Blended learning in a second year organic chemistry class: students' perceptions and preferences of the learning support

Rethabile Tekane,*[a] Lynne A. Pilcher[b] and Marietjie Potgieter[c]

Abstract

Although the implementation of blended learning in organic chemistry is rapidly growing, thus far, there are few studies published on the evaluation of supplemental types of blend in organic chemistry. This report covers a phenomenographic study that was designed to evaluate a supplemental type of blended learning approach implemented in a second-year organic chemistry course in a South African context. It offers a unique contribution in terms of catering to the needs of a diverse student body. Three open-ended questionnaires were used to probe: (1) students' perceptions of the learning support; (2) students' preferences for different types of learning support offered; and (3) students' suggestions for improvement. Semi-structured individual interviews were used to obtain clarity on some of the responses from the questionnaires. Analysis of students' responses revealed that the face-to-face component was highly valued as it gave the students the opportunity to ask questions and obtain answers in real time; the online component, especially Learnsmart, was found helpful for its flexibility and providing limitless opportunities to practice or revisit concepts. The discussion board was the least valued due to the overwhelming number of postings, and the students felt they were forced to participate in order to get marks. The students experienced the course as too fast-paced possibly reflecting cognitive overload, a potential weakness of the supplemental blend. The findings will be useful in many other contexts where the student body is diverse in terms of language proficiency and the level of preparation for the demands of organic chemistry as a discipline.

Introduction

Organic chemistry is one of the many courses that students desiring to pursue careers in STEM-related fields ought to complete successfully (Szu et al., 2011; Halford, 2016; Mooring et al., 2016). However, a number of studies have shown that organic chemistry is traditionally a difficult course with high failure and attrition rates (Ratcliffe, 2002; Johnstone, 2006; Groove et al., 2008; Eastwood, 2013; Flynn, 2015; O' Dwyer and Childs, 2017). According to Teixeira and Holman (2008), students find organic chemistry difficult because they are not able to solve multi-step synthesis problems. Furthermore, Ellis (1994) believes students find organic chemistry difficult because it requires three-dimensional thinking, it has an extensive new vocabulary, and has no problem-solving algorithms. Although general chemistry is a prerequisite for organic chemistry, the topics covered in general chemistry are different from those studied in organic chemistry. General chemistry is more quantitative (Halford, 2016) whereas emphasis in organic chemistry is more on the "relationship between structure and reactivity," (Cormier and Voisard, 2018, p.2). Various approaches to teaching have been implemented in order to help students become successful at learning organic chemistry. These approaches include the implementation of the spiral organic curriculum (Grove et al., 2008); inverted teaching designs (Christiansen, 2014); collaborative and cooperative learning (Hass, 2000; Bradley et al., 2002; Carpenter and McMillan, 2003; Hein, 2012); peer-led team learning (Tien et al., 2002); guided inquiry or discovery learning (Meany et al., 2001; Gaddis and Schoffstall, 2007); and blended learning. Although implementation of blended learning in chemistry, specifically organic chemistry, is rapidly growing, most research published on blended learning in organic chemistry classrooms is on the implementation and evaluation of the replacement type of blending often referred to as *"flipped learning"* or *"flipped classrooms,"* (Fautch, 2015; Flynn, 2015; Mooring et al., 2016; Cormier and Voisard, 2018). To date, very few reports have

[a] *Department of Chemistry, University of Pretoria, Lynnwood Road, Hatfield, Pretoria 0002. E-mail: reeh.tekane@up.ac.za or rtekane@yahoo.com
[b] Department of Chemistry, University of Pretoria, Lynnwood Road, Hatfield, Pretoria 0002. E-mail: lynne.pilcher@up.ac.za
[c] Department of Chemistry, University of Pretoria, Lynnwood Road, Hatfield, Pretoria 0002. E-mail: marietjie.potgieter@up.ac.za

[1] **Supplemental type of blended learning**: normal classroom meetings are retained and additional learning resources are made available online.

been published on the evaluation of the supplemental type of blending[1] in organic chemistry classrooms (Brown et al., 2012; Ryan 2013). Furthermore, thus far, there are no studies published on the evaluation of a supplemental type of blended learning in organic chemistry classrooms in a South African context which would offer a unique contribution in terms of catering for diverse student needs. This paper reports on a phenomenographic study that was designed to evaluate a supplemental type of a blended learning approach implemented in a second-year organic chemistry course at a large research intensive university in South Africa. Our student group consists of a diverse student body with many of the students being first generation-students for whom English is not their first language. Therefore, we were interested to see how practices well researched elsewhere in the world (e.g. North America and Europe) translate to our particular context. We anticipate that the finding of this study will be relevant to other contexts where the student body is diverse in terms of language proficiency and preparedness for tertiary chemistry.

Context

The second year organic course, which is the focus of the study, caters for a wide variety of degree programmes: it is a core second year module for degrees in biochemistry and chemistry, and an elective for degrees in physics, geology, human physiology, genetics, microbiology, plant sciences, and environmental sciences. As the class size had increased three-fold in ten years and was continuing to increase, it become very difficult to give individualized student attention and timely individualized prompt feedback on formative assessments in a resource constrained environment of limited tutors due to limited funds. Therefore, in 2016, the lecturers decided to implement a supplemental type of blended learning approach which retained normal class meetings but made additional online learning resources available to the students. The supplemental type of blended learning was introduced so as to enable students to make use of the online homework system that provided some level of real-time feedback, and provided a strong incentive to spend time on task to keep up with the pace of the course.

South Africa is known as the Rainbow Nation because of a diversity of culture, race, ethnic groups, religion, heritage and tradition. This diversity is also represented in the second year organic course in terms of race, home language, schooling systems (rural, township and city schools are reflected which represent a wide variety in the quality of the students' high school education), access to computers and the internet. In order to have access to online learning opportunities, students were expected to have a tablet or laptop, and internet access. Although 91% of the students enrolled in the second year organic course owned either a tablet or a laptop, only 39% had uncapped access to the internet during school term; 49% had limited access during school term; and 12% did not have access to the internet during school term. The students without internet access had to therefore complete the online components of the course on campus where free access is available.

Seeing that teaching and learning is such a complex phenomenon, we set out to determine which aspects of the blended learning approach were most conducive to learning by looking into students' perceptions of the affordances and hindrances associated with it. Therefore, our aim was to evaluate the blended learning approach implemented for the theoretical component of the second year organic chemistry course. In order to achieve this goal, we decided to explore students' perceptions and preferences of the learning support provided as part of the blended learning approach. By describing the full range of experiences and perceptions, we will reveal the affordances and hindrances of the supplemental type of blending; and we may be able to see if such a blend is an equitable offering.

Blended learning

Although the use of blended learning in higher education has become popular (Alammary et al., 2014), there is still no single

universally accepted definition ascribed to this term (Oliver and Trigwell, 2005). Examples of some of the widely used definitions include those proposed by Driscoll (2002), and Whitelock and Jelfs (2003 cited in Oliver and Trigwell, 2005, p.17).

According to Twigg (2003), a blended learning approach can be categorized as one of the following models, namely, replacement model, supplemental model, emporium model and buffet model. The *replacement type* of blending involves the partial or full substitution of face-to-face lectures by online learning opportunities hence resulting in the reduction of the number of face-to-face classes. Contact lectures are often replaced by videos of the lecture posted online. Since face-to-face lectures are moved online, class time meetings are usually used for answering lecture related questions and engaging in problem solving activities. The *supplemental type* of blending retains normal class meetings; however, additional learning resources are made available online. Students are required to make use of the additional technology-based learning resources either for preparing for class, homework, or further engagement with course content. The supplemental type "helps strengthen course input and motivate students who may be falling behind," (Derbel 2017 p.144). In contrast, the *emporium type* of blending is structured in such a way that face-to-face class meetings are replaced with a learning resource center "featuring online materials and on-demand personalized assistance," (Twigg 2003, p.34). This type of blended learning approach is dependent on instructional software including interactive tutorials, computational exercises, electronic hypertext books, practice exercises, solutions to frequently asked questions and online quizzes. The *buffet type* of blending is flexible in a sense that it provides various face-to-face and online learning activities, and students choose any combination that suits their needs, lifestyle or schedule. In the current study, the course design fits the supplemental model of the blended learning approach, that is, it consisted of a combination of traditional face-to-face learning with additional learning resources/learning supports made available online.

The majority of reports published in chemistry have concentrated on the replacement type of blending (usually referred to as *flipped instruction*) in which face-to-face lectures are either partially or completely replaced by online lectures. Research on the implementation of flipped instruction in chemistry falls mainly into two categories. The first type of studies investigated the influence of the flipped approach on student performance via comparison of student grades and/or class averages before and after the implementation of the flipped instructional approach (Fautch, 2015; Flynn, 2015; Weaver and Hannah, 2015; Yestrebsky, 2015; Mooring et al., 2016; Reid, 2016; Ryan and Reid, 2016; Cormier and Voisard, 2018). The second category of research concentrated on the evaluation of the flipped instructional approach through student surveys and course evaluations (Smith, 2013; Flynn, 2015; Mooring et al., 2016; Ryan and Reid, 2016). Very few studies conducted in chemistry, specifically organic chemistry, have focused on the supplemental type of blending in which face-to-face lectures are supplemented with additional online learning supports (Brown et al., 2012; Ryan, 2013). In his study, Ryan (2013) aimed to evaluate the effectiveness of using three technologies (Peer Learning Technology, Personal Response Devices and PeerWise) to promote peer learning. Results revealed that the students' evaluations of the technologies were mainly positive thus indicating that students enjoyed using them. The technologies also assisted in improving student engagement and activity in and outside class. Brown et al. (2012) supplemented lectures with videos and animations in order to help students learn and understand mechanistic organic chemistry. Students reported that the use of online learning resources improved their understanding and ability to confidently apply mechanistic knowledge.

In this article, we describe students' perceptions and preferences of a supplemental type of blended learning implemented in a second year organic chemistry course. The following research questions were addressed: (1) What are students' perceptions of the learning support provided as part of the blended learning approach? (2) What are students' preferences for the learning support provided by the blended learning approach? (3) In what ways, if any, do the students think the blended learning approach can be improved? Asking students to stipulate their preferences, and areas of improvement will help us to better understand the strengths and weaknesses of the supplemental type of blended learning approach, that is, it will inform us about the components of the blended learning approach that students found conducive for learning and those that were not conducive for learning. Learning support incorporates face-to-face lectures, face-to-face tutorials, and online learning resources.

Theoretical framework

Phenomenography is a framework that seeks to describe the perceptions, ideas, or experiences that people have towards a given phenomenon (Marton, 1981; Bodner and Orgill, 2007). Phenomenography does not concentrate on the phenomenon studied, instead, it focuses on how people experience, understand or perceive a phenomenon (Orgill, 2007). In the same way, our focus was not on the phenomenon under study, instead, it was on students' perceptions of the phenomenon which in this case was the blended organic chemistry course. Phenomenography was identified as an appropriate framework for our study because it allowed us to qualitatively identify variations in the students' experiences of the blended organic chemistry course. According to phenomenography, individuals experience a given phenomenon in various ways based on their interaction with the world (Marton 1981; Orgill 2007). It is therefore the collective sum of the participants' different experiences that defines a phenomenon. In our study, the students' various experiences of the blended organic chemistry course will give us insights into the affordances and hindrances of using the supplemental type of blended learning in a second year organic chemistry course in our particular context.

Methods

Study setting, Participants and Recruiting

The study was conducted at a large public research intensive university in South Africa as a pilot study in 2017 and full scale implementation in 2018. Recruitment of the participants was done verbally in class, that is, at the beginning of the course, students were informed about the aims and potential benefits of the study, and were asked to sign a consent form if they were interested in participating. In total, 39 of the 152 students volunteered for the full scale study in 2018. Table 1 below provides a summary of the students' demographics. All the students were enrolled in a seven-week second year organic chemistry course. Since the goal of phenomenography is to qualitatively identify variations of experiences, our aim was to recruit a wide range of participants. Fortunately, as shown in Table 1, a diverse group of students reasonably representative of the class, volunteered to participate in 2018 (see Appendix 3). The 39 students were also representative of the whole class in terms of academic performance, with 9 students each in the lowest and lower middle quartiles, 10 students in the upper middle quartile and 11 students in the top quartile. Pseudonyms are used in order to protect the participants' identities. The study obtained ethical clearance from the ethics committee of the faculty where the study was conducted (EC170130-094).

Course description

The second year organic course is offered for seven weeks from February to March. Weekly contact time consisted of four 50-minute lectures, one 50-minute tutorial session, and six hours of laboratory work. The course was divided into seven study themes taught by two lecturers: the first three themes were taught by one lecturer and the remaining four themes by the second lecturer. The prescribed textbook for the theoretical component was *Organic Chemistry by JG Smith, 3rd to 5th* edition which is supported by the online learning platform Connect. Students who progressed to second year chemistry in the year following their completion of first year chemistry would have been in possession of a valid Connect license. The Connect online resources include homework assignments and Learnsmart, an interactive, adaptive study tool linked to the e-book.

The traditional course lacked meaningful formative assessment opportunities because of a shortage of tutors/teaching assistants and funds to pay them, so all feedback through the grading of tests came from the lecturers resulting in significant delays, such that the next theme was already completed before students received feedback. In 2016 the lecturers decided to implement the supplemental type of the blended learning approach with the aim of giving students access to real-time individual personalized feedback. Although the supplemental blend has the inherent risk of overloading students by adding more activities without taking anything away, this implementation represented a conservative approach, not taking away the face-to-face contact we thought that our traditional students would need. To introduce a meaningful blend of face-to-face and online learning opportunities each activity was considered for the value it would add to learning. Given the risk of overload, it was important to evaluate each learning opportunity for the value experienced by the students.

Face-to-face classes: Classes are delivered in lecture halls based on the assumption that the students come to class having read the prescribed pages of the textbook that cover the content of the lecture. The theoretical principles are recapped or explained from a

different angle and interspersed with opportunity for students to work on simple problems during class to enable them to see how the principles can be used to solve problems. Where appropriate, students give feedback using clickers or the lecturer gets the feedback while circulating in the class. In 2018 clickers were used to monitor and reward class attendance.

Class tutorials: During a 50-minute class tutorial, the lecturer works through complex exam-type problems to show how these problems can be solved by applying theory. Students should have attempted to solve these problems for homework before attending the tutorial class. To earn marks for class tutorials, students had to submit their work for grading at the start of the tutorial session. In addition to five such sessions, one longer tutorial was offered replacing a six-hour practical session. During this session, there was an opportunity for students to work on the problems in pairs and to receive guidance and feedback from the lecturer. In order to mitigate some of the anticipated overload of the supplemental blended model, students were given the option of attending class tutorials or completing the online homework.

Table 1: Student demographics for the sample (2018)

Degree Major	Home Language	Ethnic group	Gender
BSc Biochemistry: 10/39 (25.6%)	English: 8/39 (20.5%)	African: 18/39 (46.2%)	Male: 13/39 (33.3%)
BSc Chemistry: 4/39 (10.3%)	Afrikaans: 12/39 (30.8%)	White: 18/39 (46.2%)	Female:26/39 (66.7%)
BSc Genetics: 5/39 (12.8%)	African language: 18/39 (46.2%)	Indian: 3/39 (7.7%)	
BSc Geology: 14/39 (35.9%)	Other: 1/39 (2.6%)		
BEd Senior Phase and Further Educational and Training: 3/39 (7.7%)			
BSc Physics: 3/39 (7.7%)			

Online homework assignments: The online homework assignments using the textbook platform included relevant end-of-chapter exercises. While a few questions made use of a multiple choice answer form, the platform incorporated a chemistry drawing package that accommodated open questions with organic structures as answers that could be automatically graded. The problems were organized into pools of similar questions and each student was allocated a different selection of questions from each pool to limit copying. Students were allowed four attempts per assignment. The capability of automatic grading allowed students to receive immediate feedback (correct vs incorrect on three attempts) and full answers after assignment closed. The online homework assignments were used as an alternative to attendance of the class tutorials.

Learnsmart reading assignments: The reading assignments guide the student as they read the e-book by highlighting the most relevant sections, and test conceptual gain by interspersing reading time with a few quiz questions coupled with an assessment of metacognition. The use of adaptive technology responds to the individual student's answers providing relevant follow-up questions or redirecting the student to the foundation section of the e-book or to the next topic.

In 2017 Learnsmart assignments were used to encourage preparation for class through reading of the appropriate sections of the textbook before the work was discussed in class. However, informal student feedback suggested that Learnsmart was not being used for lecture preparation, instead students found the tool useful for enhancing conceptual understanding. Hence, in 2018, the motivation of the use of Learnsmart (Appendix 1) as presented in the course study guide was changed with Learnsmart being described as a tool to learn to read academic texts for conceptual understanding.

Discussion board: The discussion board is a functionality in the Learning Management Systems and can therefore be used by students without an individual user license. Students could use the discussion board as an alternative to completing a Learnsmart assignment to demonstrate that they had done the prescribed reading before class. To cater for weaker and stronger students, three types of contributions were recognized: 1) submitting a

question on the work, 2) answering someone else's question on the work or 3) summarizing the key ideas in their own words. These contributions were all considered to be of equal value to the completion of one Learnsmart assignment and therefore catered for students who did not have a Connect license. A "Discussion Forum" was created for each one of the seven themes of the syllabus and a "Discussion Thread" was created for each sub-theme (4 or 5 per forum). The lecturer deliberately delayed answering questions to allow time for class members to offer answers, but did monitor the discussion board and corrected answers where necessary.

In 2018 we decided to advocate the discussion board activities as the "development of language skills" rather than for lecture preparation based on our observation that it was being used more after the class than in preparation for class. Furthermore, we felt that the most important gain from the discussion board in 2017 was the improvement in the students' ability to verbalize chemistry because the discussion board did not readily cater for the use of chemical drawings. We hoped that the changed motivation for the use of the discussion board (Appendix 1) would change student's expectations and would answer to the general student request to use a forum that could incorporate chemical structures.

Contribution of course activities to semester marks

All course activities contributed a small portion to the semester mark in order to motivate students to complete the assignments within the set deadlines that were paced throughout the course. The semester mark represents the continuous assessment mark which counts 50% of the final mark for the module with the other 50% coming from the final exam. The majority of the semester mark comes from the mid-term exam (semester test) and two class tests. Class attendance, as monitored by participation with clickers, counted 5% of the semester mark. The 5% tutorial mark came from the automatically graded online homework assignments or from the manually graded assignments submitted by students who did not do the online homework. The completed Learnsmart assignments and Discussion board contributions were not graded but were counted and based on the number of submissions a grade of up to 5% was earned for engagement. To earn full marks, students needed to have completed at least one Learnsmart assignment and made at least one contribution to the discussion board. With the change in presentation of the value of Learnsmart and the discussion board, the "title" for these engagement marks was changed in 2018 to "Professional Development Points". In 2016 and 2017 many students did not engage with either Learnsmart or the discussion board and consequently forfeited the marks. In 2018, the Professional Development Points earned were updated more regularly together with an announcement reminding the students not to miss out.

Data collection and analysis

In order to address the proposed research questions and thus gain insights into the affordances and hindrances of the blended second year organic course, open-ended questionnaires and face-to-face interviews were used as data collection instruments. In total, three questionnaires (Appendix 2) were administered: the first questionnaire probed students' perceptions of the learning support; the second questionnaire probed students' preferences of the learning support; and the third questionnaire probed students' suggestions of how the blended second year organic course can be improved. Of the 39 students that volunteered to participate in the study, 32 students responded to questionnaire 1; 35 students responded questionnaire 2; and 33 students responded to questionnaire 3. Since the course was taught for a period of seven weeks, the questionnaires were administered during labs at weeks three, six and seven. Semi-structured individual interviews (Patton, 2002) were used to obtain clarity on some of the responses from the questionnaires. Ten students were invited for interviews to clarify their questionnaire responses, but only five attended. The interviews were approximately 45 minutes long. The interviews were audio-taped and transcribed verbatim (Paton, 2002).

Phenomenographic analysis aims to qualitatively identify the various ways in which participants perceive or experience a phenomenon (Marton, 1981; Orgill, 2007). Consequently, during data analysis, our aim was to identify the different ways in which the students experienced or perceived the blended second year organic course. Transcriptions were read a number of times in order to understand and become familiar with them. This was followed by the initial generation of codes that addressed the proposed research questions. Labels used for the generated codes were either directly from the data or from the researcher's mind (Strauss and Corbin 1998). The initial coding was followed by comparing the generated codes with each other and their supporting data in order to combine

similar codes to form overarching themes that portray students' perceptions of the course (Strauss and Corbin 1998; Braun and Clarke 2006). This was followed by refining the generated themes. During the process of refining the themes, excerpts of themes were read in order to check if they formed a "coherent pattern" (Braun and Clarke 2006). In cases where some data excerpts did not form a coherent pattern with the rest of the data excerpts, such excerpts were moved to other themes. Once the refinement of themes was done, data excerpts under each theme were read in order to provide a detailed description of what each theme revealed regarding students' perceptions of the course. In phenomenographic data analysis, it is important to ask "what does this tell me about the way the participants understand the phenomenon?" (Rands and Gansemer-Topt 2016, p.12). Similarly, during the analysis of data, the researchers continually asked the same question, that is, "What does this tell me about students' perceptions and preferences of the course?" It is important to state that the generation of codes, development, and refinement of themes was halted once theoretical saturation (Bowen 2008) was reached. That is, coding of data from the 39 participants was stopped once the researchers realized that there were no longer any new themes that emerged from the data.

In addition to providing a rich detailed description of the study setting and participants, peer debriefing (Creswell and Miller 2000) was also employed to establish the credibility of our findings. That is, the codes were developed and refined by two of the co-authors and the third co-author confirmed the coding and descriptions of the themes.

Results

The learning support included face-to-face lecturers, tutorial sessions, Connect online assignments, discussion board and Learnsmart. It is therefore important to point out that students' preference of a particular type of learning support does not imply that other learning supports were bad, instead, it just means that the students found their preferred learning support to be more conducive for their learning in comparison to the other types. Generally, the results from the study matched those of the pilot study of 2017, but student preferences for the discussion board differed. The results from the pilot study regarding students' preferences of the discussion board have been presented and discussed in this study to include all perceptions of this learning support.

Research Question 1: Student Perceptions of the Learning Support

The goal of the first research question was to learn more about students' thoughts/perceptions regarding the learning support provided as part of the blended learning instructional approach. As illustrated in Table 2 students had various perceptions regarding the usefulness of the learning support. Students generally found the learning support to be helpful. For example, students such as Nala, and Mbakhu found the learning support, such as the online homework, to be beneficial because it provided **flexibility** as it was readily accessible hence they were able to study at their own convenience. Furthermore, some students such as Timon and Rafiki stipulated that the learning support was helpful because it gave them the **opportunity to practice and revise** work that was done in class. Other students considered the learning support such as Learnsmart to be beneficial because it **enhanced understanding of class material**, that is, it guided them regarding what to study, and developed and assessed their understanding of concepts discussed in class.

Research Question 2: Student Preferences of the Learning Support

In order to address the second research question, students were asked to indicate their most and least preferred type of learning support. As shown in Tables 4a and 4b, students provided various reasons explaining their choices. It should be noted that frequencies were included in tables 4a and 4b because the nature of research question 2 inferred a type of ranking from the students.

Students' most preferred learning support

Some students indicated that they preferred Learnsmart because it was **convenient** as it gave them the opportunity to study at their own pace and time (Table 3a). Students such as Dominic pointed out that Learnsmart was their most preferred learning support because of the unlimited learning opportunities it provided. Other students indicated preference for face-to-face lectures because face-to-face contact presents the opportunity for **real-time communication**, that is, the students are given the chance to ask questions and get answers in real time. Furthermore, students such as Nicky and Letty preferred face-to-face lectures because they believe the **student-lecturer interaction** supports learning as lecturers provide in-class

practice to ensure they understand, and also have the ability to explain concepts. On the other hand, some students specified that they preferred tutorials because during tutorials, they got the chance to **practice, get assistance and validate** their knowledge: that is, tutorials presented the opportunity to tackle practice questions, and also confirm what students understood and what they did not understand. Of the 22 students who preferred face-to-face lectures and tutorials (Table 3a), 16 were second language English speakers; similarly, five of the six students who preferred Learnsmart were second language speakers. These ratios are very similar to the sample demographics suggesting that students with or without English as first language reported similar experiences and preferences of the learning support.

Table 2: Student perceptions of the learning support - Themes and supporting students' quotations

Learning support	Themes	Examples of student quotations
Learning support in general	**Flexibility**	"I get to do exercises and connect assignments at my own pace," (Nala). "Being able to have so many platforms available to me is a very big advantage because I can ask questions and got my work done almost any time of the day. It doesn't limit me anyhow," (Mbakhu).
	Provides practice and revision opportunity	"Yes it is helpful in terms of practice and making sure that you know topics [tutorials]. It makes you work and revise the stuff tested," (Rafiki). "the learning support is helpful, the repititon [repetition] I get from repeatedly learning topics makes it much easier to remember and understand." (Timon)
LearnSmart	**Enhances understanding of class material**	"Learnsmart is particularly helpful in [that] it tests concepts and affirms them, I use it often before tests. [..]" (Queen) "the Learnsmart is helpful. There is [are] enough practice platforms provided the [that] really helps [help us] to understand some key contents of the course." (Zuri)

Table 3a: Most preferred learning support - Themes and supporting students' quotations

Learning support	Themes	Examples of student quotations	Frequency
LearnSmart	**Learning at own pace**	**"**I can learn in my own time without being rushed by a time limit and end up making mistakes," (Ludacris) **"**I learn at my own pace and understand everything with my own voice while creating pathways to remember everything," (Diesel)	4
	Unlimited learning opportunities	"[..] I can do Learnsmart many times until I understand," (Dominic) "[..] I get more chances to learn and correct myself." (Thor)	2
Face-to-face lectures	**Opportunity to ask and receive answers/explanations immediately**	"face-to-face lecturers because you can immediately get your questions answered,"(Naomi) "face-to-face lecturers because I get a chance to ask questions and the lecture [lecturer] can explain that same time [..]"(Tamia).	10
	Student-lecturer interaction supports learning	"I prefer face-to-face lectures because Mrs. X [lecturer] is so excellent at explaining and she gives us time to do exercises [on our] own during class," (Letty). "Lectures for me are the most comprehensive way to learn as it is personal and the lecturers always explain things in a way I understand," (Nicky).	9

Tutorials	**Opportunity to practice, get assistance and validate knowledge**	"that's where I get to attempt as much as many questions as possible," (Brian). "tutorials allow for thorough explanation and going through problems deeper. Also you are able to encounter and fix all problems you may have," (Naynay)	3

Students' least preferred learning support

The majority of the students specified the discussion board as their least preferred learning support (Table 3b); one identified class tutorials as their least preferred support because of the fast pace; and the rest of the students' comments were not included because they required more clarity and the students did not show up for interview sessions citing reasons such as "unavoidable commitments." As shown in Table 3b, students provided various reasons as to why they did not like the discussion board: some students thought the discussion board was **not beneficial** as it did not meet their learning needs. Other students felt the number of questions in the discussion board was **overwhelming** hence they always felt discouraged to use it because the task of going through the questions and posts was too daunting. Furthermore, students' dislike of the discussion board also stemmed from the fact that they were **uncertain about answers provided by peers:** the answers provided by their peers could contain mistakes. Some students indicated that since **participation in the discussion board is marked** they felt compelled to make up questions just so as to get marks for participation. Others, on the other hand, pointed out that they did not like the discussion board because they did not **know how to use it**. Of the 24 students who mentioned the various challenges they had with the discussion board, 17 of them were second language speakers whereas seven were English speakers.

One interesting aspect to point out is that although the majority of the students in 2018 did not find the discussion board to be helpful, pilot data collected in 2017 (Table 3c) showed that the participating students liked the discussion board because it gave them the opportunity to **confirm** their knowledge through answering other students' questions, and writing theme-summaries. Other students appreciated the discussion board because it provided a **platform** where they could ask questions, discuss answers and see how other students thought about concepts.

Table 3b: Least preferred learning support - Themes and supporting students' quotations

Learning support	Themes	Students' quotations	Frequency
Discussion board	**Not beneficial**	"wastes time on things not specific to me," (Kaowa) "I do not find that an online communication works well for me, I do not learn anything from it," (T'Challa).	9
	The number of questions posted is overwhelming	"Discussion board most definitely. I never remember to look at the discussion board and when I do, there's over 100 questions/posts," (Layla) "sometimes there are too many messages to go through at once, and I do not understand why there is grading for the discussion board," (Shadrack)	3
	Uncertainty about answers provided by peers	**"**discussion board, I do not trust other people to give me a better answer than my lecturer," (Naomi). "[..]I also find that it may be difficult studying using it as you never know whether answers or replies on there are true," (Naynay).	3
	Participation is graded/marked	"I do not understand why there is grading for the discussion board [..] sometimes people just ask random questions because they say we must be interactive," (Shadrack). "Forced to ask questions to gain marks, when I do not have any questions," (Nicky).	4

	Do not know how to use it	"I do not know how to participate at that so I never use it. I don't understand the whole discussion board," (Ledy). "Discussion board, as nobody really uses it and it can be a hassle to use," (Mindy).	5

Table 3c: Examples of students' reasons for preferring the discussion board (**Pilot data collected in 2017**)

Themes	**Examples of student quotations**
Discussion platform	"I find the discussion board very helpful, seeing as we can ask for help on specific concepts. It also enables us to answer fellow students and demonstrate that we understand our work [..]." "On the discussion board you also get the option to share your opinions with one another and it's nice to see how the people interpret the things as well."
Confirmation of knowledge learnt	"But, uhh, I didn't really ask questions, I more answered them, it helped when you are answering you solidifying your own knowledge, [..]" "I think when I used it to learn, it was more so, when there was an option to create summaries and that really helped me where I would create a summary and then just post it there under whatever heading it was under because the answering of questions, it did help,[..]"

Research Question 3: Students' Suggested Course Improvements

To address the third research question, students were asked to state their suggestions regarding how the course could be improved. As shown in Table 4, the main themes that emerged are: the course duration; the pace at which it is taught; the number of tutorial sessions offered; and participation in the discussion board. Students such as Mbakhu and Noah suggested that the course should be offered as a **semester course** instead of a quarterly course because it is a lot of work. Other students proposed that the **pace** at which the course is taught should be slowed down in order to help them learn more. Some students pointed out that having **more tutorial sessions** would be helpful since they would have more time to learn, whereas other students suggested that **participation in discussion board** should not be for marks.

Table 4: Suggestions of improving the course - Themes and supporting students' quotations

	Themes	**Examples of student quotations**
General improvements	**Semester course**	"The number of themes, or they should make the module a semester module," (Noah) **"**make chemistry a semester module. [..] have it as a semester module and then have chemistry 282 and 284 both as two chemistries, semester modules. So we will have like 282 and 284 running simultaneously. [..] yeah, but then they are semester modules, they are both longer, and like we will understand both more better, both of them, than having everything as a separate module, it's very strenuous, it's a lot," (Mbakhu).
	Slower pace	"#The pace should be slowed a little," (Zuri) "We must be taught at a slower pace." (Nelly) "The only thing I would like to improve tutorial-wise is that they shouldn't rush over tutorials so quickly," (Simba)
Tutorial sessions	**More tutorial sessions**	"Extra tutorials as well as extra tutors should be introduced, to make sure that most students understand the content covered during the course," (Nala). "Having more tutorials, that will help us ask questions and connect with other [second year organic course] themes," (Mufasa).

Discussion board	**Participation should not be graded/marked**	"Not focus too much on giving credit for things like attendance and discussion board," (Shrek). "Remove the discussion board or make it not count for marks [grades]," (King).

Discussion

One of the main findings of this study is that students considered the learning support in general to be helpful because it gave them the opportunity to study, practice and revise concepts learnt in class at their own pace, and convenience. The fact that some students took the initiative to make use of Learnsmart to ensure that they understood what they learnt in class suggests that they were interested in the subject. According to Zimmerman (2002), students who are interested in a subject become motivated to learn that particular subject and ensure that they understand the concepts/content. Furthermore, students' initiative to use Learnsmart implies that they had the ability to learn independently taking responsibility and ownership for their learning. The ability to learn independently and have self-regulated learning strategies is important for students (Ganda and Boruchovitch, 2018) specifically those in blended learning environments. Students in blended learning courses ought to take responsibility and ownership of their learning (Horn, 2013; Ossiannilson, 2017) and have to be in charge of the time, place, and pace during which their learning occurs (Ossiannilson, 2017). The comments endorsing the blend indicate that the students possessed aspects of self-regulation skills such as self-motivation and self-control (Zimmerman, 2002). Students with self-regulatory skills are "proactive in their efforts to learn because they are aware of their strengths and limitations," (Zimmerman, 2002, p.65); and engage in activities aimed at promoting self-observation, self-evaluation and self-improvement (Zimmerman, 2002).

The second main finding of this study is students' preference for face-to-face lectures and tutorials because these provided student-lecturer interaction which allowed students to ask questions and obtain answers in real time, and also gave the lecturer the opportunity to explain concepts thoroughly. A number of studies into students' perceptions of blended learning have reported that although students favoured the online components of blended learning (Chen and Jones, 2007; Akkoyunlu and Soylu, 2008; Chandra and Fisher, 2009) they also valued face-to-face interaction as an important part of learning. The reason being in face-to-face interaction, instruction is clearer (Chen and Jones, 2007), and they are given the opportunity to ask questions and receive immediate feedback (Akkoyunlu and Soylu, 2008; Chandra and Fisher, 2009; Horn, 2013). Giving students immediate feedback is considered to be one of the seven principles of good practice in undergraduate education (Chickering and Gamson, 1987) as it (i) improves students' self-awareness and confidence (Horn, 2013); (ii) assists lecturers to monitor individual progression (Cormier and Voisard, 2018); (iii) and helps "reduce the gap between current and desired understanding" for students (Hattie and Timperley, 2007, p. 86).

The third main finding of this study is that the discussion board was the least preferred of the range of learning opportunities offered. The reasons given for it not meeting their needs could provide insight for improving the offering and for blended course design. About a third of respondents indicated that the discussion board did not meet their learning needs without expanding on the details. The second most frequent reason given for not preferring the discussion board was that they did not know how to use it. One tends to make the assumption that 21st century students will navigate their way through e-platforms without assistance, but this should not be taken for granted in a class from diverse backgrounds. The discussions became unstructured with questions and answers being separated reflecting the students' uncertainty of how and where to make a contribution. The introduction of a few short instructions at the point of use e.g. "to ask a question or post a summary 'reply' to the relevant topic; to answer a question 'reply' to the question," could address this need. It also became clear that discussions with many participants got messy when not tightly managed to avoid postings under wrong headings and duplication of content. The third most common complaint indicates that balance is needed in using marks to encourage engagement versus controlling participation. In the course design, the discussion board was meant to be an alternative to Learnsmart. Students were required to make one contribution to qualify for the full 5% in order to encourage them to experience what the discussion board has to offer. Several students expressed the view that the discussion board should not be for marks which

indicates either that they had not understood that the discussion board and Learnsmart were meant to be alternatives or that they resented the requirement to make at least one contribution. Deadlines were not as tightly managed for the discussion board. It is therefore possible that some students made use of the opportunity simply to gain marks by participation in the discussion when they had missed the deadlines to complete Learnsmart assignments. This participation led to the fourth reason given for not preferring the discussion board: the number of posts was overwhelming. The number of new posts would have been particularly daunting to intermittent users or first time visitors to the discussion board because time is required to read the postings, think about a response, prepare a response, and examine responses from other students (Ryan, 2013). As one student recommended, a regular group of more committed participants could have transformed the discussion board into a more useful learning platform. Therefore, when using discussion forums in blended learning courses, there is a need for lecturers to provide clear instructions regarding what they expect from students; motivate the students to participate constructively in the discussion; provide constant feedback; and organize the discussions in such a way that students will find it easy to find useful information at a later stage (Roper,2007). The fifth significant concern expressed by a few students was that they did not have confidence in the validity of the contributions of their peers. While lecturers did correct content behind the scenes, there was no obvious endorsement of answers by the lecturers. In a small class, students might know the other class members and be able to recognize contributions coming from stronger students as trustworthy, but this was not the case for this course. If an environment could be created where mistakes are valued as learning opportunities and openly corrected by lecturers with sensitivity and appreciation, there could be great learning gain. The effectiveness of the discussion forum is influenced by the lecturer's involvement "especially in the form of technical support, providing constructive feedback, and setting clear expectations to help students understand what is expected of them," (Mokoena, 2013 p.97). Offering feedback provides evidence to the students that the lecturer is interested in their comments, (Mokoena, 2013). Despite the lack of preference for the discussion board as a learning opportunity in the 2018 study, the pilot study showed that some students did find the discussions useful for peer learning from the questions and answers of others; and through the discipline of summarizing the work for the benefit of others. This suggests that there is value in providing a selection of different activities and allowing students to choose to use those that best suit their needs.

The consistent rating of the discussion board as the least preferred learning support in 2018 came as a surprise given that it had received some positive endorsement in 2017 and there had been no negative comments. There were two changes in implementation from one year to the next: i) how it was advocated in the study guide with a corresponding change in the title for the marks earned – "Professional Development Points"; and ii) the marks earned were regularly updated on the LMS with students being reminded not to forfeit the opportunity to earn marks through either doing Learnsmart or contributing to the discussions. The number of contributions in the discussion forums for themes 4, 5 and 7 were substantially higher in 2018 compared to 2017. Comments from students that participation was "forced" taken together with the observation that participation increased suggests that the regular reminders and updating of marks had a bigger effect on the student experience than how it was advocated in the study guide. It appears that participation for the purpose of collecting points rather than learning may have led to lower quality contributions, overcrowding of certain themes and loss of structure. This had a detrimental effect on the overall learning experience.

The fourth main finding is that students were not satisfied with the format of the course. They suggested that the course should be offered over a semester (14 weeks) rather than quarterly (7 weeks); the pace at which the course is taught should be slowed down; more tutorial sessions should be offered; and participation in the discussion board should not be marked. Students might have suggested these improvements because they believe these will create a better learning environment. For instance, if the course is offered as a semester course, the students will have more time between classes to digest the work taught. Exposing students to too much information too quickly is a disadvantage because the human information processing system has limited capacity (Mayer and Moreno, 2003). These comments also suggest that the supplemental blend may be overloading the students, but without it, those without good self-regulation skills would fall behind in such a challenging fast-paced course.

Lastly, we had anticipated that the learning experience of students with English as a second language might have differed from the experience of English speaking students, but language issues did not feature in the students' responses. This might be because the questionnaires were not designed to probe for such differences. It is also possible that because the lecturers were aware of and sensitive to the needs of second language students, the language of instruction was not a primary obstacle to learning.

Conclusion and Limitations

The aim of our study was to evaluate the supplemental type of blended learning approach implemented for the theoretical component of the second year organic course. The results showed that the face-to-face component was highly valued for quality explanations and the opportunity to ask questions; and that the online component was helpful for its flexibility and for providing repeated opportunities to practice or revisit concepts. According to the students, face-to-face lectures and tutorials, Learnsmart, and online homework were preferred learning supports, whereas the discussion board was the least valued. The students did experience the course as too fast-paced reflecting cognitive overload, a potential weakness of the supplemental blend. There were also complaints that the learning support activities, particularly the discussion board, were time-consuming and "forced".

Although students found the delivery of the course very demanding, the composition of the blend was validated as all components of the blend were endorsed by at least some students. It is beneficial to make a range of learning resources available in the supplemental model and students be given the flexibility to choose to use the supplemental support that serves their individual learning needs best so that they are not overloaded with learning resources. However, apart from providing a range of learning resources, we recommend that lecturers should advocate for their potential value, and students should be required to engage with each type of resource at least once in order to make an informed decision about how best to use their time. In addition, in the supplemental model assignments should be kept short or in the case of the discussion board constructive participation should be encouraged and rewarded, and it should be better structured to ensure that relevant content is found quickly.

In this study, the views of students representing diverse backgrounds were captured. The study was conducted in the context of a student body from diverse backgrounds in terms of language diversity, with the majority of students learning in their second language, and prior exposure to technology. This group endorsed the face-to-face component thus verifying that the conservative choice to implement a supplemental type of blending was best suited to their needs. For second language speakers the language demand of reading constitutes additional cognitive load. In this study all online support depended on reading in English. The most preferred online learning support was Learnsmart which guided students in reading the textbook. This matches our expectation that second language students would appreciate this resource and that it would help them make sense of the textbook. Some of the reasons given for not liking the online activities reflected the discomfort of some students in working with technology.

The study has several limitations which could impact on the generalizability of the findings, namely the limited size of the sample, and the unique context within which the study was conducted. Although the participants in this study represented students from diverse backgrounds, the study did not reveal how different demographics influenced the perception of each learning support. More data would have to be collected to address this matter. However, despite these limitations, our study provided powerful insights to inform the improvement of the second year organic course for future students. We anticipate that the findings will be useful in other contexts where the student body is diverse in terms of language proficiency and the level of preparation for the demands of organic chemistry as a discipline.

Conflicts of interest

There are no conflicts to declare

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Appendix 1: Extract from 2018 study guide

Conceptual learning and the language of Organic Chemistry

In an education system that focuses on marks as a measure of academic performance and subject mastery, it is easy to forget that the real purpose of studying is to gain the necessary knowledge and skills needed to perform successfully in your future career. We will be providing two online systems to help you to grasp organic chemistry: 1) a tool to help you read the textbook with a greater focus on gaining conceptual knowledge (Learnsmart) and 2) a tool to help you acquire the language skills for organic chemistry (Discussion board) as outlined below. You may choose to benefit equally from both tools or to focus more on one of the tools.

Learnsmart is an online tool that is designed to help students to read the textbook and understand core concepts by linking conceptual questions with the text book. This is not the same as learning procedures for solving test and exam problems. To get the most out of Learnsmart, you should make sure you understand the answers entered and not just look for keywords in the text. We would recommend that you use this tool if you find the textbook overwhelming or you aren't used to using textbooks. Each completed Learnsmart assignment earns you 1 Professional Development (PD) point. There will be 11 Learnsmart assignments.

The *Discussion Board* on ClickUP is used to help you to develop the language skills for Organic Chemistry. Since the Discussion Board does not accommodate chemical drawings, you will need to use scientific English to describe chemistry. Fluent scientific language is necessary for job interviews, scientific discussions and presentations. There are three ways to make a contribution on the Discussion board:

- formulating meaningful questions about what you don't understand;
- using references to the textbook in answering another student's question on the discussion board in a meaningful manner that involves interpretation of material from the textbook to make it more understandable for a fellow student;
- writing a summary of a topic.

Each quality contribution on the Discussion forum counts 1-PD point. To encourage you to stay up to date with the work in order to be ready for the next topic, the discussion forum for each theme will close at the end of each study theme. We recommend that you use this tool to help you develop your language skills. It is also really useful to put in words what you don't understand or what you think you understand as this makes it clear where you need to focus your attention to improve your marks.

You will be expected to complete at least one Learnsmart assignment and make at least one quality contribution on the Discussion Board. To earn the full 5% professional development mark, you must have 12 PD points. The 12 PD's can be made up from a random combination of Learnsmart Assignments and Discussion board contributions. Fewer contributions are awarded fewer marks as

follows: 12 or more = 5%; 10-11 = 4%; 7-9 = 3%; 5-6 = 2%; 3-4 = 1%; 2 or less = 0%.

Appendix 2: Questionnaires

Questionnaire 1

So what do you think about the learning support that the lecturer has made available for you: that is, do you find it helpful or not? Explain. (**N.B:** Learning support includes discussion board, Learnsmart, tutorials, online assignments, and face-to-face lectures).

Questionnaire 2

Which learning support do you:

a) Prefer the most? Explain

b) Prefer the least? Explain

(N.B: Learning support includes discussion board, Learnsmart, tutorials, online assignments, and face-to-face lectures).

Questionnaire 3

In what ways, if any, do you think the instruction of course can be improved?

Appendix 3: Demographic details of the second year organic course

Degree Major	Home Language	Ethnic group	Gender
BSc Biochemistry: 51/152	English: 26/152	African: 92/152	Male: 61/152
BSc Chemistry: 34/152	Afrikaans: 28/152	White: 54/152	Female: 91/152
BSc Genetics: 10/152	African language: 96/152	Indian: 6/152	
BSc Geology: 31/152	Other:2/152		
BEd Senior Phase and Further Educational and Training: 14/152			
BSc Physics: 8/152			
BSc Microbiology: 2/152			
BSc Environmental and Engineering Geology: 2/152			