-learning framework for large-scale community projects contributes to a more holistic approach to service-learning. It must be acknowledged that the technologies applied to enable the knowledge-based service-learning conceptual architecture, will be HEI specific as different hardware and software configurations are utilised in each.

In order to learn from practice, as guided by our research approach, we proceeded to map an HEI service-learning module at a HEI in South Africa to the proposed framework. The mapping and implications are discussed in detail in the next section.

## 5. Knowledge-based Service-learning Framework Mapping

An HEI in South Africa presents a compulsory free-standing undergraduate module, the Community-based Project (JCP) module. The decision to create the independent course was motivated by the need to integrate community service and service-learning projects, including humanitarian engineering projects, in the curriculum of all the undergraduate programmes in the particular Faculty in addition to adhering to the University's strategic social responsiveness goal [39].

The course's primary objectives include a beneficial impact on a relevant section of society by exposing groups of students to real-life challenges. Subsequently, students get the opportunity to become more aware of their social responsibility. Social awareness is created when students apply existing or newly acquired knowledge for the betterment of the community by illustrating their understanding of the social issues that are relevant to the project. Students must learn to work collaboratively in a multidisciplinary and multilingual environment, applying various life skills such as communication, interpersonal, technological and leadership skills. Through their projects, the students must become aware of and cultivate personal, social and cultural values [40].

The project-orientated course must be completed within the allocated 80 notional hours. Students do at least 40 hours of fieldwork, after which they reflect on their experiences through various reflective assignments, including a final presentation, reflective video and report [41]. It is a macro community engagement course due to the substantial number of enrolled students and projects. Since 2011, more than 1 600 students have registered for the course annually, with an average completion rate of 95% [42]. Generally, the students work in 500 groups each year to help more than 370 different campus-community partners. Typical projects are basic renovation and building projects, teaching Mathematics and Physical Sciences, as well as projects at zoos and animal shelters [6]. Implementing this large number of projects successfully requires a unique teaching and assessment model, sustainable campus-community partnerships, robust logistical and financial processes, effective communication and passionate administrative and academic staff.

In order to evaluate the proposed knowledge-based service-learning framework for large-scale community projects, we considered the individual components of the proposed framework, and the scope and outcome achieved from the class of 2018. Tables 2 and 3 present the mapping. The first column refers to the framework element. The second column contains the JCP module information and implications and our reflection is presented in the third column.

Table 2 presents an overview of the role players and interaction goals in the service-learning module. It provides a view of the question of who the role players are and what interrelationships must be considered for service-learning design. We could identify clear examples from the JCP module that confirm the relationships that are defined in the framework. The engagement among the partners is positive, and an extract from one of the student's reflections indicates that the students experience the community engagement outreach as an exciting learning experience. In terms of the knowledge conversion processes shown in Table 3, internalisation, socialisation and externalisation, we could map each process to the JCP module and identify the knowledge conversion mechanisms the module uses to enhance knowledge and skills. Table 3 offers an example of the question of what knowledge conversion guiding principles inform knowledge-based flows in a service-learning module.

A student reflected on this knowledge conversion process: "*It is really good to experience and take part in community-based projects, as it makes people realise that there are bigger things in this world. People should be optimistic about taking part in community-based projects because even though we might think that there are better things to do with our time, someone else is being advantaged and uplifted. A person should also see the struggle of other people as when they are in the big world one day; they will realise that we all need to look after one another as we all live in this world after all*".

Based on this evaluation of the knowledge-based service-learning framework for large-scale community projects in an HEI, we believe that the framework provides good coverage of considerations for developing a service-learning course. In addition, the observations and reflection columns in Tables 2 and 3 present examples of the application of the proposed knowledge-based service-learning framework that may be referenced for service-learning module design.

**Table 2.** Service-learning module mapping to the knowledge-based service-learning framework for large-scale community projects in HEIs.

| Framework component | Module information for 2018 | Observations and reflection |
|---|---|---|
| Students | In 2018, students enrolled for the module were mainly second-year students who came from three different schools. Some 979 students came from the School of Engineering (10 different degrees), 299 from the School of Information Technology (nine different degrees) and 288 from the School for the Built Environment (six different degrees), yielding a total of 1 499 students | When the students were briefed, they had to indicate whether they had done community work before. Some 53% indicated that they had participated in community work before; 33% indicated that they had not; and 14% indicated that they were "unsure". Nearly half of the students enrolled in the module had never been involved in a community engagement experience before enrolling in the module. |
| Faculty or lecturer | The academic staff for the JCP module consists of one lecturer and one administrative support person. The JCP service-learning module is a graduation requirement that bears eight academic credits. | Each student is required to work at least 40 hours with their community partner, and a small budget of R400 is awarded per student. Students are allowed to raise the funds that are required to complete their project. They may choose a project from the projects identified by the JCP office or they may propose their own project within set criteria. The lecturer follows a detailed plan and timeline to ensure that all the students propose a project, execute the project and do a final presentation on the project's outcomes. |
| Community partners | In 2018, 235 campus-community partners participated in the different service-learning projects. More than 175 campus-community partners are sustainable partners, and some have been working with the module for 14 years. | The campus-community partners provide a wide variety of opportunities, as they oversee museums, children's homes, animal sanctuaries, schools and nursing homes, among other things. Students may not work for a for-profit organisation, earn money during the 40 hours or do elementary repetitive work such as the cleaning of cages. |
| Lecturer – students | In a contact session, the lecturer briefed all the students regarding the learning outcomes, health and safety, and professional conduct of the service-learning community project. | Students worked on projects in five countries in 2018 and fundamental aspects, including how to identify a project, the steps to complete the project and the assignments that need to be done to complete the module successfully, are covered during the briefing. The lecture includes a security talk by one of the campus security officers. |
| Lecturer – community partners | Campus-community partners may submit projects to the lecturer even before the students have registered for the module. | The lecturer maintains a close partnership with her campus-community partners and visits them from time to time. Clear feedback is given and information is shared. Campus-community partners are updated on the outcomes of the module via a newsletter, as well as an annual function where campus-community partners are acknowledged for the role they play in the module. An award for the most engaged community partner is presented at the annual award event. |
| Community partners – students | Campus-community partners may identify possible projects and propose them to the JCP office. They are responsible for monitoring the students' | Students stay accountable to the community partner to ensure that they deliver a quality product. |

| | | |
|---|---|---|
| | hours and controlling the quality of projects. At the end of the project, the community partner also assesses the students' final projects. The community partner also needs to indicate whether YouTube vido may become "public". | |

**Table 3.** Service-learning module mapping to the knowledge-based service-learning framework for large-scale community projects in HEIs.

| Framework component | Module information for 2018 | Observations and reflection |
|---|---|---|
| Internalisation and combination knowledge conversion | Students who completed the module become mentors for new students or project leaders for groups. Alumni remain involved as campus-community partners and mentors.<br>Each group attended a project proposal session where the identified project's execution, logistics and budget are discussed, identified and allocated. | Mentors and project leaders guide and assist the teams. All groups identify a group leader and a financial manager. The lecturer and administrative officer assist with logistical support, among other thing. |
| Socialisation knowledge conversion | Campus-community partners and alumni mentor the students, monitor their hours, do quality control of the project, assess the students and give feedback on the outcomes to the lecturer. | Within certain criteria, students may choose the community in which they want to work. The students may report any problems to the lecturer and may move to another project if the preferred community cannot accommodate them for all the allocated hours. Students reflect positively on their experience and see it as exposure to real-life situations and their future world of work. |
| Externalisation knowledge conversion | The six most prominent skills that the 2018 students learnt through the JCP module include group work (84%), project management (67%), communication and interpersonal skills (66%), leadership skills (55%), creative thinking (53%) and financial management skills (53%). | The students reflect on their service-learning via multiple mechanisms. Students complete reflection assignments on the e-learning management system, a final report, presentation and a reflective YouTube video.<br>Celebrating the students' success is important to the JCP module, and an annual celebration and prize-giving function is hosted. |

In terms of the last component of the framework, the knowledge-based service-learning conceptual architecture, we have included an example of the architecture at the HEI that enables the JCP programme. This knowledge-based architecture is depicted in Fig. 3.

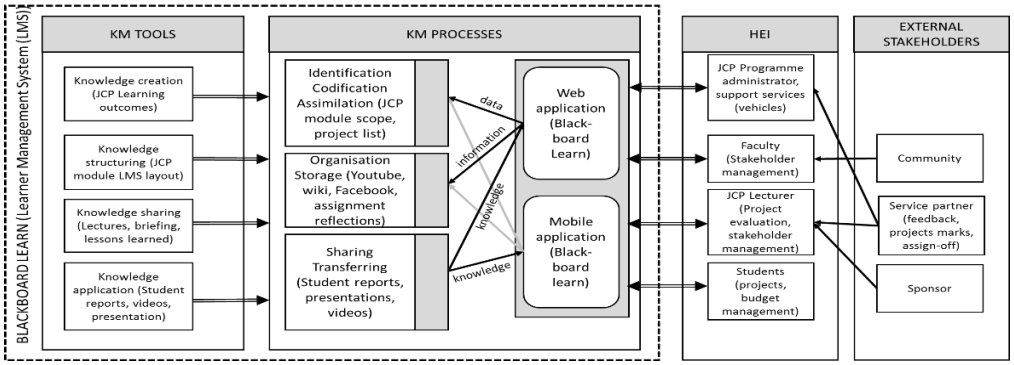


**Fig. 3.** Example knowledge-based service-learning conceptual architecture.

The knowledge base in this instance contains text documents, video, presentations and reflection reports. It also holds an external stakeholder (service partner) list, details, community requirements and contact people, as well as pertinent information about the potential community project.

By comparing the knowledge-based service-learning framework components (Fig. 1 and 2), and the example architecture (Fig. 3), to the existing service learning models (summarised in Table 1), the contrast between the standard service learning approach and knowledge-based approach are illustrated.

## 6. Conclusion

Scholars stated that service-learning programmes provide a richer, more practical experience for students and can deliver more benefits to the community by undertaking larger projects that are not limited by the length of a semester. However, such long-term projects with a broader scope present both knowledge conversion and project management challenges. For these service-learning community projects, students must quickly learn enough about the community partner's problem or service requirement to deliver effective solutions and quality products to the campus-community partners. Campus-community partners have long recognised the value of involving students in their service activities, as students can provide additional volunteer help in meeting community needs. Campus-community partners plan and coordinate activities, and direct and mentor student volunteers to complete predetermined tasks towards providing a service to the community. Furthermore, from an HEI point of view, a service-learning module must achieve certain learning outcomes, and classroom knowledge must be turned into practical knowledge, over and above the enhancement of student knowledge and skill.

In this study, we designed a knowledge-based service-learning framework for large-scale community projects in higher education by considering all role players, their

interrelationships, the unique composition of service-learning outcomes, as well as a knowledge-based service-learning conceptual architecture. We applied the framework by mapping it to a service-learning module from an HEI using the elements of the framework as a guide. We established that the service-learning module that was mapped conformed well to the components identified in the knowledge-based service-learning framework.

By using the knowledge-based service-learning framework for large-scale community projects in higher education, the faculty, lecturers and instructional designers can warrant that the service-learning design enables strong support to the community, while students' knowledge and skills are enhanced. In this way, they can ensure that the needs and expectations of all parties involved in service-learning are considered through this knowledge based approach.

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# The Influence of Learning Style Theory within a Blended Learning Environment: A Systematic Review

**Full Paper**

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**Abstract.** Blended Learning (BL), is about blending traditional classroom instruction with online learning activities using both asynchronous communication as well as real-time synchronous communication modes [1]. The complexity of designing a blended learning intervention comes into play when considering the variety of blended learning tools, both asynchronous and synchronous, and learning styles of students. This paper presents a systematic review of literature on how to create an effective blended learning intervention when considering learning styles. The literature reveals that there is a relationship between learning styles and blended learning. The research suggests that certain learning styles are better suited to a synchronous learning environment while others are more suited to an asynchronous learning environment. This study proposes two frameworks, which together provide educators with insight into the link between learning styles and the use of asynchronous and synchronous technologies in terms of learning effectiveness of students.

**Keywords:** Blended Learning, Learning Styles, Asynchronous and Synchronous, Learning Environment.

## 1 Introduction

### 1.1 Background

The way in which a student grasps and intellectualizes information, interacts with and observes their learning environment is unique to that individual [2]. This speaks to the idea of learning styles - the way in which different human beings learn and process information in different manners [3]. For example, certain students may show a higher ability of learning when information is provided through words, whereas other scholars have a greater learning ability when information is provided through pictures [4]. The

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concept of learning styles has gradually gained importance and acceptance not only amongst educators but also among parents of students and the greater public [3].

Over the last 30 years, more than 70 theories have been developed around learning styles [5]. As distributed in the literature there are numerous learning style models such as Visual, Auditory, and Kinaesthetic Learning Styles (VAK), Kolb's Model, Honey and Mumford Model, Felder and Silverman learning style model and the list goes on [5]. The most broadly used model is the Felder and Silverman learning style model (FSLSM) which consists of four dimensions: active-reflective, sensing-intuitive, visual-verbal and sequential-global [6]. In each aspect, a student will be more suited to one or the other [2]. A student can be either an active learner (extroverted person, learn by doing things) or a reflective learner (introverted person, learn by evaluating things on their own). They can be either a sensing learner (practical thinker, favour facts and methods) or an intuitive learner (theoretical thinker, favour theories and principles). They may be a visual learner (learn better through information that is presented visually), or a verbal learner (learn better through written or articulated information) and lastly one can be a sequential learner (linear thinking process) or a global learner (holistic thinking process) [6]. Learning styles can be determined with tests and indicators such as the Myers-Briggs Type Indicator.

A vast amount of literature suggests that learning styles relate to student participation and can therefore affect the performance of a student [7], [8], [4]. The performance of a student can be compromised when the teaching style and method used by an educator is incompatible with the students learning style. This leads to the student's tendency to find their environment uncomfortable, thus causing them to lack focus and interest in class, and become despondent in a course, which in certain circumstances can lead to dropping the subject itself [2]. Thus, it is vital for educators to address the different types of learning styles when creating or designing a module or course.

The idea of blended learning started in the late 1999's early 2000s and has increasingly gained popularity [9]. Blended learning is a modern-day learning approach that combines the best methods of traditional classroom learning with online learning to provide a learner with an effective yet flexible method to learn [9]. It is the integration of synchronous and asynchronous components. The synchronous component of blended learning is considered to be a real-time experience between the learner and facilitator. It is a face-to-face experience, which can be provided by means of a live e-learning virtual classroom or the traditional physical classroom experience [9]. The asynchronous component of a blended learning approach is not limited by time or place. It is combined self-paced formats such as online learning modules, online resource links, communities and discussion forums and within asynchronous learning, certain digital technologies such as gamification, online quizzes and videos may be used [10]. Educators can address a wider variety of students learning styles through the means of a blended learning approach [11].

Incorporating learning styles with blended learning in a higher education environment delivers different advantages to students as it uses a combination of various learning methods and approaches rather than that of a traditional learning

approach that uses a single learning distribution platform [11]. Blended learning has been shown to decrease dropout rates, increase exam pass rates and provide students with a higher degree of satisfaction and motivation [7].

The research question this paper will address is: How can learning style theory guide educators when planning a blended learning intervention?

## 2 Method

This research makes use of a systematic literature review and content analysis.

### 2.1 Search Strategy

A WWHW table was used to assist in the creation of the key search terms and ultimately the research string. The WWHW table, Table 1 is presented below. The development of the search string was an iterative process.

**Table 1.** The WWHW table used for refining the research string.

| | WHO | WHAT | HOW | WHERE | OTHER ISSUES |
|---|---|---|---|---|---|
| To what extent can learning style theory guide educators when planning a blended learning intervention? | Educators | Learning style theory | Guide / plan | Blended learning intervention | Digital learning tools / synchronous learning / asynchronous learning |

The resultant research string was:

*("blended learning" OR "hybrid learning" OR "mixed-mode instruction" OR "e-learning") AND ("learning styles" OR "learning style theory") AND ("distributed learning environment" OR "synchronous" OR "asynchronous") AND ("higher education" OR "tertiary education")*

The bibliographic databases used for this study, were EBSCOhost Research database; Emerald Insight; Science Direct and Google Scholar. The search string remained unchanged when used in each of the selected databases. Both initial and secondary screening was conducted and the results were entered into Rayyan, a web-based application that is designed to help researchers create and manage their systematic reviews, [12].

The inclusion and exclusion criteria are included in Table 2. below.

**Table 2.** Inclusion and Exclusion criteria.

| INCLUSION CRITERIA | EXCLUSION CRITERIA |
|---|---|
| • E-learning; blended learning; hybrid learning; mixed-mode instruction<br>• Higher education; university; college; tertiary education<br>• Learning styles; learning style theory<br>• Asynchronous; synchronous; distributed learning<br>• Learning technologies; digital technologies | • Not applicable<br>• Not relevant (outdated)<br>• No abstract<br>• Full-text unavailable<br>• Foreign language |

Finally, a quality assessment tool consisting of fourteen (14) questions categorized under Design, Conduct, Analysis, Conclusion and General was used to filter each paper. Possible responses were: Yes, No and Partial.

## 3 Findings

A total of 572 citations were identified and retrieved. The research was limited to studies from 2006 until present, with the exception of referred articles relating to the learning style models stated in many citations. See Table 3. Below.

**Table 3.** Results of the initial search string.

| **Search String** | "(blended learning" OR "hybrid learning" OR "mixed mode instruction" OR "e-Learning") AND ("learning styles" OR "learning style theory") AND ("distributed learning environment" OR "synchronous" OR "asynchronous") AND ("higher education" OR "tertiary education") |
|---|---|
| **Database** | **Number of Hits** |
| Emerald Insight | 102 |
| EBSCOHost | 13 |
| Science Direct | 437 |
| Google Scholar | 20 |

Having applied the research string with the results as indicted in Table 3, a PRISMA diagram, which is used to provide a graphical representation of the flow of information through the different phases of the systematic review, was established for reporting the results from the conducted searches. See Fig. 1. below.

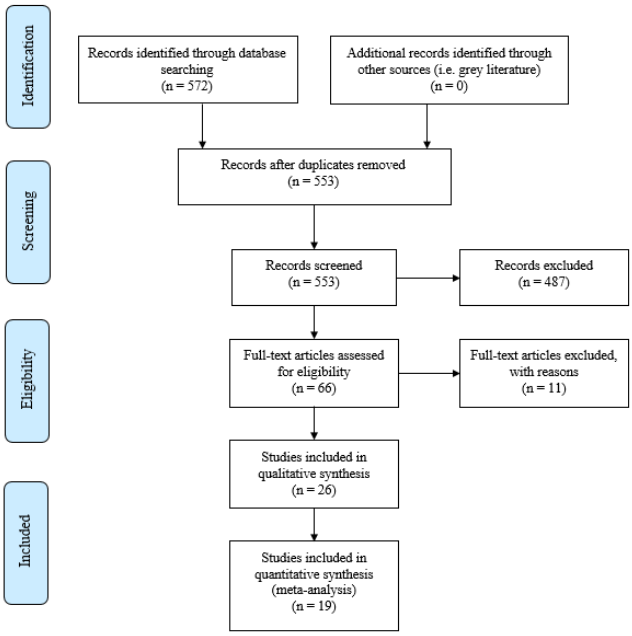


**Fig. 1.** Systematic review PRISMA flow diagram.

A quality assessment was conducted on twenty six (26) articles that passed as eligible. This resulted in a total of nineteen papers (19) papers being considered appropriate for this systematic review.

Data extraction tables were used to display the results of the papers considered of value and significance to this research. This resulted in six (6) pages of data extraction tables. For expediency sake, the six (6) pages are summarised in Table 4. below.

**Table 4.** Summary of Data Extraction Tables.

| | **Blended Learning** | | | **Digital Tools / Components** | | **Digital Tools and Components** | |
|---|---|---|---|---|---|---|---|
| **Sub-categories** | Components | Relationships / interactions | Importance of learning styles and the blended environment | Type of learning style | Participation, performance and preferences | Synchronous components and tools | Asynchronous components and tools |
| **Citing** | 14 | 10 | 12 | 16 | 13 | 9 | 8 |

As may be seen in Table 4, the majority of papers relating to Blended Learning, 14, focused on blended learning components followed by 12 papers relating to blended learning styles. A remaining 10 papers focused on relationships and interactions in a blended learning environment. Under the category, learning styles, the majority, 16 papers, focused on the type of learning style, while 13 papers investigated participation, preferences and performance. Finally, under the category of digital tools, 9 papers focused on synchronous components while 8 papers discussed asynchronous components.

# 4 Results

## 4.1 Data Synthesis

The Data synthesis report aims to display the information collected from the data extraction process. The report will consist of each theme that arose from the data extraction table and the relevant evidence found within each theme. This report will allow the reader to view a summarized version of results from the numerous studies to obtain an understanding of the overall findings that relate to the research problem posed in this study.

**Blended learning**

*The blended learning components.* Out of the 19 papers, 12 speak to the nature of blended learning environments. Nine of the papers address blended learning as a combination of traditional classroom and web based/online teaching methods – a multimedia approach to learning, mainly being that of a synchronous and asynchronous nature. [10] speaks of the three major components of blended learning: learning environment, media and instructional. The three e-learning tools commonly used are

that of interactive e-learning, non-interactive/learner-centred and non-interactive/teacher-centred [13].

*The relationships and interactions within the blended environment.* There are three main types of interactions within a blended environment, these being a learner-learner/student-student interaction; learner-content/student-content interaction and learner-instructor/student-instructor interaction [11], [14], [15], [16]. The support provided by educators can contribute towards a students' success and course satisfaction [4]. Increased student-centeredness within a blended environment can contribute positively to student performance [17].

*The importance of learning styles and the blended environment.* Three papers address the mismatch between course delivery and learning preference; traditional teaching styles and learning styles of students and what students expect out of e-learning and the delivery of an e-learning course [13], [6]. A blended learning environment supports students' engagement and learning due to the various teaching mediums that accommodate diverse types of learning styles [17]. Two studies suggest that students' performance and satisfaction are higher when teaching methods complement their learning style [15], [16]. One author suggests that catering for different learning styles in a blended/ e-learning environment can result in greater retention of students [18]. This is supported by [19] who state that if a blended learning environment accommodates various learning styles it will increase learning performance and the gaining of course knowledge of learners.

**Learning styles**

*Type of learning style.* Various models and indicators can determine the type of learning style one has but the four most commonly used among all the studies were the Felder and Silverman Learning Style Model (FSLSM), Kolb's learning style model, Myers-Briggs Type Indicator (MBTI) and VAK model. Eight out of the nineteen papers referred to the FSLSM to define the type of learning style as it the most commonly used model. The FSLSM consists of four dimension of learning styles: processing information, active-reflective; perceiving information, sensory-intuitive; receiving information, visual-verbal; understanding information, sequential-global [22], [8], [11], [6], [21], [4], [16]. The measurement tool utilized to determine the learning style of individuals in the FSLSM is the FSLSM questionnaire- ILS (inventor of learning style) [22], [8], [11], [6], [21], [4], [16], [5].

Six out of the 19 papers referred to the Kolb's learning style model to define the learning style [22], [13], [11], [9]. The Kolb's learning style theory separates learning preference by using two continuums: active-reflective and abstract-concrete. From there four types of learning styles can be described: active-abstract (converging);

active-concrete (accommodating); reflective-abstract (assimilating) and reflective-concrete (diverging) [9]. The KLSI is the tool utilized to measure the learning style of individuals in Kolb's learning style model [13], [21], [9].

Two papers used the Myers-Briggs Type indicator to define the type of learning style. The MBTI addresses the four learning style dimensions as: Extrovert (E)-Introvert(I), Sensing(S)-Intuition(N), Thinking(T)-Feeling(F) and Judging(J)-Perceiving(P) [24]. The VAK (visual, auditory and kinaesthetic) model was used as a determinant in one study [21].

*Performance, participation and preferences.* Active learners obtain more central position than reflective learners, active students respond better to synchronous activities, reflective and sensing learners respond better to asynchronous activities. Visual-verbal learners depend on the educators' study materials and techniques, there is no significance with regards to participation and performance relating to sequential-global learners [22], [6], [21]. There is a correlation between learning styles and student performance. The more central a learners' position is in the environment the better their academic performance [21].

[4] speak to four types of online participation: information access, interactive learning, networked learning and materials development. Sensing learners respond to information access, interactive learning and networked learning. Reflective learners prefer materials development. When looking at the Kolb's learning style model, two papers found that Assimilators respond to information presented in an organised manner and benefit on reflective tasks. Diverges require more interactions with peers and educators as they are emotional and sensitive to people. When comparing learner types of Kolb's learning style model, it was said that an Accommodator learning type preferred email as a communication tool. An assimilator learning type preferred offline meetings and general discussion board as a communication tool; diverges appeared to prefer asking an educator as a communication tool and lastly converges have no significant preference for a particular communication tool [18], [25].

One paper specifically states that learning styles do not affect academic performance in a blended environment but can act as a guide [22]. Another mentions that learning styles are related to academic performance of students in a synchronous environment whereas in an asynchronous environment there is no relation between learning styles and academic performance of students [9].

**The synchronous and asynchronous components and digital tools**

*Synchronous components and digital tools.* The synchronous component of blended learning consists of real time interaction [20], [17], [6]. Synchronous learning originated from three key influences: the classroom, the media and the conference [9]. The various synchronous tools are audio-conferencing, video-conferencing, live classroom/virtual classroom, live product practice, interactive chatrooms, cyber-whiteboard, internet telephony and two-way live broadcasts [20], [17], [9], [6], [14],

[9], [16]. Within a synchronous e-learning environment, there is a difference between learning styles and academic performance [9]. The most preferred learning style in a synchronous e-learning environment is the assimilating learning style. To match this learning style the synchronous e-learning tools should include interactive synchronous tutorials, theory and analytical models, lectures, e-face to face communications with educators [9].

*Asynchronous component and digital tools.* The asynchronous e-learning environment is not limited by time or location [9]. The asynchronous component caters for students who think deeply, it involves self-paced learning that is internet-based [17]. The asynchronous digital tools are learning management system (LMS), e-mail, scheduled online assignments, online bulletin boards, listservs, online communities, on-demand videos, LMS Moodle-post readings, wikis, forums, blogs [20], [10], [6], [14], [9], [4], [16].

# 5 Discussion

The purpose of this study was to conduct a systematic review on any accessible literature pertaining to blended learning and learning styles, with the goal to discover to what extent learning style theory can guide educators when planning a blended learning intervention.

## 5.1 Discussion of the Review Process

There is a strong debate about the extent to which learning styles influence student satisfaction and performance within a blended learning environment. Some authors such as [20] suggest there is no influence however they argue in favour of using learning style to guide teaching interventions. Other authors suggest that catering for learning styles can increase student interest and engagement, retention, satisfaction and their academic results [8], [18], [21], [16], [4].

It is evident that the four most frequently used models are the Felder and Silverman Learning Style Model, Kolb's model, Myers-Briggs Type Indicator and VAK model. [6] argue that in terms of the Felder and Silverman Learning Style Model and blended learning, Active learners benefit from face-to-face interaction such as a real-time video as they study better through conversations and group work, Reflective learners benefit from on-demand videos. Active learners obtain more of a central position than reflective learners and learn better in a synchronous environments where they can interact with lecturers and or peers. Reflective and sensing learners learn better in an asynchronous environment due to the nature of off-line time to reflect and assimilate

the information. Sensing learners learn well through online quizzes, simulations and learning games as they respond to interactive learning [4]. Intuitive learners retain more knowledge through on-demand videos as well as face-to-face interactions. Visual and verbal learners depend on what study materials and techniques are used. In a blended environment, there is no significance in regard to participation and performance relating to sequential-global learners [20], [6], [21].

Kolb on the other hand, proposes four types of learners; Assimilators respond to information presented in an organised manner and benefit on reflective tasks. Accommodators prefer email as a communication tool, prefer reading a handbook and relate best to their personal experiences [19]. Diverges require more interaction with peers and educators, Converges have no significant preference for a particular communication tool, they organize knowledge into models/frameworks and prefer analysing data [18], [23], [9].

The following section links the learning style theories with the environmental demands of both synchronous and asynchronous blended learning.

**Synchronous components in support of a blended learning approach.** The synchronous component of blended learning is a live, real time interaction. An educator conducts these interactions. Examples of the various synchronous digital tools are audio-conferencing, video-conferencing, live classroom/virtual classroom, live product practice, interactive chatrooms, cyber-whiteboard, internet telephony, two-way live broadcasts, round table discussions [20], [17], [10], [6], [14], [9], [16].

In terms of the FSLSM and the MBTI, active learners, sensing learners, extroverted learners and perceiving learners are better suited in a synchronous environment as they thrive off interacting and engaging with people [6], [21]. The synchronous tools that address active and extroverted learning styles is live/virtual classroom, on demand videos [6]; [21]. Sensing learners come across as participating well in both synchronous and asynchronous environments. One study suggests that sensing students participate in interactive learning, networked learning and information access. Interactive learning has a synchronous focus whereas networked learning has a more asynchronous focus. Thus, sensing learners as well as perceiving learners can be accommodated in a synchronous environment through interactive games and live classrooms [4].

In terms of Kolb's learning style model, the most preferred learning style in a synchronous e-learning environment is the assimilating learning style followed by the divergent learning style, the subsequent learning style is the converging and accommodating. Therefore, to accommodate students with an assimilating or divergent learning style, the synchronous e-learning tools should include interactive synchronous tutorial concepts, theory and analytical models, lectures, e-face to face communications with instructors [9].

**Asynchronous components in support of a blended learning approach.** The asynchronous component of blended learning is internet based and it is not limited to time or location. Examples of the various asynchronous digital tools are learning management system (LMS), e-mail, scheduled online assignments, online bulletin

boards, listservs, online communities, on-demand videos, LMS Moodle-post readings, wikis, forums, blogs [20], [10], [6], [14], [9], [16].

In terms of both the FSLSM and MBTI instruments, reflective learners and introverts learn better in an asynchronous environment. Asynchronous tools such as on-demand videos, blogs, and reflective independent online assignments address these particular learning styles [6], [21]. Sensing learners learn effectively in both a synchronous and asynchronous environment. They participate in networked learning which has a focus on online forums and wikis that are asynchronous tools [4].

In terms of Kolb's learning style model, the most preferred learning style in an asynchronous e-learning environment is the converging learning style [9]. The subsequent learning style preference is accommodating, assimilating and divergent. The asynchronous tools that address a converging learning style should include a learning management system that includes activities such as individualized learning projects, practical application of theories and concepts. Accommodators communicate best through E-mail. An assimilating learning style once again can be addressed in both a synchronous or asynchronous environment; the asynchronous tools that address this learning style is online forums and discussion boards [23].

Through the discussion of the results and the answering of the sub-questions it is evident that learning styles can, to an extent, act as a guide for educators when planning a blended learning intervention. Studies suggest there is evidence of a relation between learning styles and blended learning. When a students' learning style correlates to a suitable technology, participation and satisfaction increases.

## 6 Recommendation

In order to conceptualise themes raised in the systematic literature review and to guide educators when planning a blended learning intervention, two frameworks are proposed. The Blended Learning Effectiveness Framework, Fig. 2 below, displays how learning styles contribute to the overall effectiveness of a blended learning intervention. The second framework, Table 5 below, is an extension of the first framework. Both frameworks have been constructed to link asynchronous and synchronous learning tools to the FSLSM, MBTI and Kolb's learning style models. Framework one (Fig. 2) displays how learning styles and the two main components of blended learning (synchronous and asynchronous) when combined, can provide an optimal learning environment for leaners with a particular learning preference. As indicated, the pillars that support blended learning are the synchronous and asynchronous components. Together with learning styles, these pillars create an effective blend by taking into consideration the learning styles best suited to each component. Within this framework the learning styles that are most prominently suited to each pillar are highlighted by their wider /darker boarder. Taking learning styles into consideration when creating a

blended learning intervention can support the overall effectiveness of the intervention by increasing the satisfaction and participation of the learner.

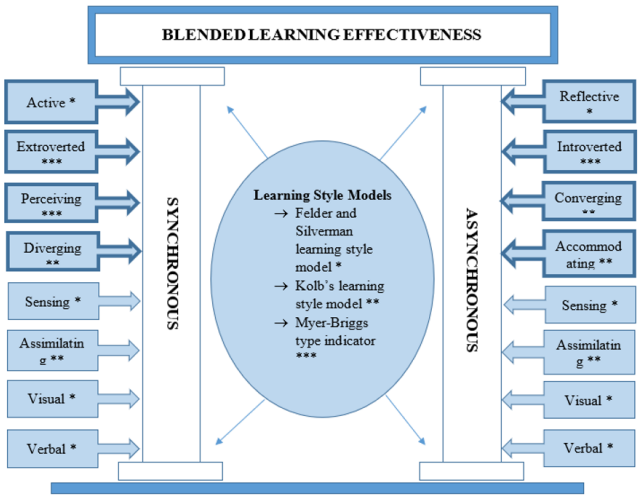


**Fig. 2.** Blended Learning Effectiveness Framework.

The second part of the framework (Table 5) can assist educators when planning a blended learning intervention. The learning styles are matched according to which blended component they are best suited to and the suggested tools are identified. In a blended environment, there is no significance in regard to participation and performance relating to a sequential-global learner. Educators should provide their students with either one of the three learning style tests: the FSLSM questionnaire, Kolb's learning style questionnaire, MBTI, in order to determine the preferred learning style of their students. Being aware of student preferences would assist educators in their choice of a/synchronous learning interventions. It may also be to the advantage of the students to have some insight of their own learning style preferences. The framework is presented in a tabular format below.

**Table 5.** Learning Styles and A/Synchronous Tools.

| Learning Styles | Synchronous tools |
|---|---|
| Active / Extroverted | • Live/virtual classroom<br>• Group work<br>• Interactive in class activities |
| Sensing / Perceiving | • Interactive games<br>• Interactive chatrooms<br>• Virtual lectures |
| Assimilating/ | • Interactive synchronous tutorial concepts |

| | |
|---|---|
| Diverging | • Theory and analytical models<br>• Virtual lectures<br>• E-face-to-face communication with instructors |
| Visual | • Video conferencing<br>• Graphic content<br>• Visuals such as flow charts, timelines<br>• Demonstrations |
| Verbal | • Audio conferencing<br>• Discussion and debates |
| Learning styles | Asynchronous tools |
| Reflective / Introvert | • Learning management system Moodle post readings<br>• Blogs<br>• Reflective independent on-line assignments<br>• Videos of lecture content |
| Sensing | • Forums<br>• Wiki<br>• Online quizzes |
| Converging | • Individualized learning projects<br>• Online practical application of theories and concepts |
| Accommodating | • E-mail<br>• Learning management system Moodle post readings<br>• Course material handouts posted online |
| Assimilating | • Discussion boards/Forums/chatrooms<br>• Bulletin boards |
| Visual | • Good graphic video content<br>• Course material/handouts including visuals such as pictures, diagrams, flowcharts and time lines. |
| Verbal | • Recorded lectures with good audio.<br>• Discussion forums/ chatrooms |

# 7 Conclusion

This report presents a systematic review of literature on identifying the link between learning styles and blended learning to allow for the establishment of a guideline for educators when planning a digital teaching intervention. The objective of this research paper is to provide educators with insight into the link between learning styles and the use of asynchronous and synchronous technologies in terms of learning effectiveness of students. The researcher took this as the research problem and from it stemmed the main research question:

*How can learning style theory guide educators when planning a blended learning intervention?*

This question along with its sub-questions were discussed. Existing literature identified that there is indeed a relationship between learning styles and blended learning. It showed that student engagement, participation and satisfaction, key elements to successful learning, increased when teaching methods were complementary to their learning style.

In an attempt to simplify the complex relationship between various learning styles and blended learning technologies, two frameworks were developed, Fig. 2 and Table 5, based on FSLSM, MBTI and Kolb's learning style models. The proposed frameworks were developed with the knowledge gained from the findings and results of the literature used in this review. The first framework (Fig. 2) is designed to highlight the effectiveness of blended learning when considering learning styles. The second framework (Table 5) integrates learning styles with their suited asynchronous and synchronous technologies. The purpose of both frameworks is to guide educators when planning and developing a blended learning intervention in order to accommodate their students learning styles.

There is some deliberation amongst educators that it is impractical and unrealistic to cater for every student's learning style and that the onus is on the student to change their learning style according to the educators teaching style. What these frameworks propose, however, is that it is possible to design a blended learning intervention that caters for the majority of learning styles. After all, blended learning is about "blending" synchronous as well as asynchronous teaching methods. By definition, this means that a variety of tools and technologies should be included when planning for a particular course. It is believed that any blended learning intervention should surely benefit both educators and students if indeed there is an awareness of learning styles amongst both groups.

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# Students' Perceptions of Gamification Mechanics and Dynamics in a Gamified Learning Environment

**Full Paper**

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**Abstract.** The infusion of learning material with game elements have been used to capture the attention of students, improving engagement and motivation. Some gamified learning environments have not been successful and educators should pilot test these platforms before full scale implementation. The goal of this study was to explore a gamified learning environment to determine if the use thereof could successfully be incorporated in a first year programming module. A group of 92 students used the Khan Academy platform for one academic term. Semi-structured interviews were used to collect qualitative data from students. The results indicate that students enjoyed using this platform and a large percentage of students reported that the lessons on the Khan Academy platform assisted them to better understand programming principles. The gamification elements in the platform namely points, badges and a leaderboard also motivated students to keep using the platform.

**Keywords:** Gamification, Points, Badges, Leaderboard, Khan Academy.

## 1. Introduction

"You can't design a gamified experience only by putting points, badges, and leaderboards to it. Gamification is an art and every gamified adventure is unique. So you won't be able to find a repetitive pattern to make everything engaging over and over again" [1]. Despite a prevalent confidence in the advantages of gamification, evaluation of gamification successes have often been ambiguous and cynical [2]. One reason for the failure of many gamified applications might be that designers have failed to give heed to the important principle emphasised by Ali Akhtari in the opening sentence of this paper.

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Gamification, refers to the usage of game elements, such as game mechanics and design techniques, to enrich non-game settings in order to motivate and engage users [3]. Since the widespread use of gamification, less than a decade ago, it has been used for educational purposes, as well as in other settings such as marketing and health [4]. When scrutinising reviews on how researchers have studied gamification in education, most studies report an emphasis on engagement and motivation as main variables [5, 6]. However, evidence is inconsistent about the impact of game elements, such as points, badges and leaderboards on user engagement. In addition, it is not clear why some gamified applications effectively engage users while others are not successful at all [2]. Programming courses are notoriously viewed as being highly challenging causing negative perceptions and lower levels of motivation among students [7]. The purpose of this paper is therefore to investigate the Khan Academy gamified programming platform as a potential means to improve the engagement and motivation of first year students at a University of Technology in South Africa. Specifically, the following research questions were asked:

- How do students experience the Khan Academy gamified programming platform?
- How do students experience the points, badges and leaderboard game elements in Khan Academy?

The paper is structured to provide an analysis of previous research conducted on gamification in Higher Education institutions in Section 2, followed by an explanation of the theoretical framework of the study in Section 3. In Section 4, the Khan Academy environment is discussed. Furthermore, in Section 5 the research methodology is discussed followed by the results in Section 6, the discussions in Section 7 and the conclusions in Section 8.

## 2. Gamification in Higher Education

Previous empirical studies that was published in peer reviewed academic journals that investigated gamification in higher education settings were reviewed for the past 3 years (2016-2018). The EBSCOhost and Science Direct platforms were used to locate appropriate studies. Only studies that focused on the usage of gamification elements and gamification of teaching platforms in higher education settings were included in the review. These studies are summarised in Table 1. The following information was reported for every study: a) authors and year, b) topic of study, c) main conclusions, d) advantages e) gamification elements used. A number of studies reported that gamification was beneficial in terms of academic / cognitive related matters including improved student performance (three studies) improved learning outcomes (two studies), higher quality of work (one study), perceived learning (one study), more academic effort (one study), improved attendance (one study) and attention (one study). Reported physiological or emotional benefits included, engagement (eight studies), motivation (four studies), enjoyment (two studies), confidence (two studies),

satisfaction (one study) and attitude (one study). The most predominant gamification elements that were investigated include points (10 studies), leaderboards (seven studies), badges (five studies), feedback (three studies), competition (two studies), challenges (two studies), and rewards (two studies).

**Table 1.** Review of the literature of gamification in higher education.

| Author and Year | Topic | Main Conclusions | Advantages | Gamification Elements |
|---|---|---|---|---|
| Wiggins, 2016 [8] | Game-based learning (GBL) and gamification and in higher education | Acknowledged that non-digital GBL is more dominant than digital GBL.<br>Established that the communication faculty were to a large extent not familiar with gamification concepts, but did recognise game elements. | Not included | Not included |
| Kuo & Chuang, 2016 [9] | Game mechanics employed in an online platform | Established that discussion board, graphical incentives and gamified thematic activities, were the most significant gamification elements for user retention and engagement.<br>Indicated that a website where gamification elements were employed demonstrated an increase in the number of visitors to the site, as well as an increase in the duration of visitation. | Retention and engagement and | Points, discussion board, leaderboard, graphical incentives, thematic activities, rewards, levels, and invitations |
| Hew, Huang, Chu & Chiu, 2016 [10] | Influence of game mechanics on student engagement and motivation and | Revealed that the use of a leaderboard, points, badges, and enhanced cognitive and behavioural engagement.<br>Discovered that game elements inspired students to select more challenging activities and to deliver work of better quality. | Engagement, increased effort, and higher quality work | Points, badges, and leaderboard |
| Morillas Barrio, Munoz Organero & Sanchez Soriano, 2016 [11] | Gamified student response systems (SRS) | Development of a gamified SRS.<br>Established that gamified SRSs improved motivation, reduced boredom with lectures, and boosted student confidence. | Motivation, engagement, confidence, and attention | Goal, feedback, challenges, illustration |
| Buckley & Doyle, 2016 [12] | Student learning and motivation | Determined that rewards, rules, feedback, and competition are the main game mechanics to employ in course gamification.<br>Established that gamification motivated students to learn additional material not covered in class. | Enhanced learning outcomes | Competition, rewards, rules, feedback |

**Table 1.** Review of the literature of gamification in higher education. (Continued)

| Author and Year | Topic | Main Conclusions | Advantages | Gamification Elements |
|---|---|---|---|---|
| Yildirim, 2017 [13] | Student attitude and performance | Identification of main gamification elements. Indicated that gamification enhanced student attitude towards lessons as well as increased performance. | Improved learning outcomes and attitude | Collaboration points, badges, leaderboard |
| Sanchez-Martin, Canada-Canada & Davila-Acedo, 2017 [14] | Student competitive-collaborative attitudes and performance | • Showed a statistical significant correlation between grades on the final exam and accumulated points in the game.<br>• Discovered that gamification instigated competitive student behaviour. | Increased competition | Points and challenges |
| De Marcos, Garcia Cabot & Garcia Lopez, 2017 [15] | Social gamification | • Discovered that the gamified group performed better in practical projects than the group that was used as the control.<br>• Noticed that students portrayed an affirmative attitude towards social gamification. | Improved student performance | Badges, leaderboard, points, virtual shop |
| Stansbury & Earnest, 2017 [16] | Meaningful gamification | • Discovered that the self-reported learning of the gamified student group exceeded the self-reported learning of the student group that was used as a control.<br>• Discovered that the student group that was gamified, was more motivated, engaged and enjoyed the learning experience more. . | Perceived learning, engagement, motivation and enjoyment | Points, feedback role-play and narrative |
| Sailer, Hense, Mayr & Mandl, 2017 [17] | Game design elements | • Gamification elements were identified that promoted emotional need gratification.<br>• Identified gamification as a potent means to motivate students. | Psychological satisfaction | Badges, leaderboard, teammates, avatars and stories |
| Cakiroglu, Basibuyuk, Guler, Atabay & Memis, 2017 [18] | Effect of gamification on student engagement | • Indicated that the usage of points, quests and leaderboards enhanced the engagement of students.<br>• Indicated an improvement in the self-reported levels of student academic effort, confidence, engagement and motivation. | Engagement, confidence, performance, academic effort, motivation | Leaderboard, points reputation and real gifts |

**Table 1.** Review of the literature of gamification in higher education. (Continued)

| Author and Year | Topic | Main Conclusions | Advantages | Gamification Elements |
|---|---|---|---|---|
| Dias, 2017 [19] | Comparison of student performance and engagement of a gamified course to a course that is not gamified | • Observed that the student group that was gamified displayed higher pass rates, attendance percentages and participation rates than the group that was not gamified.<br>• Identified that advantages were the result of the gamification elements added to the course. | Performance, engagement, and attendance | Points, badges, and leaderboard |
| Song, Ju & Xu, 2017 [20] | Influence of points on the engagement of students | • Indicated that the usage of points enhanced enjoyment and engagement of students.<br>• Detected that shy and unfocussed students had the highest likelihood to be engaged in a gamified class | Enjoyment and engagement | Points |
| Lin & Kaur, 2018 [21] | Investigating the appropriateness of a game-based learning environment. | • Students had a positive experience with Kahoot!.<br>• Results indicate that Kahoot! is a gamification platform that can enhance extrinsic and intrinsic motivation of higher education students. | Engagement, motivation, | Competition, quiz, points, fantasy. |

## 3. Mechanics-dynamics-aesthetics Theory

The theoretical base for the study is mechanics-dynamics-aesthetics theory (MDAT). MDAT is a formal approach to understanding games, and it offers an appropriate model to explain how gamification works [22]. The MDA framework was developed by [23] and delineates how game design elements result in certain responses from players. The MDAT model summarises a player's consumption process of a game into three components namely rules, system, and fun. The player first understand the rules of the game, and then proceeds to interact with the system and start to have fun. These three parts match the complements in a game designer's design process: (1) mechanics, (2) dynamics, and (3) aesthetics [23].

**Game mechanics** allude to the techniques, tools and gadgets that are the foundation that a game is built on, for example points, badges, avatars and leader boards [24]. The addition of game mechanics to an IS permits designers to embed more captivating user experiences into current tasks. These gamified tasks direct and gratify basic human

needs, producing the habit-forming experiences that compel users to take part in specified activities, and to come back on a regular basis [25].

**Game dynamics** in a gamification context refer to fundamental desires system users have. Users have needs for status, reward, achievement, competition and self-expression. Game designers are in possession of the knowledge to address these desires within gaming settings, and gamification now make it possible for these principles to be used in broader contexts [25].

**Game aesthetics** is the feelings that players experience when they play a game. The emotional reactions from individuals will be dependent on the game dynamics. Emotions could vary from relaxation to excitement, or from rising tension to frustration to name but a few [2]. In classic game settings, game aesthetics refer to explicit types of "fun" that players pursue and experience while interacting with games [23]. When contrasting classic games (where users are looking for hedonic gratification – fun and entertainment) to enterprise gamification it should be noted that users are generally looking for instrumental gratifications where there main aim is to achieve a specified outcome for example learning or recognition that could lead to aesthetics such as confidence or cognisance [26].

MDAT has been created to theorise about classic games, but is adopted in this study for gamified systems, where game elements are used in contexts that are not games. MDAT elucidates that game mechanics like levels, points, badges, avatars and leader boards, set into motion gameplay dynamics like the desire for rewards, status and competition [27]. Even though some game elements tend to generate a specific game dynamics, there does not exist a fixed relationship between game dynamics and game elements. This means that a particular game dynamic can be caused by more than one game element and one game element can trigger multiple game dynamics [2]**.** Table 2 summarises the most commonly reported game dynamics that can be generated by various game elements (game mechanics).

In addition to the game dynamics showed in Fig. 2 (that is generated by various game mechanics), Umar Ruhi expanded the MDAT of Hunicke et al. [23] by including additional game mechanics and game elements in the "MDA framework and the 20 Cs of meaningful enterprise gamification" [26] as shown in Fig. 1. The expanded MDA framework was developed after rigorous research of gamified systems used in industry and the goal of the framework is to explain the relationships between the motivations of users, gameplay elements, and technology functions and characteristics that constitute productive gamification enterprise interventions [26].

**Table 2.** Game dynamics and related game elements.

| Game dynamics | Related game elements / mechanics |
|---|---|
| **Rewards:**<br>• People are motivated by getting something of value given for performing some action. A reward is offered after the incidence of a behaviour or action intending to cause that behaviour to recur [25]. | **Points, Levels, Badges/trophies:**<br>• Users acquire points as award for carrying out appointed activities. Points comprise one game elements in a gamified IS, which activate a dynamic that causes users to try obtaining more rewards [28].<br>• Levels bring about a dynamic that inspires users to attempt to increase their status by accomplishing appointed objectives or by the attainment of mileposts within a gamified IS [28].<br>• Trophies or badges represent a user's esteemed activities, thus inspiring people to try to attain noticeable rewards that reveal their achievements [28]. |
| **Competition:**<br>• People are regularly motivated by competition. Literature indicate that higher levels of performance can be attained when a competitive setting is created and the winner compensated. People gain gratification by comparing their achievements to that of others [25]. | **Points, levels, badges, and leaderboards**<br>• Leaderboards offer users the opportunity to compare themselves to others and compete against others. Users try to obtain higher points or scores for an activity, earn more trophies and badges and achieve higher levels [28]. |
| **Self-expression:**<br>• Individuals often search for an appropriate time to demonstrate their originality and autonomy, to distinguish themselves as unique. This refers to the human desire to display a particular style, personality and identity, and to produce group association [25]. | **Points, levels, badges, and leaderboards, avatars and emoticons**<br>• Points, levels, badges, leaderboards, and virtual goods bring about a dynamic of self-expression that give user the opportunity to produce their own personal identity or style. Moreover, by conveying their feelings and emotions through virtual goods (for example emoticons and avatars) users can connect with the other users (payers) in a more personalised manner [3]. |

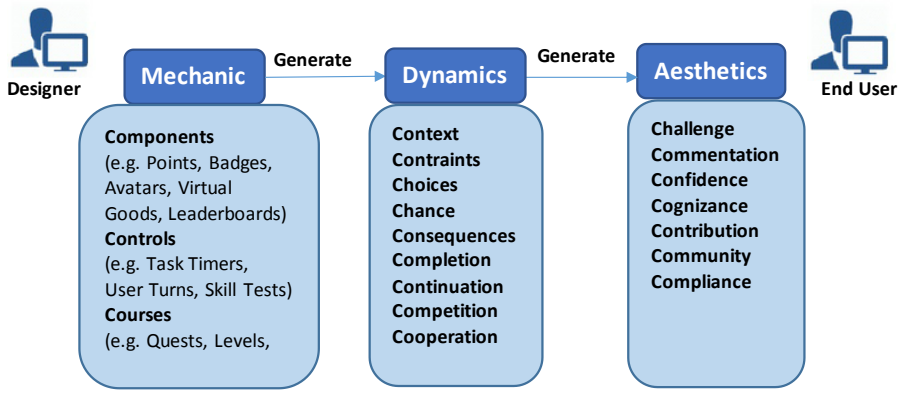


**Fig. 1.** Ruhi's MDA framework and the 20 Cs of meaningful enterprise gamification [26].

## 4. Online Gamified Learning Environment

The online gamified learning environment that was used in this study is the Khan Academy platform. This platform is a free open source educational platform which provides a comprehensive set of courses, covering many areas of science, arts & humanities, economics and computing [29]. The computer programming subject of Khan Academy that was used for this study is the "Introduction to JavaScript: Drawing and Animation" subject.

The Khan Academy programming learning environment predominantly comprises of the watching of a video explanation of the topic followed by an exercise that must be completed by the student. Users are expected to complete the exercise in a simulated environment where feedback is provided by various game characters. Students are rewarded with energy points for watching videos and successfully completing assignments. Various badges are rewarded based on the performance level of the user. Users are able to view their statistics at any given point in their dashboard shown in Fig. 2.

The Khan Academy platform provide students with the option of enrolling in a course with an instructor. The instructor is able to assign numerous tasks to students with due dates when these tasks should be completed. The instructor of a course in Khan Academy can obtain a list containing the performance of all students including the total points they have gained as well as the time in minutes that they spent on completing activities. Instructors can convert these lists into leaderboards by sorting the list in descending order according to obtained points. It is the responsibility of the instructor to post this leaderboard for students where they can all see it.

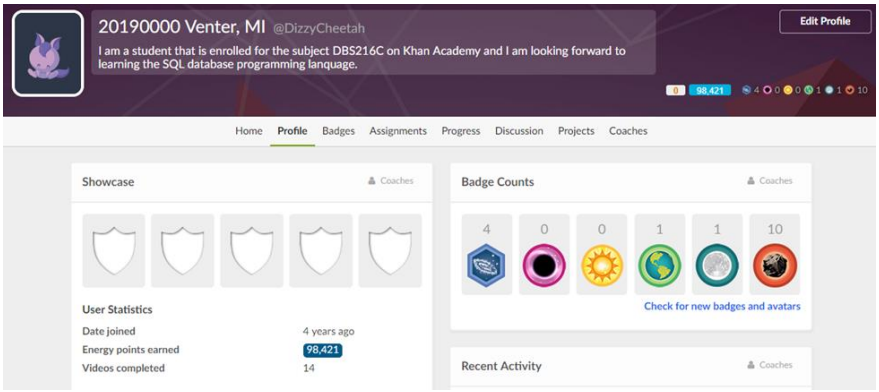


**Fig. 2.** Khan Academy Dashboard.

## 5. Methods

A qualitative research design was used for the study. A qualitative approach is one in which the researcher frequently makes knowledge claims based primarily on constructivist/interpretivist perspectives [30]. This approach focuses on understanding and discovering the perspectives, experiences and thoughts of the participants [31]. The population for the study was limited to 92 students enrolled for the Extended Information Technology Diploma at the Central University of Technology in the Free State province. Students enrolled for the subject Life Skills I, were exposed to the Khan Academy environment for two practical periods per week for one academic term. The lecturer created a subject on Khan Academy "Life Skills I" and all students enrolled for this subject on Khan Academy. The instructor assigned various activities to students in Khan Academy, and they had to complete these activities on the Khan Academy platform. Students received marks for their completion of these assignments and this mark contributed 5% of the final mark of the Life Skills 1 subject. Data was collected by semi-structured group interviews and students were asked to voluntary take part in these interviews. Ethical procedures as stipulated by the Central University of Technology were adhered to. Data gathered from the interviews were transcribed and analysed with MS Excel by using content analysis. The content analysis of the transcribed data was conducted according to the procedure suggested by Ezzy [32]. The steps as suggested by Ezzy [32] are as follows: Define the unit of analysis, e.g. words or sentences; review the text in order to code it; review all codes and place them into categories; count and log the occurrences of words, codes and categories; make use of

statistical analysis and quantitative methods to interpret the results. Usage data of students, including the total number of minutes spent in the Khan Academy environment, number of points and badges were directly downloaded from the Khan Academy platform.

## 6. Results

Table 3 summarises the usage data of students that was downloaded directly from the Khan Academy environment. It can be seen that on average students earned a total of 18892.59 points and 8.16 badges while spending an average amount of 128.99 minutes on the Khan Academy platform.

**Table 3.** Khan Academy usage data.

| | Badges Earned | Point Earned | Total Minutes Spent |
|---|---|---|---|
| n | 92 | 92 | 92 |
| Mean | 8.16 | 18892.59 | 128.99 |
| Std. Deviation | 3.452 | 10372.394 | 87.581 |
| Minimum | 1 | 486 | 9 |
| Maximum | 16 | 67505 | 697 |

### 6.1 Overall Experience of Khan Academy Environment

The first research question of the study was: "How do students experience the Khan Academy gamified programming platform?" In order to determine how students experienced the Khan Academy environment the first interview question that was asked was: "What is your overall experience of the Khan Academy environment?" Students were asked to freely comment on all interview questions and no multiple choice answers were provided. A total of 68 responses were categorised into seven themes and the results are shown in Table 4.

**Table 4.** Overall Experience of the Khan Academy Environment.

| Theme | Count | % |
|---|---|---|
| Understand programming / learn skills | 26 | 38 |
| Enjoyment | 23 | 34 |
| Time too limited | 8 | 12 |
| Easy to use | 4 | 6 |
| Unpleasant experience | 3 | 4 |
| Want more challenge | 2 | 3 |
| Difficult to relate to JavaScript | 2 | 3 |

The largest majority of students (26) said that the Khan Academy environment assisted them to understand programming or to learn various skills. Students also experienced the platform in a very positive light with 23 students saying that they found the Khan Academy environment enjoyable and four students commenting that it was easy to use.

In addition, eight students commented that the time was too limited for them to complete their assignments and that they needed more time. Only a small percentage of students experienced the Khan Academy environment in a negative light with three students reporting they had an unpleasant experience, while two students wanted a more challenging environment and two students struggled to relate to the Khan Academy environment.

### 6.2 Experience of Points, Badges and Leaderboard

The second research question of the study was: "How do students experience the points, badges and leaderboard game elements in Khan Academy? In order to investigate this research question the following interview questions were posed:
Interview question 2: "How did you experience the points you received in Khan Academy?"
Interview question 3: "How did you experience the badges you received in Khan Academy?"
Interview question 4: "How did you experience the leaderboard you received in Khan Academy?"

The results of these interview questions is summarised in Table 5, 6 and 7.

A total of 54 responses were categorized into five themes for interview question 2 and the results are shown in Table 5.

**Table 5.** Perceptions regarding points.

| Theme | Count | % |
|---|---|---|
| Rewarding Experience | 23 | 43 |
| Motivation to obtain more points | 16 | 30 |
| Don't understand the point system | 6 | 11 |
| Don't care about points | 5 | 9 |
| Not Satisfied | 4 | 7 |

From Table 5 it can be seen that students experienced the points that they received in the Khan Academy environment in a very positive light with 23 students commenting that it was a rewarding experience. Some specific comments made by students were:

"It was inspiring and enjoyable because we were rewarded by something".
"It is very exciting to earn points after watching a video".

The points that students received also motivated them and 16 students commented that receiving points motivated them to obtain more points. Some comments made by student are listed below:
"It motivated to work harder to receive more points."
"The points want you want to do more considering you want to get more points on the next one".

A small number of students commented that they did not understand the point system (six students) or that they were not motivated by receiving points (five students) or who were not satisfied by the points they received (four students).

A total of 52 responses were categorized into four themes for interview question 3 and the results are shown in Table 6.

**Table 6.** Perceptions regarding badges.

| Theme | Count | % |
|---|---|---|
| Rewarding Experience | 24 | 46 |
| Did not know it existed | 16 | 31 |
| Motivation to work harder | 7 | 10 |
| Don't care about badges | 5 | 13 |

From Table 6 it can be seen that 24 students commented that receiving badges was a rewarding experience and some comments made by students are outlined below:

- "I felt awesome earning badges, I earned seven."
- "They were fulfilling because after completing a task they pop up on the screen."

Furthermore, a number of students (16) commented that they did not know that they could earn badges and five students commented that they don't care about badges. Moreover, seven students commented that badges motivated them to work harder.

A total of 50 responses were categorized into six themes for interview question 4 and the results are shown in Table 7.

**Table 7.** Perceptions regarding leaderboard.

| Theme | Count | % |
|---|---|---|
| Motivated to work harder to compete | 20 | 40 |
| Positive Experience | 10 | 20 |
| Did not know it existed | 7 | 14 |
| Tool for comparison | 7 | 14 |
| Did not matter to me | 4 | 4 |
| Negative experience | 2 | 2 |

Table 7 shows that 20 students commented that the leaderboard made them want to work harder in order to compete with other students. In addition, 10 students had a positive experience with the leaderboard and seven students perceived the leaderboard to be a tool to compare them to others. As with badges, seven students commented that they did not know about the leaderboard and four students commented that the leaderboard did not matter to them. Only two students commented that they had a negative experience with the leaderboard.

## 7. Discussion

The objective of this study was to investigate how students experience the Khan Academy gamified programming platform and the embedded gaming elements before full-scale implementation of this platform in a first year programming course. The overall experience students had with the Khan Academy platform is very encouraging due to the fact that 38% of students reported that the platform improved their understanding of programming principles and 34% of students reported that they enjoyed using this platform. This finding is in line with research that found that the largest majority of students who were enrolled for the Hour of Code programming intervention on Khan Academy, improved their programming knowledge and experienced the environment as "fun" and "engaging" [33].

Moreover, the results of the study also supports the prediction of the MDAT that users' experience of game dynamics while using a gamified information system lead to a positive attitude, which inspires them to engage with the system on a deeper level [28]. It was found that the gameful experiences provided by the Khan Academy platform lead to a positive state of mind of students which is evident in the responses that was provided by students in terms of their perceptions of the points, badges and leaderboard used in the Khan Academy platform. More specifically, it was reported by students that the points and badges game elements lead to the rewards game dynamic with 43% of students reporting that the obtaining of points was a rewarding experience, while 46% of students reported that receiving badges was a rewarding experience.

Furthermore, the leaderboard game element generated the competition game dynamic with 40% of students reporting that the leaderboard motivated them to work harder in order to compete and 14% of students mentioned that they used the leaderboard to compare themselves to other students. This finding in in agreement with research conducted by [14] that found that gamification caused students to become more competitive.

Another game dynamic that was generated by the points and badges game elements in Khan Academy platform was the "continuation" game dynamic as portrayed in the expanded MDA framework of Ruhi [26] shown in Fig. 1. According to [26] various

game elements in a gamified information system motivate user to complete a task and to continue to the next phase. Students reported that they wanted to continue using the Khan Academy platform with 30% of them stating that they wanted to continue in order to obtain more points and 10% of them saying that they wanted to continue in order for them obtain more badges.

It is important to take note that a number of students reported that they did not understand or was not aware of the various game elements in the Khan Academy platform. A relatively small percentage of students also mentioned that they "did not care about" the game elements. The most important critique that students had towards the usage of the Khan Academy environment is that time was too limited to complete their assignments due in their formal class periods.

## 8. Conclusions

The objective of this study was to pilot test the Khan Academy gamified learning platform before a full scale implementation thereof. The results indicate that the Khan Academy environment provided various benefits to students including an improvement of programming knowledge and providing an enjoyable environment for students. In addition, students perceived the points, badges and leaderboard game elements of the Khan Academy environment in a very positive light and these game elements successfully managed to generate game dynamics of rewards, competition and motivation to continue using the platform.

Implications of this study is that educators that want to implement gamified learning environments in their courses must ensure that students are aware of the game elements in the gamified environment, and that the students understand the operation of the game elements. Educators should therefore use various means (hardcopy and softcopy formats) to communicate the progress students are making towards their accumulation of points, badges and their position on the leaderboard. Students also mentioned that they were not given enough time to complete gamified assignments. The Khan Academy platform can be accessed via the internet from any location, but it is a very data intensive application so educators wanting to implement this platform in their courses should ensure that students without internet access at home get enough "lab-time" to complete assignments.

A limitation of the current study is that the population of the study was limited to the Free State province in South Africa. Recommendations for future research would consequently be an appeal to researchers in institutions all over South Africa to investigate the MDAT framework in gamified educational settings in order to validate the original [23] and the expanded MDAT frameworks [26].

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# SHORT PAPERS

# Back to BASIC in Compiler Construction

**Short Paper**

**SACLA 2019**



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**Abstract.** This short paper offers an experience report about a successful way of giving an introductory compiler construction course to 3rd-year undergraduate students. Because the in-depth-presentation of compiler construction has nowadays become rather seldom at South African universities, this short paper is intended to serve as motivation and recipe for the topic's (re)introduction at other institutions of tertiary education.

**Keywords:** Compiler Construction, 3rd-year Undergraduate, Experience Report, Tertiary Education, Computer Science.

## 1 Motivation and Related Work

In bygone days there was a sharp distinction between *vocational* tertiary education in 'technikons' —which emphasised employability and industry-readiness for their students— on the one hand, and *academic* tertiary education at universities —which emphasised scientificness or scholarliness and which were by- and-large free from industrial interference— on the other hand. Recent trends in tertiary education both nationally and internationally have increasingly blurred the old line of separation between technikons and universities, whereby the former technikons are now striving for higher scholarly reputation thus competing against the classical universities. The universities are now increasingly emphasising and advertising the employability and industry-readiness of their students thus competing against the former technikons; like the curricula of the former technikons, also the curricula taught at universities are now increasingly influenced by the commercial industry (often via external advisory boards). Under these circumstances and a consequence of this line-blurring trend, which is well-documented in large quantities of literature on higher education —for

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only three example see [12][13][16]— some universities nowadays might feel tempted to dilute (if not entirely abolish) a number of classical courses that are now being regarded as 'too theoretical', 'not practical enough', or 'not industrially relevant'. Whereas the classical university of bygone days confronted its students with difficult theoretical *science* from day one onwards, nowadays trend is to first *train* students in industrially applicable *skills*, and to let the science follow only later at post-graduate level. Indicative of this trend seems to be also the nowadays mushrooming usage of the phrase "*teaching and learning*" (instead of lecturing and studying) in *tertiary* education management jargon which seems to signify an ongoing *schoolification* of tertiary education at universities.[1]

The topic of this short position-paper —*compiler construction*— cannot be separated from those above-mentioned general trends. In South Africa, for ex- ample, only few of the country's tertiary education institutions offer courses on this topic at all, and also internationally the curricular relevance of compiler construction has been disputed [7][11][22]. However, the difference between learning programming and studying compiler construction is similar to the difference between learning how to drive a car and studying automotive engineering for the sake of car-construction. Learning programming and learning to drive a car are simple enough that teenagers can do that at secondary school before entering university, whereas science-based tertiary education is necessary to master the challenges of compiler construction (i.e.: *making* new programming languages rather than merely using existing ones) as well as automotive engineering. Beheld from this perspective it should be clear that computer-*scientific* topics like compiler construction ought not to vanish from tertiary computer science curricula - though this has happened in fact from place to place. Indeed: if (as mentioned above) also universities are nowadays becoming increasingly employability-skills- oriented, and if the local IT industry mainly wants java programmers, then why bother 'learning' compilers at university? Such a point of view, however, would ignore the educational benefits of compiler construction as *computer science* in a nutshell, in which the threads of many sub-topics of computer science (e.g.: automata theory, algorithms and data structures, principles of software engineering, operating systems, artificial intelligence methods of optimisation, and the like) are woven together [9]. In the undergraduate curriculum, compiler construction is one of the few theoretically solid topics by means of which the *scientific-ness* of computer *science* (as opposed to computer engineering or software 'crafting') can be convincingly demonstrated. However, even the rather small minority of those students, who are still coming to university with a classical scientific outlook [10], do not find it easy to imagine a compiler's theoretical concepts and inner workings.

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[1] I still remember my chemistry teacher: "at school you learn; at university you study!"

In this short-paper report, I briefly describe *qualitatively* what I have done to provide a fruitful study experience for my compiler construction students under those above-mentioned circumstances. Thereby my pedagogical efforts were particularly aimed at making the students intuitively see an actually running program after its compilation — i.e.: to provide the students with some joyful personal 'eureka!' experiences, which are arguably important from a pedagogical point of view. On-the-fly I also tried to emphasise the computer-scientific foundations of compiler construction wherever possible (for example: by pointing out issues of *undecidability* on various occasions) with the aim of nurturing a scientific world-view also among those (many) students who are nowadays at university just for the above-mentioned employability skills [10]. To those students I tried to advertise the benefits of a scientific world-view rather instrumentalistically with the message: *"solid science will help you to do a better job"*.

Academic literature on compiler *education* dates back to the mid-1960s. Due to the wide-spread standardisation of compiler construction, publications on this topic appear in only irregular frequency and not in large numbers. In *"a new approach to teaching a first course in compiler construction"* from 1976, it was recommended to replace one large semester project by several smaller independent mini projects [18]; I have followed that route. An *"emulator"* approach to code generation was advocated already in 1977 [15]; I have followed that route as well. The Student Programming Language SPL used in my course is similar to the project language of [3]. The (disputed) importance of compiler construction within the computer science curriculum was emphasised again during the mid-1990s [2]. The topic-specific difficulties with which compiler construction students are typically confronted are summarised in [19]: for similar reasons the students of [4][21] were given a partly pre-fabricated compiler environment to 'play' with; this rather shallow educational 'use and play' approach, however, is not advocated by me. The often-repeated opinion about compiler construction being allegedly 'outdated', 'too old-fashioned' or 'irrelevant' for nowadays curricula was analysed and discussed in [11] wherein also some new topics for advanced compiler construction courses were presented. A similar modernisation attempt was presented in [22] — albeit with the danger that all those *"exciting"* [22] software-controlled robots might only distract the students from the scientific essentials of the topic. In [7] the topic's relevance question was raised, too, and yet another tool kit in support of new approaches to compiler construction was presented. A nice and insightful personal letter on this topic was written by the main author of the seminal 'dragon book' [1]. Whereas the practical part of my course ends with the generation, optimisation and variable-liveness analysis of *intermediate* code, whereby the generation of target machine code is merely lectured, the authors of [14] have created a small and simple set of pseudo machine code instructions by means of which their students can practice also the final compiler phase of *target* code generation. However, similar to my approach at intermediate code level, the pseudo machine code of [14] is *emulated*, too.

## 2 Experience Report

The introductory compiler construction course described in this short paper is a 3rd-year course in one academic half-year (semester). Two lectures took place per week with 50 minutes duration per lecture. Moreover, eight practicals had to be done and demonstrated. The work-time per practical was approximately 7–10 days. No additional recapitulation- or tutoring-lessons (outside the regular lectures) were provided to the students, who thus had to be highly self-sufficient, self-responsible, self-motivated, and diligent. All in all, each student implemented a fully operational compiler from scanner (lexer) and parser via static semantics analyser (name-scope analysis, DECL-APL analysis, value-flow analysis and type- checking) to intermediate code generation (translation to basic), followed by some intermediate code optimisation (on the generated basic code) as well as variable liveness analysis and variable dependency analysis (yielding a coloured dependency graph) also on the generated basic code.

Mogensen's book [17] provided the conceptual foundations, whereby the students had rather little prior knowledge from their previous study-years 1–2 in theoretical informatics, i.e.: automata theory and formal languages, graph theory, set theory, fixpoint theory, and the like. More advanced sub-topics of compiler construction (e.g.: garbage collection, parallelism, automatic type inference, compilation of object-oriented source languages with classes and sub-classes, operator overloading, dynamic typing, dynamic scoping, and the like) could merely be mentioned cursorily within the above-mentioned organisational limits of this introductory course. Nonetheless, to keep in touch with the most recent developments in the field, also a short overview-essay about obfuscating compilers (also known as 'crypto-compilers') had to be written, whereby I provided the students with some initial literature references from which they had to start with their reading-and-writing work. Five working days were allocated to this essay task.

With regard to the related work recapitulated above, I introduced a self-made imperative procedural Student's Programming Language (SPL) the context-free (albeit initially ambiguous) grammar of which contained merely the following lexical and syntactic concepts:

- a main program, optionally followed by procedure definitions (sub-routines);
- simple input/output commands;
- named variables with preceding type declarations;
- imperative assignment statements with some simple arithmetic operations on composite terms;
- conditional statements with composite condition-terms (and optional else);
- unbound iteration statements (while with composite exit condition terms);

- bound iteration statements (for, with non-composite exit conditions and loop-counter increment +1);
- call statements for the parameter-less sub-routines.

Further details of the grammar need not be provided in this short report, as every competent computer science lecturer can easily design a similar SPL. In order not to overwhelm the students with programming work, the SPL sub-routines were truly old-fashioned without any input parameters and without any return-values. Proper function calls with input parameters and return values on a runtime stack were only discussed in the lectures on the basis of the book [17]. Though SPL sub-routines can contain inner (non-global) variables in separate static-semantic scopes, their main purpose is the manipulation of global variables by way of side- effects. Even the nesting of inner sub-procedures (with their own static-semantic scopes) within procedures was a grammatical possibility.

Following the classical phases of compiler construction, the students first had to come up with regular expressions (RE), then non-deterministic finite automata (NFA), then deterministic finite automata (DFA), finally minimised finite automata (MFA) for the vocabulary of SPL. For the above-mentioned pedagogical purposes, no lexer-generator was allowed to be used; the students had to implement their own lexers from their MFA although the availability of lexer- generators for professional purposes was mentioned in the lectures. In the next phase of the project, the deliberately ambiguous grammar of SPL had to be made non-ambiguous, and the students' own parsers for it had to be demonstrated. For the sake of in-depth understanding by construction, it was again forbidden to use already available parser generators, the existence of which for professional purposes was only mentioned in the lectures. Due to the detailed instructions in the chosen book [17] about how to build a parser, this sub-task of the project was well done by all students in the course. As usual, the emitted concrete syntax tree also had to be purified to a less dense abstract syntax tree (AST) in an after-phase of the parse procedure.

More challenging, however, was the implementation of the static semantic analysis software in the last analytical (front-end) phase of the project. The large amounts of AST 'crawling' with all the inherited and synthetic attributes needed for the identification of the (nested inner) name-scopes as well as for type-checking, value-flow-analysis (etc.) turned out to be problematic particularly for those students who were weak in algorithms and data structures (study-year 2), because the chosen compiler construction book did not go deeply enough into the details of these matters. For pedagogical reasons (higher education) the students had to seek, find, and self-study whatever literature they could need for this phase. Hence, in several of the software demonstration sessions, types were not always correctly checked, or name-scopes were not consistently separated from each other. Especially in this static-semantics phase of the practical projects, several students have obtained more insight from their mistakes and errors than from their positive achievements.

After the static-semantic analysis, the generative (back-end) phase of the project ended with the production (and subsequent optimisation on the basis of variable liveness and variable dependency analysis) of intermediate code; the principles of producing hardware-specific target code from hardware-independent intermediate code were merely lectured along the lines of [17]. This last phase of the practical project was not too difficult for the students as the algorithmic generation of intermediate code (from AST and static-semantic information) was well described in the chosen book.

The ancient programming language basic in its simplest non-modernised form was chosen as the target language for the students' intermediate code generators. In its oldest form, basic is a pure *von-Neumann language* with its notoriously "harmful" [8] GOTO jumps to symbolic addresses. Thus all the high-level control structures (if-then-else, while, for) with their composite logical branching conditions had to be translated by the students' code generators into cascades of GOTO jumps, as it would also have been the case in genuine machine code (for specific hardware) at the very end of the code generation chain. The automatically generated basic programs were then further optimised by some of the not-so-difficult techniques, which the chosen book described in sufficient detail (e.g.: common sub-expression elimination, constant propagation, and the like). Run-time tests with carefully chosen input values were used to quick-check whether the students' implementations of 'optimisations' had actually damaged the operational semantics of the un-optimised basic programs — in several demo sessions that was indeed the case. After looking at their thus-generated basic code, many students were astonished about its mind-boggling cascades of GOTO jumps. Thus the students also began to appreciate the concern of Dijkstra's famous 'GOTO harmful' letter [8] (the reading of which was an additional home- work task), and began to understand that it is now the compiler's function to create those low-level GOTO jumps which the human programmer is no longer supposed to write. Because basic emulators are nowadays available on the Internet, the students could use those emulators to see, with their own eyes, how their own SPL input programs could be translated (if free of lexical, syntactic and static-semantic defects) by their own compilers to executable basic code, and how a subsequent run would proceed step by step in the observable basic emulators.[2] Insofar as the elements of SPL can be easily expressed in familiar languages like JAVA, for which well-tested compilers are already available, the students were thus also able to conduct further comparative experiments and observations by first re-writing an SPL program to JAVA and then seeing whether the basic behaviour of their compiled SPL program would match the runtime behaviour of the corresponding JAVA program. If thus, for example, a student's scope checker in the static-semantic analysis phase would still contain some undetected flaw, then his

[2] As a minor by-product of this approach, the students also obtained some insight into the history of programming languages and computing.

finally generated basic program could be expected to reveal in the online-emulator a strangely different runtime behaviour in comparison against the runtime behaviour of the SPL-equivalent JAVA program after its translation to byte code by a trustworthy JAVA compiler.

All those features provided the students with fruitful study-experiences, and the pass rate after the course's final exam was remarkably high. Anecdotal evidence (from students' various e-mails) seems to indicate that the students have by-and-large appreciated my educational approach as well as the value of the knowledge obtained from it. One student remarked explicitly that he now grasps why I had called compiler construction *computer science in a nutshell* at the very beginning of the course.

## 3 Possible Critique and Outlook to Future Developments

In some internal discussions with several colleagues before I wrote this paper a number of interesting questions had been asked — for example: why was it not allowed to use already existing lexer and parser generators? Would the use of such pre-existing tools not provide the students with the same insight as the tedious creation of their own lexers and parsers? Indeed there are some 'practically oriented' books like [20] which do not delve as deeply into the underlying theoretical concepts as we did, and I am also aware of at least one university in the country where the topic is presented in such an overview-oriented style. If, how- ever, we are willing to accept the epistemological opinion that an engineer can fully grasp only what he can construct, then the students' own lexers and parsers (no matter how simplistic) will be of better engineering-educational value than the mere inspection of the software code of already existing lexer- and parser- generators. By analogy: it is also not sufficient to inspect a car to become an automotive engineer. Why was the simple SPL, rather than a modern language like Python, used as source language? Here my answer is: for the students in the limited above-mentioned set-up of my course, the problems of type checking and code-generation for object-oriented source languages would have been too difficult. Object-oriented type checking alone (let alone code-generation) would have required a theoretical foundation along the lines of [6], which would have been far outside the scope of our curriculum. As SPL in all its simplicity is already Turing-complete, it sufficed for the implementation of the usual pedagogical ex- ample programs (like Euclid's GCD algorithm) from which the students were able to generate executable target code with reasonable effort. Why was the old basic, and not a modern language like Python used for target code? My answer is that basic is a proper von-Neumann language, with symbolic addresses (line numbers) and GOTO jumps like in genuine machine code, which is at the same time observably executable in a number of freely available interpreters and emulators. Python, with all its high-level features, is *no* such von-Neumann language and is thus far away from resembling machine code in any form. With the available basic interpreters, the students were able to empirically observe the runs of their self-translated SPL programs in the basic interpreter line by

line. For all the above-mentioned reasons I hope that this short experience re- port can serve both as a motivation and as a recipe for the (re)introduction of compiler construction at other institutions of higher education anywhere in the world. With the recent growth in new high-level special-purpose-languages (like specification- or modelling languages for software engineers), or the recent emergence of crypto-computers for which code-obfuscating compilers (also known as crypto-compilers) are needed, the topic of compiler construction might soon get rid of its (prejudiced) smell of the old-fashioned and might come back into the center even of IT-commercial interests.

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# Evaluation of Tablets for Teaching and Learning for Information Technology Extended Programme at Walter Sisulu University

**Short Paper**

**SACLA 2019**



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**Abstract:** Information and Communication Technologies have become an integral part within the Teaching and Learning environment especially in Higher Education. Despite the growth of these technologies, less research has been done to evaluate the effectiveness of tablets for teaching and learning. In this paper, we have considered tablets as the common device used at Walter Sisulu University for Extended Programme students in the Information Technology (IT) Department. The authors wanted to evaluate the usage of tablets towards teaching and learning among students and lecturers. Mixed methods approach was considered where both qualitative and quantitative methods were utilized. Data was collected through online questionnaires, focus groups and interviews. Findings show that students use tablets for sending and receiving e-mail messages, access course material posted by their lecturers and also search for information. The paper provides details on what and how the engaged participants are utilizing tablets for teaching and learning.

**Keywords:** Higher Education, Information Technology, Tablet, Technology Evaluation.

## 1. Introduction and Background

The growth of technology utilization to enhance service delivery has been witnessed in many sectors. Within the education sector, mobile technologies have been adopted to enhance teaching and learning. There are numerous devices that have been introduced

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and considered for teaching and learning, however this paper is limited to only one of the common mobile devices that is used by both students and lecturers, which are tablets. According to [1], mobile devices especially tablets are rapidly becoming popular within the teaching and learning environment.

The paper is based on the Extended Programme students from the IT Department at Walter Sisulu University. As of 2016, approximately 1000 students from WSUs four campuses have benefitted from a multi-million Rand tablet initiative designed to enhance teaching and learning in the institutions' extended curricular programmes [2]. These numbers have continuously increased. Students and lecturers use the devices for different purposes and services. The use of these tablets in lecture halls enables easy dissemination of information. These tablets are also likely to improve and support learning for extended IT students in Chiselhurst Campus since students are able to download E-books and study through their tablets. Tablets are becoming a current and dominant learning tool for the teaching space [3]. A recent study in "German second-level schools" described a tablet as a portable tool appropriate to act as an all in one tool anyplace, anytime" [4]. Tablets have the potential to motivate, inspire and enable learners to enjoy their studies, outside a classroom environment, while at the same time can cause destruction to students [5].

As explained in the WSU prospectus, an Extended programme is meant to equip students who do not meet the minimum admission requirements, with the skills to assist them in completing their studies with ease. The students enrolled under this programme are at high risk of dropping out in their first year. Initiatives such as the issuing of tablets does play a major role in motivating some of the students to enjoy their IT studies. Despite the growth of mobile technologies for teaching and learning, less research has been done to evaluate the effectiveness of the devices to improve teaching and learning. The paper answers the question: How are tablets helping WSU extended programme students at Chiselhurst campus in academic purposes?

This paper focuses on evaluating the effectiveness of tablets for teaching and learning at Walter Sisulu University in Chislehurst Campus for IT extended programme students who were given tablets. The paper comprises of a number of sections including: literature on ICTs in education, the approach used, findings and recommendations proposed. The following section provides an overview of the current literature available on mobile technologies.

## 2. Related Literature

Mobile devices are becoming a current and dominant learning tool for the teaching space [6]. According to [7] a tablet is a mobile computer that has touch screen capabilities and lacks a physical keyboard. Tablets are viewed as an extra 'always-on' device to boost and increase connectivity of learners, provide flexibility and manageable touch-screen capabilities to supplement teaching and learning improvement demanded for smartphones and laptops. There is sufficient literature on

mobile devices and tablets. For this paper, we have considered sufficient literature that explains mobile devices, usage and common challenges experienced when using tablets.

### 2.1 Technologies for Teaching and Learning

Researchers have explained a number of technologies available for teaching and learning. These technologies are in the form of applications, devices and systems. This paper has focused more on the devices. Commonly used devices in educational institutions are divided into 3 main groups [8]:

- Digital media players, are compact devices which can play both audio and video files.
- Smartphones, offer internet access, allowing users to download apps. An app is a
  piece of specialized software typically obtained through an app store.
- Tablets, generally feature a touchscreen with an onscreen keyboard and a digital pen alongside, with the ability to take photos, make calls and make video recordings.

### 2.2 Benefits of Tablets for Teaching and Learning

Tablets allow learning everywhere and anytime, letting education to be moved away from the usual student-lecturer classroom setup, where teaching is limited and restricted to teaching within the university's time [9]. According to [10] the possible advantage of a tablet would be the manageability and small feature, which would improve the "man on the street" or "student on the quad" method. According to [11] Using tablets in higher education provides single and self-determining method of education. Learners have the ability to take classes, make assignments, transmit chats, and take evaluations. Learners enjoy the free will of tablets which are intended to help them learn how to prioritize and also manage their time more efficiently, without any supervision from lecturers during class. [12].

From a study by [6] it was highlighted that learners define the benefits of tablets in education as encouraging the class in terms of empowering the implementation of shared lessons. Usage of tablets in studying or while undertaking schoolwork can offer both learners and lecturers with fast response time and improved class interaction as a result of better access to information which can also then lead to the lessening of lecture time [13].

From the findings by [14], learners quoted numerous benefits of tablets, these include: enhanced learners' structural and "note-taking skills", improvement in

learners' capability to inspire themselves in being more creative, and finally keep learners' individuality and communication capabilities. Learning with tablets allows students to expand discussions and investigate beyond the walls of the classroom. Tablets also allow learners to work together, share information and acquire skills using a great variety of content from various sources [15].

### 2.3 Challenges of Using Tablets for Academic Purposes

The challenges faced by learners and lecturers when it comes to technology utilization is usually disruption to learners, which is also a major challenge to lecturers. Students use these devices for social networks with the access to internet while in class instead of paying attention and participating in class and follow the lecturer's guidelines. Certain applications and websites should be blocked in educational institutions and lecturers should also monitor and control the use of these tablets by learners [16]. Students could get of track while looking up information on a website or attempt to use apps that are likely to be more entertaining and not central to the given task [17].

According to [16] the use of tablets in class requires "internet connectivity", for learners to login and out of each time they use. Lecturers stated that they occasionally face disturbance in their teaching schedule due to corrupt network or connectivity challenges of the "wireless network". Regardless of the development in the field of "mobile broadband connectivity", "broadband" right of entry remains costly or even unreachable for some causes [18]. Operation of consistent, maintainable and pull-out of "wireless network infrastructure" is the key issue for applying "tablets for e-learning" within the teaching space. Lack of technical support is also an issue. Technical support is a necessary element while attempting to adopt teaching technologies as educators will usually want some assistance while "they use such equipment" in teaching [13].

Issues with tablets as summarized by [9] are:

- The infrastructure necessary to run portable device.
- Protection and confidentiality of learner information.
- Lecturer expert education compulsory to assist the approval of these tools.
- Technical problems and battery life are the most common issues

### 2.4 Uses of Tablets for Academic Purposes

There are so many uses of tablets for academic purpose. Tablets can be used for [5]:

- Independent learning
- Collaboration of students
- Communication among students and lecturers
- Communication between students also for feedback.
- Inspire institutions of higher learning's students regarding education.

### 2.4.1 Learning Using a Tablet

"Mobile learning through the use of tablets presents new opportunities for strengthening the learning experiences in ways that simply other devices cannot achieve" [19]. According to [20] mobile learning is exceptional as it permits anywhere, anytime, modified education. It can similarly be utilized to improve, brighten or add different ranges to predictable teaching. The key purpose of mobile devices such as tablets in learning is mobility, by providing better learning experience. Gathered work on mobile learning cited mobile learning an advantageous method in the dissemination of lecturer's knowledge, skills and understanding while also improving "their mobile technology integration" abilities [21].

## 3. Methodological Approach

This study uses mixed approach to collect data from IT extended programme students in Chiselhurst in order to gain a detailed understanding on the effectiveness of tablets for teaching and learning. Both qualitative and quantitative methods were considered. Pragmatic paradigm is also used in this study which is a combination of interpretivist and positivism paradigm to understand the students' experience and views in using tablet devices. According to [22], pragmatic investigators are anxious about the study's problem rather than the technique to use, hence the investigators have the flexibility to combine and match some of the study methods. According to [23] pragmatic researcher is equally capable of keeping both partialities in their own images of the study and impartiality in information collected. Significantly, it has been presented as a method instead of a paradigm. Research instruments for this study are: online questionnaires, semi-structured interviews and focus group interviews.

There was a specific criteria used to choose participants who took part in this study. The participants had to meet the following criteria to be part of the study: they should be of any gender, willing to participate, must be IT extended programme students, have a tablet, and be of any ethnic group. Participants in the study were randomly selected. A total of 40 students were given an online questionnaire. Participation in the study was voluntary and anyone was able to withdraw from participation at any time. We also complied and adhered to the WSU ethical research processes of engaging students in the research.

Primary data was collected from Semi- structured interviews where one lecturer from the IT department was interviewed and two focus group interviews were conducted with IT extended programme students. Each group was made up of 5 students. Interviews were arranged with all participants, carried out in English and audio recorded using a smartphone and notes were also taken throughout the entire interview process. A link with the online questionnaire was sent to all participants via

WhatsApp and the type of questions that were asked in online questionnaire includes; closed questions, multiple choice questions and scale items.

## 4. Findings

### 4.1 Questionnaire Results

An online questionnaire was sent via WhatsApp to IT students at Walter Sisulu University Chiselhurst campus, 40 students responded to the questionnaire. The data was added into a Microsoft Excel spreadsheet and analysed. The results show that 87,5% of students use their tablets for reading notes, 85% use their tablets to do assignments, 92% use their tablets to send and receive emails, 77% use their tablet to access the blackboard where they get notifications and course materials, 70% use their tablets for communication purposes via WhatsApp, 65% use their tablets for social networks such as Facebook, 82.5% use their tablets for watching and uploading videos through YouTube, whereas another 85% of the students use their tablets for searching information and lastly 42.5% use their tablets for playing games.

### 4.2 Likert-type Scale

According to [24], in a Likert scale the respondent is requested to reply to one of the statements with items based on points, normally 5 points of agreement or disagreements. For example, in Table 1 respondents were asked to rate their views about the effective usage of tablets for learning. Respondents responded in one of the following ways: (1) Strongly agree, (2) Agree, (3) Sometimes, (4) Disagree, (5) Strongly disagree.

**Table 1:** Likert-type scale table on the effectiveness of tablets.

| Q3. Effective usage of tablets | Strongly agree | Agree | Sometimes | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| Easy to use a tablet in class | 16 | 10 | 13 | 0 | 1 |
| Learning anywhere, anytime | 30 | 5 | 4 | 0 | 1 |
| Easier learning | 28 | 9 | 2 | 0 | 1 |
| Storage of Notes & Assignments | 24 | 13 | 2 | 0 | 1 |
| Easy access of notes | 28 | 11 | 0 | 0 | 1 |
| Engaging with Lecturer | 14 | 18 | 7 | 0 | 1 |
| In contact with classmates | 23 | 12 | 3 | 1 | 1 |

### 4.3 Challenges Faced Students in Using Tablet for Learning

These results shows that tablets are a destruction to students because most students spend too much time on the internet rather than doing their schoolwork. 70% of student's access social networking sites during lectures, they send and receive WhatsApp messages, use Facebook which makes them lose focus in class. Battery life

is another challenge faced by students in using their tablets because 50% of students said they sometimes run low on battery during a lecture and 27.5% of students agreed and strongly agreed that battery life is a challenge. 45% of students mentioned that software problems they faced made them lose their work because they had no backup. Low connectivity seemed to be a major challenge as well because 47.5% of students agreed and strongly agreed that they were unable to search for information due to lack of internet access.

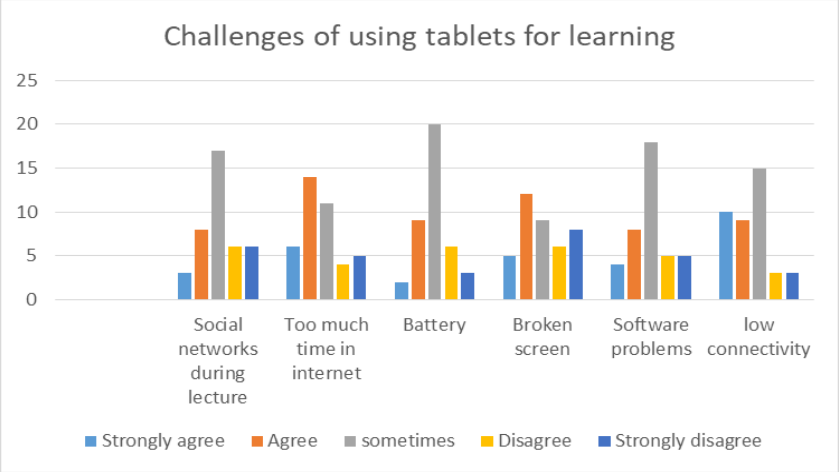


**Fig. 1.** Challenges faced by students in using tablet for learning.

### 4.4 Results Obtained from Interviews

On the 15th of October 2018 the researcher approached a group of IT extended year 2 students, outlined the objective of the research, students understood the objectives and interested students were requested to avail themselves. Students were then divided into 2 groups. Each group was made up of 5 students. The first group interviews took place the same day students were approached. The interviews were conducted in English and the researcher took notes while recording the interviewee's responses with a smartphone. The second group of interviews were conducted on the 18th of October 2018. The following section discusses the results of the focus group interviews focusing on the advantages and challenges of using tablets for learning purposes.

### 4.4.1 Tablets Enables Access Anywhere and Anytime

Tablets are seemingly beneficial for students in learning because of their usability. Students mentioned the portability of the tablets as a great advantage by allowing them to carry their notes anywhere and access them anytime. Another benefit is the ability to do their school work even if they are not within the university's premises. Students are able to see their grades, do activities and communicate with their peers and lecturer on Wiseup (blackboard). They can download course materials such as lecture notes, past question papers from the blackboard and save them on their tablets. Students can also submit their assignments via e-mail or upload them through blackboard even if they are out of the university, they do not necessarily have to hand-in their assignments.

## 5. Recommendations

This study has assessed the effectiveness of tablets for teaching and learning therefore the following recommendations are offered to support the practicality of tablets for academic purposes:

- Students should be determined to use tablets and inspired to co-operate and communicate with other students.
- Students in the focus group interviews stated that tablets are sometimes problematic to use because of technical problems and the lack of internet connectivity, so, technical problems of tablets and poor internet connection should be taken into consideration. It would be ideal for Walter Sisulu University to improve students' experience by solving the problems identified.
- More interaction during the lectures via the tablets and offering learning activities related to the student's interests and must try to deliver instant feedback, to students.
- Designers to consider solar chip enabled tablets for students.

## 6. Conclusion

The study is significant, as it has evaluated how tertiary institutions are in the process of a major technological shift in the way teaching and learning takes place through the acceptance of the mobile technologies in the education sector. The usage of tablet devices can benefit students in the education environment in terms of their needs, collaboration and increasing their skills. In this paper, the provision of tablets to Extended students is an important initiative that motivates many of these students, thus reducing the dropout rate of students. Considering the background of most students at WSU, where the majority of them are from disadvantaged backgrounds, tablets come as an important motivational device for the students. There is significant evidence that both students and lecturers engaged are using tablets for academic purposes and this has caused major changes in the way teaching and learning takes place.

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# EXTENDED ABSTRACTS

# Post-Graduate CS and IS Students' Career Awareness

**Extended Abstract**

**SACLA 2019**



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**Abstract.** The Information Technology (IT) industry is constantly creating new job positions and job titles. IT students should be familiar with new IT positions and IT job titles available in industry in order to select the appropriate IT career after completing their studies. In this study, the IT career awareness of students completing their post-graduate Computer Science (CS) or Information Systems (IS) qualification were evaluated. The CS and IS students had to self-evaluate their understanding of 10 IT job titles and then define the IT job titles and relevant job descriptions. The results of the study indicate that the students were generally not familiar with IT job titles, job descriptions and career opportunities available in industry.

**Keywords:** IT Career Choice, IT Job Titles, IT Career Awareness.

## 1. Introduction

Academic departments at Higher Education Institutions (HEIs) are increasingly engaging with students regarding career choices and IT job titles available in industry. The IT job titles found in industry include Programmers, Systems Analysts, Project Managers and Business Analysts. New IT job titles recently introduced include App

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Developers, Social Media Specialists, Lead Application Developers and Cloud Developers. Career awareness is an understanding of the various long-term employment possibilities and having the knowledge necessary to begin work in a specific career [3]. Recruiters however, are not aware that the graduates do not always have a clear understanding of the IT job titles, IT positions and career paths available in industry.

## 2. The Research Problem and Research Design

The research problem investigated in this study is that CS and IS students do not have a clear understanding of IT job titles and positions advertised in industry. A graduate IT career awareness questionnaire (GITCAS) was compiled for this study using a similar questionnaire based on a previous study evaluating the career awareness of under-graduate students [2]. The aim of this study was to evaluate the IT career awareness of post-graduate CS and IS students.

## 3. Literature Review

### 3.1 Career Decision Theories

Every person has a unique set of skills and interests, different personalities and a different context. As a result, career guidance has developed into a comprehensive system based on theories [1]. Lent, Brown and Hackett [5] anchored their Social Cognitive Career Theory in Bandura's Social Cognitive Theory. They proposed a mutually influencing relationship between people and their context or environment. Alvin Leung [5] notes that the time has come for indigenous theories to be developed as most of the career decision theories emanate from the USA.

### 3.2 Under-Graduate Student Career Awareness Surveys

Post-graduate students do not have a realistic understanding and lack in-depth knowledge of the job titles and the additional career knowledge of what IT tasks are performed in the various IT positions [6]. Businesses advertise various IT positions and students are expected to be familiar with the IT job titles and the tasks that are generally performed by people in these IT job positions. In a study conducted on under-graduate CS and IS students' career awareness, the results indicate that a limited number of students who participated in the survey have made a definite career choice and could not define or explain IT job titles [2]. The under-graduate students indicated in certain cases that they understood the job descriptions of IT job titles, however when requested to explain the job titles, they were not knowledgeable and lacked IT career awareness. The results obtained in the Calitz et al. [2] study, confirm similar research study results

that indicate that students are uninformed or misinformed about the job descriptions of a computing professional [4, 6].

## 4. Post-Graduate Career Awareness Survey Results

The post-graduate career survey was completed by 16 post-graduate students, a 52% response rate and included 3 females and 13 males. Nine students indicated that they have made an IT career choice, which included software developer/programmer (n=4), business analysts (n=3) and the other careers included software engineer and IT consultant. The post-graduate students were required to rate their understanding of the 10 IT positions on a 5-point Likert scale and then define and explain the 10 IT positions. Fig. 1 shows the post-graduate students' self-evaluations and their written definitions are provided. The mean scores for the 10 IT positions self-evaluation understanding of IT job titles were $\mu$=4.4 and for the written component $\mu$= 2.0.

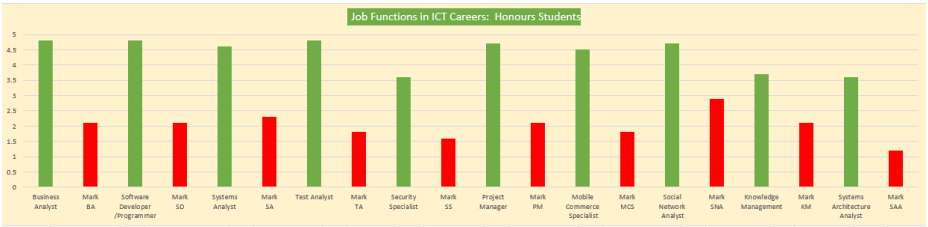


**Fig. 10.** IT Job Title results for post-graduate students.

## 5. Conclusion

Research has indicated that university students generally are not aware of IT career opportunities, IT career paths, IT job descriptions and career tracks [2, 6]. Academic departments are also required by accreditation bodies to provide career guidance to students. The students indicated in all cases that they understood the job descriptions of IT job titles, however when requested to define the job titles, they were not knowledgeable and lacked IT career awareness. This exploratory study has provided the foundation for further research into students' IT career awareness. Future research will focus on implementing an IT career awareness programme in the CS/IS department.

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# Lecturer-Chatbot: An AI for Advising Struggling Students in Introductory Programming

## Extended Abstract

## SACLA 2019



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**Abstract.** Students often struggle to communicate with their peers or lecturers about some of the issues they face during their time at university, be it either academic or personal. One of these issues is introductory programming, in some instances they choose to memorise code in order to pass rather than understanding how the logic behind the code actually works. Programming requires an understanding of how a certain logical flows and algorithm work. In this article, we discuss the difficulties that students face in introductory programming. We have also developed an interactive AI chatbot (called Lecturer-Chatbot) that students can interact with on some of the academic issues they face. Lecturer-Chatbot can provide many practice algorithms and their solutions to students. Additionally, Lecturer-Chatbot provides personal advice to students. An evaluation of Lecturer-Chatbot showed that there is a need for such a tool in aiding students through their university life.

**Keywords:** Novice Programmers, Introductory Programming, Chatbot, Automated Advisory, Artificial Intelligence in Education.

## Extended Abstract

Students often struggle to communicate with their peers or lecturers about some of the issues they face during their time at university, either it be academic or personal [1]. One of these issues is understanding Introductory Programming. Programming requires

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an understanding of how certain logical flows or algorithm work [2]. Teaching students takes a great deal of time, and at times students who lack confidence prefer not to ask questions in class. This results in students failing to understand the foundations of introductory programming. Some investigations have been conducted on students battling with the initial steps of figuring out the basic programming concepts [1].

For many first year students, adapting to the new university environment is a struggle and can take a considerable amount of time. Sometimes students may not attend their lectures and may generally drop out of university in the middle of their first year. Changes in the environment are not the only challenges students face. Financial aspects play a big role in a students academic life [3]. Some students may miss classes in order to work for funding for their tuition. Other students opt to take out bank loans with high interest rates in order to pay their tuition [4, 5, 6].

The reason for creating a Lecturer-Chatbot is to enable students to get advice based on topics that they may be afraid to ask from lecturers or peers. With this tool they will be able to talk to an Artificial Intelligence program that gives them advice on specific issues. This tool will allow students to get advice so that they are able to cope with some of the issues they face and resolve problems in a viable manner as well as mitigate the thoughts of dropping out.

Lecturer-Chatbot differs from many other chatbots because it is an Advisory Tool for struggling student compared to other popular chatbots like SIRI (A virtual assistant for apple users) [7], Google Assistant (This is a virtual assistant used by android users) [7], BIXBY (This is Samsung's virtual assistant for all users who are using Samsung devices) and ALEXA (a virtual assistant developed by amazon) [7, 8, 9]. Lecturer-Chatbot is different in that it helps students struggling with academic issues specifically in introductory programming and other personal problems. A student can either choose to solve a problem, be entertained, or follow a more formal approach and ask relevant questions on how to overcome introductory programming learning problems [10, 11].

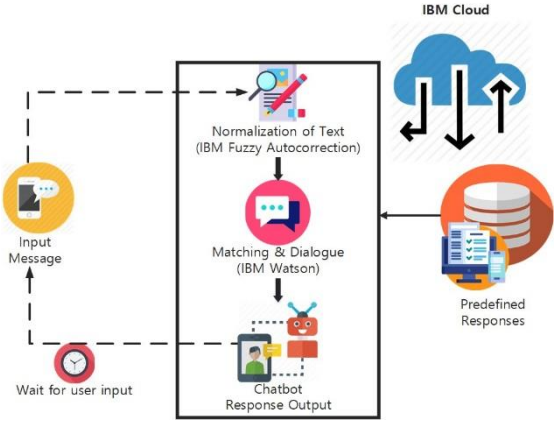


**Fig. 1.** The workings of Lecturer-Chatbot.

In Fig. 1, we can see a graphical representation of the workflow of Lecturer- Chatbot. A student having an issue chats with Lecturer-Chatbot; the chatbot will then cross-reference the question with its predefined responses, and then produce a response for the user.

To summarise the contributions of this paper, we have:

1. designed a working prototype of Lecturer-Chatbot mobile application that produces relevant responses.
2. introduced machine learning to produce the best responses. The application is able to identify typing mistakes and to learn new synonyms so that it may give the best response based on the present questions.
3. sent out a survey to students who used the Lecturer-Chatbot demo to evaluate its usefulness.

The following are the functions of Lecturer-Chatbot.

1. Lecturer-Chatbot is able to have general conversations with the user. The user can ask Lecturer-Chatbot for a joke.
2. Lecturer-Chatbot can advise students on academic issues. Lecturer-Chatbot will ask the user various questions to analyse if the student is attending class or not, it will then give the students programming example and solutions, or give them a YouTube link to learn Introductory Programming online.
3. Lecturer-Chatbot can advise students on personal issues. Lecturer-Chatbot will ask the user various questions to understand the emotions of the user and then give them advise accordingly. Lecturer-Chatbot will then advise the student to head to the psycad[1] in order to get professional help thereafter.
4. Lecturer-Chatbot will advise students on what steps to take when they are facing a certain situation. Lecturer-Chatbot may either tell them to visit the psycad or visit the lecturer with the module they are struggling with.
5. Lecturer-Chatbot can also do daily tasks. The user can request for a doctor and it will call the nearest doctor from the user. Lecturer-Chatbot will first get the location of the user and then contact the nearest medical facility from the user.

In Fig. 2, we show the various branches of the bot's inference. Each node represents the state the Lecturer-Chatbot can be in.

[1] Centre for Psychological Services and Career Development

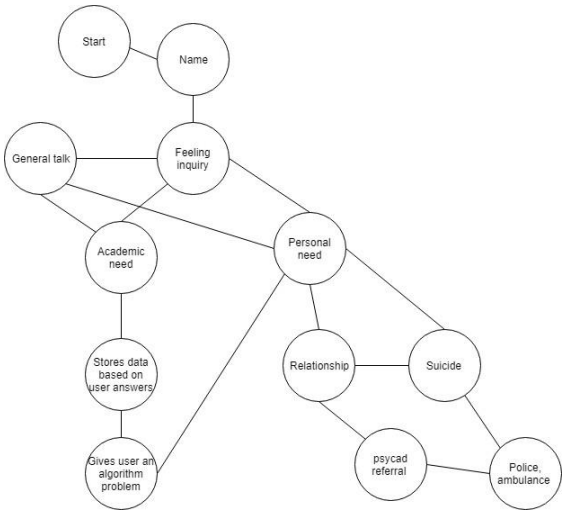


**Fig. 2.** Various States of Lecturer-Chatbot

In this paper, we discussed the difficulties that students face in Introductory Programming. We have also developed an interactive AI chatbot (called Lecturer-Chatbot) that students can interact with on some of the academic is- sues they face. Lecturer-Chatbot can provide many practice algorithms and their solutions to students. Additionally, Lecturer-Chatbot provides personal advises to students. An evaluation of Lecturer-Chatbot showed that there is a need for such a tool in aiding students through their university life. 60% of respondents said programming was difficult, which is a cause for concern. So by implementing a tool like Lecturer-Chatbot we may be able to solve this problem.

**Keywords:** Novice Programmers, Introductory Programming, Chatbot, Automated Advisory, Artificial Intelligence in Education.

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# Recommendations for Improvements to the South African IT Curriculum: A Case Study of New Graduates' First Year of Employment
## Extended Abstract
## SACLA 2019
## © The authors/SACLA

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## 1 Introduction

Employment issues in South Africa pose a substantial problem. Both employers and prospective employees (IT graduates) experience shortfalls and frustrations regarding the required skills [1]. Research aimed at reducing job shortages and creating a better cooperative liaison between academia and industry are encouraged, necessitating investigations into the possible causes of IT graduates' lack of preparedness for the job market and recommendations for improving the IT curriculum.

Main research question:
What recommendations for improvement to the South African IT curriculum can be extracted from a case study of new graduates' first year of employment?
Sub-questions:
1. What key skills do South African IT graduates lack upon employment?
2. What is the impact of graduates not being fully equipped to productively enter the workplace?
3. What measures does industry take when performance gaps are identified amongst employed IT graduates?
4. What would industry recommend for the improvement of the higher education IT curriculum so that graduates are fully equipped to productively enter the workplace?

## 2 Research Context

The research was conducted at a South African accredited private higher education institution in the IT Department of the Applied Science faculty. The department offers two modes of study: the traditional face-to-face (lecturing) contact mode called Lecture-based Learning (LBL) and the self-directed, self-study contact learning mode

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called the Mastery Learning Methodology (MLM) according to which most of the study material is covered via self-study whilst on campus. The modules must be completed consecutively in the specified time frame and require a 60% pass mark. The MLM mode of study offers only Higher Certificate qualifications at National Qualifications Framework (NQF) level 5. This study considered only graduates who follow the MLM mode of study.

## 3 Methodology

A descriptive case study determined industry's experience with newly MLM-graduated employees to obtain guidelines for improving the curriculum. Questionnaires and interviews collected data from three IT companies employing MLM-mode graduates. Three different questionnaires were used for the line managers of employed graduates, the employed graduates themselves, and the recruitment staff. The line managers of the employed graduates and the graduates were also interviewed. Recruiting personnel shared their experiences via a questionnaire. Table 1 depicts the 12 participants' demographics.

**Table 7.** Participants' demographics.

| Participant | Duration of employment | Age range | Gender |
|---|---|---|---|
| Employed Graduate 1 | 2 years 4 months | 21 – 24 | Male |
| Employed Graduate 2 | 1 year 8 months | 21 – 23 | Male |
| Employed Graduate 3 | 3 years 6 months | 22 – 25 | Male |
| Employed Graduate 4 | 1 year 10 months | 21 – 23 | Female |
| Line manager – Company 1 | 12 years | 35 – 40 | Male |
| Line manager – Company 2 | 18 years | 40 – 45 | Male |
| Line manager – Company 3 | 15 years | 40 – 45 | Male |
| Line manager – Company 3 | 20 years | 45 – 50 | Male |
| Recruitment personnel 1 | 10 years | 25 – 30 | Male |
| Recruitment personnel 2 | 8 years | 25 – 30 | Female |
| Recruitment personnel 3 | 12 years | 30 – 35 | Male |
| Recruitment personnel 4 | 15 years | 30 – 35 | Male |

Interviews were recorded preserving the anonymity of participants. The data from questionnaires and interviews were prepped manually for easier analysis by transcribing all recordings systematically. Triangulation was used to check if the same or similar data sets and patterns are attained from multiple sources by way of manual colour coding.

## 4 Findings

Sub-question 1: What key skills do South African IT graduates lack upon employment?

1. Soft skills (communication skills and professionalism). New graduates find it difficult to express themselves adequately when faced with problems and to communicate with different levels of management. They also lack professionalism.
2. Practical/technical skills in specific IT areas of software and hardware such as the proper use of version control tools, web services and servers.
3. Problem-solving skills.
4. Core subject knowledge skills such as multithreading in application development, networking and server concepts.

Sub-question 2: What is the impact of graduates not being fully equipped to productively enter the workplace?

Inadequately prepared graduates have a financial impact on a department without realising this. Line managers offer extra courses or identify specific certifications to upskill unprepared graduates. The employer bears the cost of the courses or certifications as well as the loss of revenue due to the graduate not being productive. Most participants believed that their higher education results did not affect the time taken to become productive. One participant offered a different view, explaining that the knowledge gained during his studies assisted him in quickly becoming productive.

Sub-question 3: What measures does industry take when performance gaps are identified among employed IT graduates?

1. Line managers provide mentorship or coaching.
2. Training in specialised IT areas with Java, Microsoft and CompTIA certifications.
3. Employed graduates are subjected to performance management on a weekly basis.

Sub-question 4: What would industry recommend to improve the higher education IT curriculum so that graduates are fully equipped to productively enter the workplace?

1. Pay more attention to soft skills and incorporate these in the curriculum.
2. Engage extensively with work-related practical and technical aspects.
3. Expose graduates to the latest tools and concepts used in the industry.
4. Align the curriculum to keep up with industry trends.

Main research question: What recommendations for improvement to the South African IT curriculum can be extracted from a case study of new graduates' first year of employment?

1. Strengthen graduates' skill sets by covering more soft skills, hard skills, critical-thinking skills and trending technologies.
2. Amend the curriculum design to include more exposure to industry-related practical work with greater exposure to industry environments using industry liaisons.
3. Expose graduates to the latest tools used in the industry.
4. Enhance their employability by including IT-related certifications in specialised areas (e.g. alignment with and/or the addition of international certifications).

## 5 Conclusion

The data reflect noticeable trends and offer preliminary points for more studies on curriculum enhancement in higher education in the IT sector. The findings show that unprepared graduates affect industry financially. Vital skills that graduates lack include both soft and industry-related practical skills. Enhancing the IT curriculum in accordance with the recommendations would help to equip new graduates with industry-required skills and prepare them to be more productive on employment.

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# Evaluating Alumni Satisfaction in the School of ICT

## Extended Abstract

## SACLA 2019



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**Abstract.** Alumni are important stakeholders in academic institutions and can provide valuable feedback on service offerings. In the academic environment, customer/student satisfaction and perceived value positively influence graduate/Alumni satisfaction. The purpose of this research study was to measure the perception and satisfaction of the Alumni of the School of ICT at the Nelson Mandela University and to identify areas for improvement by performing a systematic analysis of the determinants of satisfaction. Eight key factors affecting Alumni satisfaction with the School of ICT were investigated. The results indicate that the Alumni agreed that the academic staff and administrative staff maintained high academic standards and that possible new courses and modern technologies could be introduced. Closer links between the School of ICT and Alumni must also be established.

**Keywords:** Alumni Satisfaction, Alumni Perceptions.

## 1 Introduction

Alumni are seen and regarded as important assets and stakeholders of a university. Once they have left the university, they become representatives of the university and its departments in the real world and industry [1]. Historically, Alumni networks were created from regional groups brought together for fundraising purposes. Over time these networks developed, both in their own importance and for the university community. The Nelson Mandela University Alumni mission states that, amongst other things, it wishes to use the Alumni's expertise to support the university [2]. This paper provides additional supporting evidence regarding Alumni perceptions on the perceived value of a service being offered in Information Technology (IT) education.

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## 2 The Research Problem and Research Methodology

Graduates from HEIs are Alumni of the institutions and are important stakeholders for universities. In this study, the Alumni satisfaction in the School of ICT at the Nelson Mandela University was investigated. The School of ICT qualifications focus on software development, communication networks and support services. Alumni surveys are not conducted on a regular basis by the Information Technology departments in South Africa and therefore they do not fully understand the graduate perceptions of the study offerings at their academic institutions [3].

The problem statement investigated in this study is that the School of ICT at Nelson Mandela University (NMU) has not considered Alumni perceptions of their study experience at the institution. The main research objective of this study is to measure the perception and satisfaction of Alumni of the School of ICT and identify areas for improvement. An Alumni questionnaire was compiled for this study using a similar questionnaire based on a previous study evaluating the Alumni satisfaction for students in the Department of Computing Sciences at NMU [4]. The proposed model evaluated by Glaum [4] and the factors that influence Alumni perception included Customer Perception, Course Contents, Modern Technologies, Academic Staff, Administrative and Technical Staff, University Atmosphere and Perceived Value.

## 3 Literature Review

Alumni are recognised as one of the most important assets of a tertiary institution. They are an important asset as the university is represented in the work place by the Alumni of an institution [1]. The achievements of Alumni directly reflect on the institution and any improvements to the quality of the education at the university automatically improve the perceived value of the graduates' qualification. Alumni are a university's best ambassadors and should be kept informed and involved in the vision and priorities of the university and departments. Understanding the Alumni's' satisfaction is important to universities as it plays a role in improving the institution's reputation, as well as the educational program [5].

Glaum's study [4] indicated that there is a relationship between the Alumni perception and quality of academic Staff. The study identified the following factors: The quality of academic staff; The quality of administrative and technical staff; The quality of technology used; The course content; The quality of service provided; The academic institution's culture and structure; The perceived value of service delivered; and The Alumni network.

## 4 Alumni Survey Results

The Alumni survey was completed by *only* 34 School of ICT Alumni and the majority were from South Africa (90%). The gender of the group included 24 (71%) males and 10 (29%) females. Age of the respondents was 20-24 years (n=1), 25-34 years (n=24) and 35-44 years (n=9). Twenty one (62%) of the respondents have worked less than 5 years in the IT industry, five (15%) 5 to 9 years and eight (24%) 10-19 years. The response to the question: How quickly after completing your studies did you find a job in the ICT industry? The respondents indicated that 14 (41%) immediately and 10 (29%) within a year. Seven of the 8 factors (Fig. 1) received *Good/Excellent* evaluations ($\mu > 4.0$), however the factor Alumni Network ($\mu = 3.25$) received a *Neutral* rating, indicating that this factor requires attention by the School of ICT.

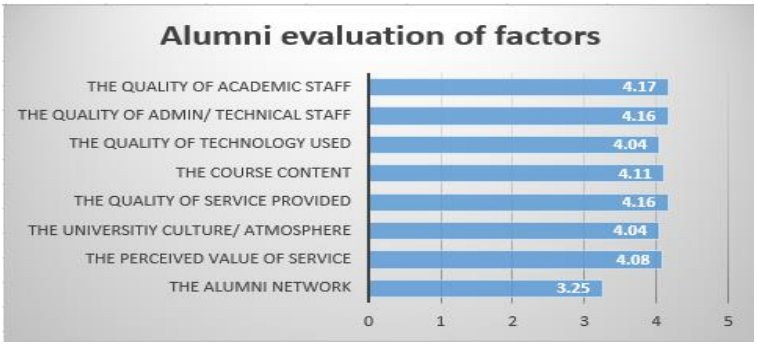


**Fig. 1.** Alumni evaluation of eight factors.

## 5 Conclusions

The main research objective of this study was to measure the perception and satisfaction of Alumni of the School of ICT and identify areas for improvement. The Perceived Value on offer at the School of ICT had a positive score ($\mu = 4.1$) indicating *Good/Excellent* Alumni satisfaction. It is important to have satisfied Alumni who can increase under-graduate numbers by recommending the institution to their colleagues, friends and family. The limitations of this research study include the limited number of respondents. The School of ICT should also investigate ways of growing ties with its Alumni.

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# APPENDICES

# CCIS Articles:

# Abstracts

# Approach towards Secure Programming in Undergraduate Computing Curricula

## Full Paper

## SACLA 2019



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**Abstract.** The security aspect of software applications is considered as the important aspect that can reflect the ability of a system to prevent data exposures and loss of information. For businesses that rely on software solutions to keep operations running, a failure of a software solution can stop production, interrupt processes, and may lead to data breaches and financial losses. Many software developers are not competent in secure programming, resulting in risks that are caused by vulnerabilities in the application code of software applications. Although there are various techniques for writing secure code in the current body of knowledge, these techniques are rarely fundamental components of a computing curriculum, resulting in incompetent graduate software developers. This paper argues that secure programming education needs to be included across computing curricula. It proposes the incorporation of secure coding practices into undergraduate computing curricula through a step-by-step approach. This approach includes the identification of application risks and secure coding practices as they relate to each other and to fundamental programming concepts. It specifically aims to improve the security of software applications developed in the .Net environment.

**Keywords:** Computing Curricula, Software Security, Application Risks, Secure Coding Practices, Fundamental Programming Concepts.

# Detecting Similarity in Student Multi-procedure Programs Using Program Structure

## Full Paper

## SACLA 2019



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**Abstract.** Plagiarism is prevalent in most undergraduate programming courses, including those where more advanced programming is taught. Typical strategies used to avoid detection include changing variable names and adding empty spaces or comments to the code. Although these changes affect the visual components of the source code, the underlying structure of the code remains the same. This similarity in structure can indicate that plagiarism has taken place.

A similarity detection system has been developed to detect the similarity in the structure of two given programs. The system works in two phases, the first phase parses the source code and creates a syntax tree, representing the syntactical structure for each of the programs. The second phase takes as inputs two pro- gram syntax trees and applies various comparison algorithms to detect their similarity. The result of the comparison allows the system to report a result from one of four similarity categories: identical structure, isomorphic structure, containing many structural similarities, and containing few structural similarities. Empirical tests on example programs show that the prototype implementation is effective in detecting plagiarism in source code, although in some cases manual checking is needed to confirm the plagiarism.

**Keywords:** Plagiarism Detection, Code Structure, Student Code.

# Making Sense of Unstructured Data: An Experiential Learning Approach

## Full Paper

## SACLA 2019



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**Abstract.** The need for competent data scientists are recognised by industry practitioners worldwide. Competent data scientists are human resources that are highly skilled, ready and able to work on industry data related projects upon graduation and the ability to work with data (to name a few). Currently tertiary education institutions focus on the teaching of concepts related to structured data (fixed format) for example database management. However, the hidden value contained in unstructured data (data with no fixed format) introduced the need to introduce students to methods for working with these data sets. As a result, an experiential learning approach was adopted to expose students to real-life unstructured data. Third year students were given an assignment whereby they could use any publicly available unstructured data set or an unstructured dataset supplied to them following a set methodology (CRISP-DM) to discover and re- port on the hidden meaning of the data. As part of the assignments students had to reflect on the process. Twenty student assignments were analysed in an attempt to identify the effectiveness of the experiential learning approach in the acquisition of skills pertaining to unstructured data. The findings of the study indicate that the experiential learning approach is successful in die teaching of the basic skills necessary to work with unstructured data. The positive aspects as well as challenges the students experienced are reported on. The lecturer's reflection re- ports on the appropriateness of the pre-scribed methodology, the students' performance and lessons learnt. The lessons learnt from this experience are offered up as recommendations to educators to improve on the learning experience associated with ELA within the context of educating future data scientists.

**Keywords:** Experiential Learning, Big Data, Unstructured Data, CRISP-DM Methodology, Data Scientist.

# Developing a Digital Forensics Curriculum: Exploring Trends from 2007 to 2017

## Full Paper

## SACLA 2019



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**Abstract.** The young science of digital forensics has made great strides in the last decade, but so too has cybercrime. The growing complexity of cybercrime has necessitated that traditional forensics methods be updated to accommodate new technologies and that further research is carried out to keep up with the rate of technological innovation. The main purpose of this research was to determine how academic teaching and research can support the needs of industry when investigating cybercrime. The research initially explores digital forensics and its challenges before describing past academic research conducted around digital forensics ontologies and taxonomies. Current digital forensics higher education curricula are discussed thereafter, along with limited information relating to forensics trends observed via social media sources. This is followed by a research analysis of academic research trends for this discipline for the period 2007 to
2017. It ends by highlighting research trends for which more research is required, and which could possibly contribute towards shaping future teaching and learning for digital forensics and also suggests future research to be conducted.

**Keywords:** Digital Forensics, Cybercrime, Curriculum, Research Trends

# Synthesis of Social Media Messages and Tweets as Feedback Medium in Introductory Programming

## Full Paper

## SACLA 2019



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**Abstract.** Social media has been recognised as a supportive tool in Education, creating benefits that supplement student collaboration, class interactions and communication between instructors and students. Active informal interactions and feedback between instructors and students outside class is one of the main reasons behind Social Media pedagogy. With many innovative usage methods of social media in Education this creates new opportunities, one being automatic feedback for students. Despite the prevalence of traditional email methods of providing feedback to students, many studies show that they do not check their emails as frequent as they check their social media accounts. In this paper, we present the automatic generation of feedback messages and tweets using a Con- text-Free Grammars (CFG). Our design takes a class list of students and their mark sheets and automatically composes tweets (using the CFG rules) about statistical "fun facts" about programming problems, exercises, class performances, and private messages about individual student performances. These tweets and messages are then pushed to Tweeter using the Twitter Application Programming Interface (API). A survey of 116 student participants at a South African university showed that the majority of the students will love to get such notifications on social media, rather than check their emails; and that lecturers also find this initiative to be a forward thinking one.

**Keywords:** Synthesis of Things, Social Media, Tweet Synthesis, Context-Free Grammar, Introductory Programming, Procedural Generation.

# Exercise Task Generation for UML Class/Object Diagrams, via Alloy Model Instance Finding

## Full Paper

## SACLA 2019



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**Abstract.** The Unified Modelling Language (UML) is the standard for designing and documenting object-oriented software systems. Its most frequent use is for static modelling in the form of class diagrams. A correlated concept is that of object diagrams. An object diagram may or may not adhere to a given class diagram, and the understanding of this connection is key to correctly using class diagrams in practice. We pre- sent an approach for automatic generation of verified, non-trivial, conceptually relevant examples and counterexamples of class/object diagram combinations, aimed at providing exercise tasks in a university course setting. The underlying technique is a model instance finding using Alloy specification language and analyser. We provide an implementation of our approach in an e-learning tool.

**Keywords:** E-Learning, UML, Alloy

# Decoding Source Code Comprehension: Bottlenecks Experienced by Senior Computer Science Students

## Full Paper

## SACLA 2019



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**Abstract.** Source code comprehension (SCC) continues to be a challenge to undergraduate CS students. Understanding the mental processes that students follow while comprehending source code can be crucial in helping students to over- come related challenges. Set within the Decoding the Disciplines paradigm, this paper reports on a study aimed at uncovering common SCC bottlenecks that senior CS students experienced. Thematic analysis of the collected data revealed eight common SCC difficulties specifically related to arrays, programming logic and control structures. The identified difficulties, together with findings from existing literature as well as the authors' personal experiences, were then used to formulate six usable SCC bottlenecks. The identified bottlenecks point to student learning difficulties that should be addressed in introductory CS courses. This paper intends to create awareness among CS instructors regarding the role that a systematic decoding approach can play in exposing the mental processes and bottlenecks unique to the CS discipline. Further investigations are needed to uncover the mental tasks that expert programmers follow to overcome the identified bottlenecks so that students can be taught more explicit SCC strategies.

**Keywords:** Undergraduate Programming, Source Code Comprehension, Stu- dent Learning Bottlenecks, Decoding the Disciplines.

# Enhancing Computer Students' Academic Performance through Explanatory Modeling

## Full Paper

## SACLA 2019



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**Abstract.** A key challenge facing universities today is the growing attrition rate of computer studies students, attributed to poor academic performance. While extensive research has been conducted on how to enhance students' performance in computer programming, very little research investigates other computer courses, more so in sub-Saharan Africa. This study set out to address this gap by conducting experiments that revealed some of the factors that influence a student's overall academic performance at university through explanatory modeling. Results obtained showed that a student's background in mathematics and their performance in the Introduction to Information Systems course were key in determining performance. Unexpectedly, prior computer skills or secondary school grades had less impact. The strategies identified for enhancing students' performance include an emphasis on building a student's mathematics background, providing a string teaching approach to foundational computing courses, restructuring of courses in the computer program, and linking courses across the curriculum. Therefore, explanatory modeling creates an opportunity to adopt a proactive approach to enhancing the performance of computer studies students.

**Keywords:** Computer Science Education, Academic Performance, Explanatory Modeling.

# Integrating Secure Coding Principles into Undergraduate Programming Modules

## Full Paper

## SACLA 2019



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**Abstract.** The rise of the use of the internet has led to significant growth in soft- ware applications for conducting business, entertainment and socialising, which in turn has led to a higher rate of attacks on software applications. This problem has led to the Information Technology industry requiring that software developers be skilled in developing software in a secure manner. The challenge that industry faces is that many software development graduates requiring employment do not have the requisite knowledge regarding secure programming. The need is therefore for academia to address the needs of industry by integrating secure coding principles into undergraduate programming modules. This paper highlights some secure coding principles that could be integrated into such modules. In addition, it discusses the challenges of, and various approaches to, integrating these principles into programming modules. Finally, it presents a framework for integrating secure coding principles into undergraduate programming modules to assist university departments in integrating these principles into their undergraduate programming modules.

**Keywords:** Secure Software Applications, Secure Coding Principles, Under- graduate Programming Modules, Secure Programming.

# A Connectivist View of a Research Methodology Semantic Wiki

## Full Paper

## SACLA 2019



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**Abstract.** The use of virtual learning spaces for learning and teaching needs to be underpinned by a pedagogy that provides a basis for the approach used. Connectivism takes a networked view of knowledge, and its characteristics and understanding of learning were investigated. The development and structure of a research methodology semantic wiki were described, including how the semantics present in the wiki allowed for the exploration of the structure of a research methodology. Positive student evaluation of the wiki led to examining it from a connectivist point of view -- how connectivism's nodal and networked structure could be identified in the wiki and how learning could be understood in terms of the activities and levels of interactions in connectivist learning.

**Keywords:** Connectivism, Semantic Wiki, Research Methodology.

# Modernizing the Introduction to Software Engineering Course

## Full Paper

## SACLA 2019



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**Abstract.** We report on the modernization of an undergraduate, introductory course in software engineering that started in 2017-2018 semester 2 offered at the University of Puerto Rico, Mayagüez. We present the institutional setting, our underlying philosophy, and resources considered. We aimed at complementing informal descriptions in any phase with formal ones. We describe the revised course, discuss evaluations of the modernized course as held in two subsequent semesters, and outline options for future improvement.

**Keywords:** Software Engineering, Formal Methods, Education.

# Connecting Generation Z to Technology through the Task-technology Fit Theory

## Full Paper

## SACLA 2019



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**Abstract.** This study investigated how an interactive e-resource could be used to increase students' performance for a specific assignment given. As academics we are struggling to find sources that really talk to generation Z and how they prefer to learn and understand knowledge. The authors wanted to determine if one can create such a resource to increase student performance. This study investigates the usefulness of a self-created e-textbook through the task-technology fit theory lens. A quantitative data analysis was conducted on a group of undergraduate students at an urban university. A significant association between the characteristics of the tasks, and the technology used to perform the specific task was found. A significant association between the students' (generation Z) understanding of the work and improving his/her knowledge as well as the contribution in a team was also determined. Another significant finding is that generation Z relies heavily on their peers for assistance even though literature says their social skills are underdeveloped. This means that as academics, we need to understand the generation Z and how they prefer to study, and then create content and tools for them so that they can indeed broaden their own knowledge and become life-long learners. Higher education institutions should become more learner-centered and not so much teacher-centered.

**Keywords:** e-Textbook, e-Resource, Interactive Textbook, Generation Z, Millennials, Task-technology Fit Theory.

# The Use of Industry Advisory Boards at Higher Education Institutions in Southern Africa

## Full Paper

## SACLA 2019



Estelle Taylor[1][0000-0003-2848-7829] and Andre P. Calitz[2][0000-0002-2555-9041]

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**Abstract.** An Industry Advisory Board (IAB) can provide useful feedback to academic schools or departments relating to topics such as industry graduate requirements, IT trends, programme quality and curriculum development. Academic literature provides general guidelines on the role and responsibilities, membership, composition and functioning of IABs. Accreditation bodies further provide guidelines for the implementation and functioning of IABs at Higher Education Institutions (HEIs). Presently, recent literature on the use of IABs by HEIs in Southern Africa is limited. No literature studies on best practices and perspectives for the use of IABs for Computer Science (CS), Information Systems (IS) and other related IT departments (IT) in Southern Africa exists.

The research question addressed in this study is: How are IABs used by CS/IS/IT departments at HEIs in Southern Africa? The aim of the study is to investigate the use and practices of IABs by CS/IS/IT schools and departments at HEIs in Southern Africa. An IAB questionnaire was compiled and distributed to the Head of Departments (HODs) of 32 universities in Southern Africa. A total of 23 HODs or representatives at 17 HEIs completed the survey over a two-week period. The data were statistically analysed and the results of the study indicate that 17 of the 23 respondents actively use IABs and that the IABs play an important role in academic programme development and maintaining high academic standards. This research study could assist CS/IS/IT academic departments to implement and maintain an IAB and follow best-practice standards.

**Keywords:** Industry Advisory Boards, Quality Management, IAB Usage

# Hackathons as a Formal Teaching Approach in Information Systems Capstone Courses

## Full Paper

## SACLA 2019



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**Abstract.** Hackathons are hack[ing mar]athons where participants collaboratively and rapidly prototype new applications (apps) over a 24-48 hour period. The potential of hackathons as an informal strategy for stimulating interest in the CS fields is well established. Their application as a formal teaching strategy in the CS/IS curriculum is less prevalent. This paper reports on the introduction of such a closed hackathon in a third year IS capstone course at a South African University. An exploratory case study method was used to evaluate the feedback from the participants and organisers. In the process, the students completed seven novel apps which they had started during the course. They also learned about new technologies and programming interfaces (API's) as well as exhibited growth in personal and inter-personal competencies. Seven fundamental differences be- tween curricular and traditional hackathons are highlighted in this paper. Some suggestions for integrating hackathons in the undergraduate CS/IS capstone course are provided together with possible areas for further research.

**Keywords:** Capstone Projects, Computer Science, Hackathons, Information Systems, Software Application Development, Teaching Approach, Undergraduates.

# Cohort Supervision: Towards a Sustainable Model for Distance Learning?

## Full Paper

## SACLA 2019



Judy van Biljon[0000-0002-4646-1641], Colin Pilkington[0000-0001-6996-0841], and Ronell van der Merwe[0000-0003-2714-9967]

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**Abstract.** In response to the challenge of increasing supervision capacity while improving the supervision experience, we used a design science research approach to guide the design, implementation and evaluation of a cohort supervision model for master's students in computing at an open-distance learning university. First, a systematic literature review was done to identify and report on the factors influencing cohort supervision. Second, this paper reports on the implementation of a cohort programme in 2018 and the findings from data collected during a focus group with students and supervisors, student reflective evaluations at the end of the proposal module, feedback from the supervisors and our reflective notes. The main theoretical contribution is the cohort model proposed for developing supervision capacity on master's level. The practical contribution is the methodology that describes a practical supervision model for master's students based on the concepts of co-operative learning and conversational theory.

**Keywords:** Postgraduate Supervision, Group Supervision, Cohort Supervision, Co-supervision.

# Guidelines for Conducting Design Science Research in Information Systems

## Full Paper

## SACLA 2019



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**Abstract.** Information Systems (IS) as a discipline is still young and is continuously involved in building its own research knowledge base. Design Science Research (DSR) in IS is a research strategy for design that has emerged in the last 16 years. IS researchers are often lost when they start with a project in DSR,
especially young researchers. We identified a need for a set of guidelines with supporting reference literature that can assist such novice users of DSR. We identified major themes relevant to DSR and proposed a set of six guidelines for the novice researcher supported with references and summaries of seminal works from the IS DSR literature. We believe that someone new to the field can use these guidelines to prepare him/herself to embark on a DSR study.

**Keywords:** Design Science Research, Design Science Guidelines, Design Science Process, Design, Artefact, Information Systems, Methodology for Design Science.

# Conference Programme


SACLA 2019

UNISA college of science, engineering and technology

# PROGRAMME

**48th Annual Conference of the Southern African Computer Lecturers' Association**
**15 to 17 July 2019**
**Alpine Heath, Northern Drakensberg, South Africa**
**Hosted by the School of Computing, University of South Africa**

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| Monday 15 July 2019 | | | |
|---|---|---|---|
| 9:00- 12:00 | 3 hours | **WORKSHOPS** | |
| | | Academic Writing for Junior Informaticians / Computer Scientists [Sutherland, 09h00-12h00]<br>South African Computer Accreditation Board - SACAB [Kelly, 11h00-12h00]<br>Amazon Web Services (AWS) Educate and Academy Programs [Gardiner, 09h00-12h00] | |
| 12:00-13:00 | 1 hour | Arrival, registration | |
| 13:00-14:00 | 1 hour | Lunch [Le Gruyéres Restaurant] | |
| 14:00-14:15 | 15 minutes | Welcome and opening [Lammergeyer A] | |
| 14:15-15:00 | 45 minutes | Keynote [Lammergeyer A] | |
| | | *Dolf Steyn*<br>Is big data a DNA or a diet problem? Either way it does not fit comfortably yet | |
| 15:05-16:35 | 1 hour 30 mins | **PAPER SESSION 1 [LAMMERGEYER A]** | **PAPER SESSION 2 [LAMMERGEYER B]** |
| | | Broad theme: Learning<br>Chair: Alta van der Merwe<br><br>***Adriana Steyn, Carina de Villiers, Joyce Jordaan and Tshegofatso Pitso***<br>Connecting Generation Z to Technology Through the Task-Technology Fit Theory<br>***Pakiso J. Khomokhoana and Liezel Nel***<br>Decoding Source Code Comprehension: Bottlenecks Experienced by Senior Computer Science Students<br>***Chris Upfold and Kayleigh Bell***<br>The Influence of Learning Style Theory Within a Blended Learning Environment: A Systematic Review | Broad theme: Teaching<br>Chair: Karen Bradshaw<br><br>***Morné Botha and Lizette Weilbach***<br>Design Guidelines to Develop e-Textbook Readers: A Task-Technology Fit Approach<br>***Marisa Venter***<br>Student's Perceptions of Gamification Mechanics and Dynamics in a Gamified Learning Environment<br>***Sunet Eybers and Marie Hattingh***<br>Making Sense of Unstructured Data: An Experiential Learning Approach |
| 16:35-16:50 | 15 minutes | Tea | |
| 16:40-17:40 | 1 hour | Waterfall hike | |
| 16:50-17:50 | 1 hour | HOD meeting [Arbousset], followed by SACLA Exec meeting. | |
| 19:00 | | Welcome reception [Muzos Studio Bar] | |
| **Tuesday 16 July 2019** | | | |
| Breakfast [Muzos Studio Bar] | | | |
| 9:15-09:45 | 30 minutes | Amazon Web Services (AWS) Educate [Lammergeyer A] | |
| 09:45-11:15 | 1 hour 30 mins | **PAPER SESSION 3 [LAMMERGEYER A]** | **PAPER SESSION 4 [LAMMERGEYER B]** |
| | | Broad theme: Research<br>Chair: Walter Uys<br><br>***Brenda Scholtz and Lynn Futcher***<br>Investigation into Best Practice Approaches for Computing Research Programmes in South Africa<br>***Alta Van der Merwe, Aurona Gerber and Hanlie Smuts***<br>Guidelines for Conducting Design Science Research in Information Systems<br>***Colin Pilkington and Laurette Pretorius***<br>A Connectivist View of a Research Methodology Semantic Wiki | Broad theme: Strategies<br>Chair: Pakiso Khomokhoana<br><br>***Marko Schütz-Schmuck***<br>Modernizing the Introduction to Software Engineering Course<br>***Hanlie Smuts and Martina Jordaan***<br>A Knowledge-Based Service-Learning Framework for Large-Scale Community Projects in Higher Education<br>***Sifiso Bangani, Lynn Futcher and Johan Van Niekerk***<br>An Approach Towards Secure Programming in Undergraduate Computing Curricula |

| | | | | |
|---|---|---|---|---|
| 11:15-11:30 | 15 minutes | Tea | | |
| 11:30-13:00 | 1 hour 30 mins | **PAPER SESSION 5 [LAMMERGEYER A]** | **PAPER SESSION 6 [LAMMERGEYER B]** | **PAPER SESSION 7 [ARBOUSSET]** |
| | | Broad theme: Learning<br>Chair: Adriana Steyn<br><br>***Abueng Molotsi and Leila Goosen***<br>e-Tutors' Perspectives on the Collaborative Learning Approach as a Means of Computing Student Support Matters of Course!<br>***Leah Mutanu and Philip Machoka***<br>Enhancing Computer Students Academic Performance through Explanatory Modelling<br>***Judy van Biljon, Colin Pilkington and Ronell Van der Merwe***<br>Cohort Supervision: Towards a Sustainable Model for Distance Learning? | Broad theme: Teaching<br>Chair: Sifiso Bangani<br><br>***Violet Kafa, Marcellus Siegburg and Janis Voigtländer***<br>Exercise Task Generation for UML Class/Object Diagrams, via Alloy Model Instance Finding<br>***Karen Bradshaw and Vongai Chindeka***<br>Detecting similarity in student multi-procedure programs using program structure<br>***Sandile Ngwenya and Lynn Futcher***<br>Integrating Secure Coding Principles into Undergraduate Programming Modules | Broad theme: Tools<br>Chair Brenda Scholtz<br><br>***George Musumba and Ruth Wario***<br>A Decision-making Approach to Evaluation of Learning Components in Adaptive Educational Systems<br>***Nobert Jere, Phumeza Hendrick and Nosipho Mavuso***<br>Evaluation of Tablets for Teaching and Learning for Information Technology Extended Programme at Walter Sisulu University [Short paper]<br>***Mohammed Ismail and Abejide Ade-Ibijola***<br>Lecturer-chatbot: An AI for Advising Struggling Students in Introductory Programming [Abstract] |
| 13:00-14:00 | 1 hour | Lunch [Le Gruyéres Restaurant] | | |
| 14:00-14:30 | 30 minutes | IITPSA [Lammergeyer A] | | |
| 14:30-15:30 | 1 hour | **PAPER SESSION 8 [LAMMERGEYER A]** | **PAPER SESSION 9 [LAMMERGEYER B]** | |
| | | Broad theme: General<br>Chair: George Musumba<br><br>***Leila Goosen and James K. Ngugi***<br>Innovation for Computing Students Matters, Of Course!<br>***Amanda Esterhuyse, Andre P. Calitz and Margaret Cullen***<br>Post-Graduate CS and IS Students' Career Awareness [Abstract] | Broad theme: Teaching<br>Chair: Janis Voigtländer<br><br>***Walter Uys***<br>Hackathons as a Formal Teaching Approach in Capstone Courses<br>***Stefan Gruner***<br>Back to BASIC in Compiler Construction [Short paper] | |
| 15:30-15:45 | 15 minutes | Tea | | |
| 15:45-16:45 | 1 hour | Open discussion [Lammergeyer A] | | |
| | | Hosts*: Wynand van Staden and Colin Pilkington*<br>The corporatisation of universities | | |
| 16:45-17:45 | 1 hour | AGM [Lammergeyer A] | | |
| 19:00- | | Gala dinner [Boma] | | |

| Wednesday 17 July 2019 | | | |
|---|---|---|---|
| Breakfast [Muzos Studio Bar] | | | |
| 9:30-10:00 | 30 minutes | Oracle Academy [Lammergeyer A] | |
| 10:00-11:30 | 1 hr 30 minutes | **PAPER SESSION 10 [LAMMERGEYER A]** | **PAPER SESSION 11 [LAMMERGEYER B]** |
| | | Broad theme: Curriculum<br>Chair: Sandile Ngwenya<br>***Estelle Taylor* and *Andre Calitz***<br>The Use of Industry Advisory Boards at Higher Education Institutions in Southern Africa<br>***Roshan Harneker* and *Adrie Stander***<br>Developing a Digital Forensics Curriculum: Exploring Trends from 2007 to 2017<br>***Annelee Panday* and *Marthie Schoeman***<br>Recommendations for Improvements to the South African IT Curriculum: A Case Study of New Graduates' First Year of Employment. [Abstract]<br>***Sue Petratos* and *Andre Calitz***<br>Evaluating Alumni Satisfaction in the School of ICT [Abstract] | Broad theme: Tools/General<br>Chair: Colin Pilkington<br>***Sonny Kabaso* and *Abejide Ade-Ibijola***<br>Synthesis of Social Media Messages and Tweets as Feedback Medium in Introductory Programming<br>***Pariksha Singh* and *Tania Prinsloo***<br>The Application of Teaching Interventions in a First-Year Fundamental IT Course in Improving Throughput Using the PAC Framework: 2013 To 2018 |
| 11:30-11:45 | 15 minutes | Tea | |
| 11:45-12:45 | 1 hour | Open discussion [Lammergeyer A] | |
| | | Host: *Stefan Gruner*<br>Perspectives for the Establishment of Didactics of Informatics Chairs at South African Universities | |
| 12:45-13:00 | 15 minutes | Closing [Lammergeyer A] | |
| 13:00-14:00 | 1 hour | Lunch [Le Gruyéres Restaurant] | |


With thanks to NEMISA for the use of the digital countdown clocks.