Can an adaptive lesson really make fundamental chemistry interactive & flexible?

Kelly Linden
Charles Sturt University, Australia

Louise Pemberton
Charles Sturt University, Australia

Lucy Webster
Charles Sturt University, Australia

First year undergraduate allied health students commence physiology with an extremely variable understanding of fundamental chemistry principles. Chemistry is also often perceived as difficult, dull and unrelated to daily life, when, in reality nothing is further from the truth. Adaptive learning has been shown to be an effective tool for chemistry homework, but we wanted to assess its value in teaching fundamental chemistry concepts to undergraduate allied health students. An adaptive online chemistry lesson was developed in the Smart Sparrow platform. The lesson was piloted and evaluated using a survey and access to Smart Sparrow learning analytics (n=33). Students reported that the lesson met their needs for flexibility (4.9/6), and that the lesson enhanced motivation to learn chemistry (4.9/6). Importantly all students that completed the survey indicated that they had a better understanding of chemistry after they completed the lesson (4.7 ±2.3 vs 7.63 ± 1.54, $p<0.00001$). Findings from this pilot study indicate that online adaptive learning resources are an effective, flexible and fun tool for teaching fundamental chemistry.

Keywords: Adaptive learning, Smart Sparrow, Innovative Practice, Chemistry.

Introduction

Undergraduate students frequently perceive introductory chemistry as not only difficult to comprehend, but also rather dull. Students often struggle to gain a full understanding of key chemical concepts and see it as unrelated to daily life, when, in reality nothing is further from the truth (Klara, Hou, Lawman, & Wang, 2013). A basic understanding of chemical concepts is essential to gaining a good understanding of more complex physiological, pathophysiological and pharmacological processes that are essential to nursing and allied health students. For this reason, fundamental chemical concepts are often taught in the first few weeks of a first-year undergraduate physiology course. Students enrol in physiology with an extremely variable understanding of fundamental chemistry principles, some will not know the structure of an atom, while others have a good understanding of advanced stoichiometry. This presents a challenge to the physiology lecturer in terms of which group they should target in class? If the content is taught at a basic level, the students with a good understanding will quickly become disengaged and the lecturer will quickly run out of time to teach all of the material. Vice versa, if some chemistry knowledge is assumed and lectures start at too high of a level, many students will never have the opportunity to learn these key concepts and will be at a disadvantage through much of the science taught later in their course.

Modern students often report that they need to fit their study around other life commitments so flexibility with learning resources that allow students to learn when, where and how they want to is imperative for success. Importantly, time flexibility with learning resources allow students to learn when, where and how they want to, and time flexibility and pace of learning that allow student control have been indicated as two key factors to learning success particularly as they enable learning around other social, family and professional commitments (Collis, Moonen, & Vingerhoets, 1997; Felix, 2001; Valenta, Therriault, Dieter, & Mrtek, 2001).

It is known that active student participation in self-directed study outside of class is linked with student success and is also a requirement for learning (Cuadros, Yaron, & Leinhardt, 2007). Adaptively responsive learning provides response specific feedback, and continuously adapts learning activities to students based on their current mastery of the content (Oxman, 2014; P. Polly, Velan, G, & Hawkins, N., 2015; Wong, 2015). Well-designed adaptive lessons present an opportunity to create a flexible learning environment for students of all levels regardless of prior knowledge. There is also evidence to suggest that adaptive learning lessons that targets students' prior knowledge are an effective tool for chemistry homework (Eichler & Peeples, 2013; Richards-Babb, Curtis, Ratcliff, Roy, & Mikalik, 2018), however it is not yet known if adaptive learning can be used to teach first year allied health students' fundamental chemical concepts. The overall aim of this pilot study was to

examine students' perceptions of learning and flexibility using a Smart Sparrow adaptive and interactive online chemistry lesson.

Methods

Thirty-three allied health undergraduate students who were enrolled in an introductory physiology subject in 2017 and 2018 agreed to participate in this study after completing the Smart Sparrow lesson. Ethics approval was received from The Charles Sturt University Human Research Ethics Committee (HREC Protocol No 2015/265).

The adaptive chemistry lesson was developed using Smart Sparrow (http://www.smartsparrow.com). The lesson was divided into a number of parts, and at the beginning of each part students were asked 5-10 questions related to the specific topic. Immediate feedback built into the tutorials was adapted and provided to students based on their individual responses. If students answered the questions correctly they were taken to the next set of questions. If students answered the questions incorrectly they were directed to a combination of explanatory text, images and videos and were then given an opportunity to answer the questions again before moving onto the next topic (Figure 1).

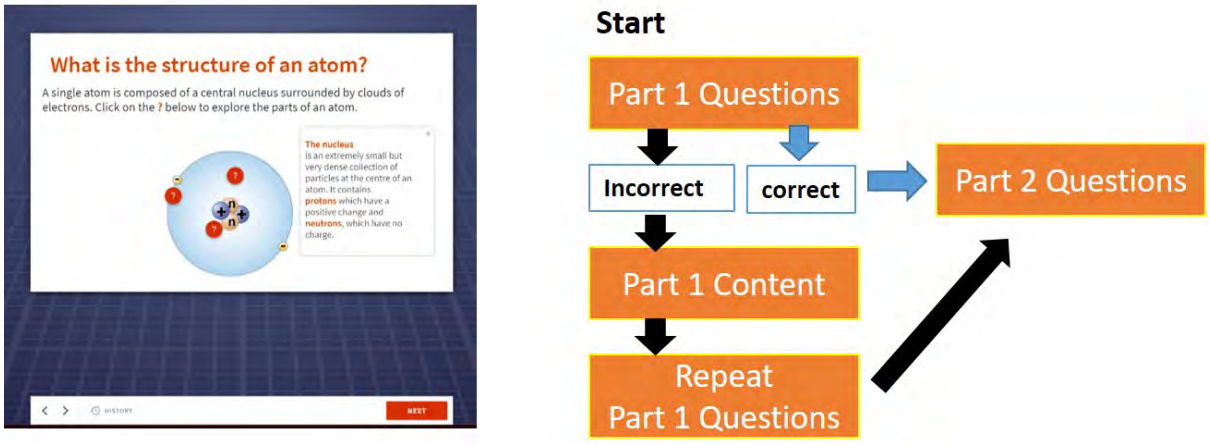

Figure 1. The lesson covered all of the material taught in the chemistry topic and prepared students for similar questions in the final exam. Students were given 3 attempts at each question.

Participants in the study evaluated the effectiveness of the adaptive online lesson for their learning by consenting to an online survey and making Smart Sparrow learning analytics available. A structured online survey using items drawn from existing instruments such as the Course Experience Questionnaire was used to measure perceptions of flexibility and learning. The survey contained 8 questions measured on a 6-point Likert scale to assess the level of (i) flexibility and (ii) student engagement and learning of the lesson. In addition, students were also asked to rate their understanding of the topic before and after the lesson. The remaining 2 questions were open-ended items related to what students liked most about the resources, and what changes they would like to see to further improve the lessons.

Group means were compared using a paired student t-test and were analysed utilising the statistical package GraphPad Prism (version 7.04). The significance level was set at $P<0.05$.

Findings

The survey data in combination with the Smart Sparrow analytics revealed that students found the adaptive chemistry lesson met their needs for flexibility and it also assisted in their learning of the chemistry topic. Recurrent positive themes emerging from student commentary were that the lessons focused on individuality of learning styles, interactivity of the content, and learning. Additionally, students also felt that the lesson met their needs for flexibility (Likert scale [from 1 to 6], 4.9 of 6; Table 1). Students also indicated that the lessons provided an individualised learning environment (4.4 of 6) and that the lesson helped to identify priorities in learning (5 of 6; Table 1).

I like that it covers all areas of the topic and tests you until you have got the questions right. I find this method of repetition works really well for me and it is interactive. (Student 5)

It was simple to use interactively on my iPad. What I liked the most was the change from questions to content knowledge. (Student 31)

Table 1. Compiled Responses to Likert Scale Questions (rated out of 6)

Likert Scale Question	Score (1-6)	n
Flexibility		
It met my needs for flexibility in my learning	4.9	21
It provided an individualised learning environment	4.4	20
It helped me to identify priorities for my learning	5	19
Learning		
It made my learning more efficient (saved time)	4.6	20
It enhanced my motivation to learn about this topic	4.9	19
It provided feedback that enhanced my learning	4.2	22
It made my learning more efficient (saved time)	4.6	20
It improved my understanding of the topic	4.8	19

It has been reported that the flexibility to choose *when to learn* and *how to learn* are key factors for learning success. Not only does adaptive learning offer students flexibility in the way that content is delivered, but there is also true flexibility in regards to the time that students can access resources. Smart Sparrow learning analytics were used to investigate the time of the day, and day of the week that students were accessing the chemistry lesson, and it was interesting to note that the majority of students accessed the lesson during conventional business hours (Figure 2). Further analysis revealed that 27% of students completed the adaptive lesson before the chemistry topic was taught in lectures. A further 48% of students completed the lesson in the weeks after the chemistry lectures and 27% completed the lesson in the week of the end of semester exam.

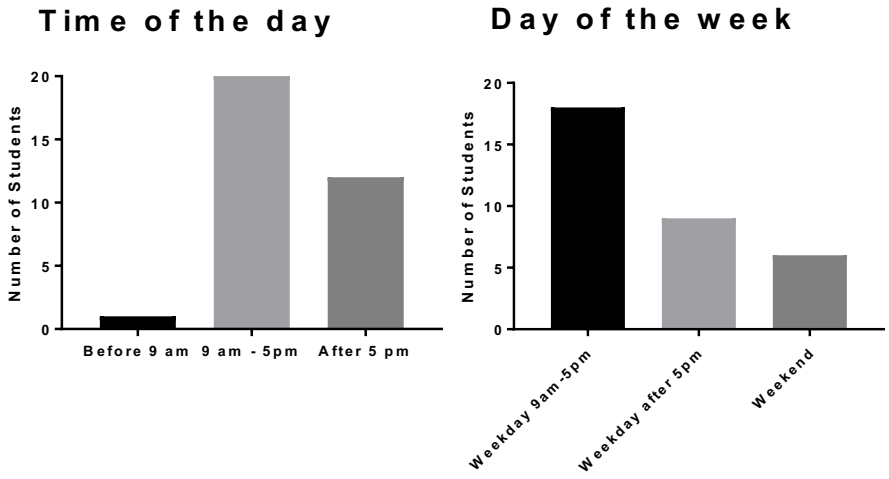

Figure 2. Student access of the adaptive chemistry lesson.

When asked to "*rate your understanding of the topic on a scale of 1 to 10 before you used this lesson*", and to "*rate your understanding of the topic on a scale of 1 to 10 after you used this lesson*", students reported a significantly increased understanding of the chemistry topic 4.6 ± 2.3 vs 7.8 ± 1.5 ($p<0.001$; Figure 3). Importantly, all students indicated that they had a better understanding of the chemistry topic after they completed the lesson.

> The interactive learning was very helpful. The ability to be tested on previous knowledge, then to be given information about the topics and then questioned again. This allowed me to see where my weaknesses were and if I was improving at all. (Student 26)

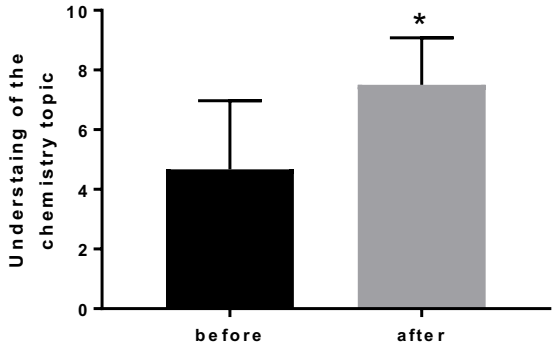

Figure 3. Improvements in students' self-reported understanding of the chemistry topic before and after completing the Smart Sparrow adaptive lesson * p<0.00001.

Adaptive learning provides deep and rich engagement with the content, while at the same time assisting students' learning through visualisation and embedded feedback. The success of this lesson was in part due to the fact that students had the opportunity to work through the content at a level adapted to their current level of knowledge. Students were retested if they answered the questions in a section incorrectly, or could progress quickly through the lesson if they were confident with the lesson content. There is an increasing body of literature supporting the effective use of Smart Sparrow adaptive lessons in a range of undergraduate disciplines including radiology, histology, molecular biology and microbiology (Makransky, Thisgaard, & Gadegaard, 2016; P. Polly, Marcus, N, Maguire, D, Belinson, Z, & Velan, G., 2014; Velan, 2015; Wong, 2015). This pilot study provides evidence to suggest that adaptive learning is a useful tool to students in learning a fundamental topic; while at the same time providing the flexibility to engage students with varied levels of prior knowledge.

Conclusion

This pilot study describes the success of an adaptive learning resource, within a first-year level chemistry topic. Our results indicate that students found the resource met their needs for flexibility in their learning. Students also reported that the lesson enhanced their motivation and self-reported improvements in their understanding of this difficult topic area following completion of the adaptive lesson. In conclusion, adaptive learning resources are an effective and flexible tool for teaching fundamental chemistry.

References

Collis, B., Moonen, J., & Vingerhoets, J. (1997). Flexibility as a Key Construct in European Training: Experiences from the TeleScopia Project. British Journal of Educational Technology, 28(3), 199-217. doi:10.1111/1467-8535.00026

Cuadros, J., Yaron, D., & Leinhardt, G. (2007). "One Firm Spot": The Role of Homework as Lever in Acquiring Conceptual and Performance Competence in College Chemistry. Journal of Chemical Education, 84(6), 1047. https://doi.org/10.1021/ed084p1047

Eichler, J. F., & Peeples, J. (2013). Online Homework Put to the Test: A Report on the Impact of Two Online Learning Systems on Student Performance in General Chemistry. Journal of Chemical Education, 90(9), 1137-1143. doi:10.1021/ed3006264

Felix, U. (2001). A multivariate analysis of students' experience of web based learning. Australian Journal of Educational Technology, 17(1), 21-36. https://doi.org/10.14742/ajet.1770

Klara, K., Hou, N., Lawman, A., & Wang, L.-Q. (2013). Developing and Implementing a Collaborative Teaching Innovation in Introductory Chemistry from the Perspective of an Undergraduate Student. Journal of Chemical Education, 90(4), 401-405. doi:10.1021/ed300525g

Makransky, G., Thisgaard, M. W., & Gadegaard, H. (2016). Virtual Simulations as Preparation for Lab Exercises: Assessing Learning of Key Laboratory Skills in Microbiology and Improvement of Essential Non-Cognitive Skills. PLoS ONE, 11(6), 1-11. doi:10.1371/journal.pone.0155895

Oxman, S., & Wong, W. (2014). White paper: Adaptive learning systems. In D. X. D. E. G. I. E. Solutions (Ed.): Integrated Education Solutions.

Polly, P., Marcus, N, Maguire, D, Belinson, Z, & Velan, G. (2014). Evaluation of an adaptive virtual laboratory environment using Western Blotting for diagnosis of disease. BMC Medical Education, 14(1), 222. doi:10.1186/1472-6920-14-222

Polly, P., Velan, G, & Hawkins, N. (2015, October 19-22). Development of online science practical lesson resources to enhance student learning in phases 1 and 2 medicine at UNSW Australia. E-Learn 2015.

Richards-Babb, M., Curtis, R., Ratcliff, B., Roy, A., & Mikalik, T. (2018). General Chemistry Student Attitudes and Success with Use of Online Homework: Traditional-Responsive versus Adaptive-Responsive. Journal of Chemical Education, 95(5), 691-699. doi:10.1021/acs.jchemed.7b00829

Valenta, A., Therriault, D., Dieter, M., & Mrtek, R. (2001). Identifying student attitudes and learning styles in distance education. Journal of Asynchronous Learning Network, 5(2).

Velan, G., Ben-Naim, D., Kumar, R., Bain, M., Kan, B., & Marcus, N. (2015). Adaptive tutorials using virtual slides to enhance learning of microscopic morphology. Paper presented at the E-Learn, Kona, Hawaii, USA.

Wong, V., Smith, Ariella, Hawking, N, Kumar, R, Young, N, Kyaw, M, & Velan, G. (2015). Adaptive tutorials versus web-based resources in radiology: A mixed methods comparison of efficacy and student engagement. Academic Radiology, 22(10), 1299-1307. https://doi.org/10.1016/j.acra.2015.07.002

Please cite as: Linden, K., Pemberton, L. & Webster, L. (2018). Can an adaptive lesson really make fundamental chemistry interactive & flexible? In M. Campbell, J. Willems, C. Adachi, D. Blake, I. Doherty, S. Krishnan, S. Macfarlane, L. Ngo, M. O'Donnell, S. Palmer, L. Riddell, I. Story, H. Suri & J. Tai (Eds.), Open Oceans: Learning without borders. Proceedings ASCILITE 2018 Geelong (pp. 446-450).

https://doi.org/10.14742/apubs.2018.1951