Adaptive learning through technology: A technical review and implementation

Abstract

Purpose: There is an increase globally of students using technology to support their learning. The purpose of this paper is to outline the technical aspects of adaptive learning and contribute to the development of pedagogy that incorporates this method in teaching and learning.

Design/methodology/approach: This is a technical review article that summarises key guidance on the application of adaptive learning and then reflects on its application in a UK and Vietnamese context.

Findings: Initial analysis demonstrates that learning can occur asynchronously because of students engaging with adaptive learning. Issues and recommendations were derived from the reflections and practice of both UK and Vietnamese practitioners. Recommendations focussed on the more practical elements of constructing and maintaining adaptive learning. Questions were then constructed to make the decision of whether to implement adaptive learning into teaching and learning practices.

Originality: This academic commentary reflects on the implementation of asynchronous learning adaptive technologies in both the UK and Vietnam. Specifically, exploring the use of a ‘mastery path’ and ‘computerised adaptive testing’ to enhance student understanding.

Introduction

Higher education institutions are encountering considerable transformation in the face of issues such as growing student cohorts and student mobility (e.g., Hewitt, 2020; UNESCO, 2023), heightening pressure on reducing levels of student non-continuation across programmes (e.g., Hillman, 2021), and ensuring students are employable post-graduation (e.g., Atfield *et al.,* 2021; Cheng *et al.,* 2022) – all within an increasingly competitive marketplace (e.g., Szekeres, 2010; Kettunen *et al.,* 2022). Such challenges have been further met by the higher education classroom being increasingly made up of a diverse set of student populations, with learners from varied backgrounds and varied educational experiences (Boelens *et al*., 2018) whilst possessing varied levels of knowledge and skills when entering the setting (Wanner and Palmer, 2015). A one size fits all approach to teaching that has previously pervaded higher education (Ernst and Ernst, 2005) thus becomes inappropriate when considering a students' path to learning because of these differences in "skill levels, expectations, experience[s], goals, and learning strategies" (Koenig and Guertler, 2021, pg. 304).

Educators have therefore begun to transition to a more learner-centred approach, aiming to put individual student needs and interests at the fore (Alamri *et al.*, 2021). This has witnessed higher education institutions growingly employ technology to support personalise a students' learning and master their expertise (Lesser, 2016). Indeed, according to Kara and Sevim (2013), the opportunity and capability to integrate digital tools into the teaching and learning (T&L) process have truly transformed higher education. The use of such practices has been accelerated, in part, by Covid-19 (e.g., O'Dea and Stern, 2021) as well as pedagogical research (e.g., Armellini and Rodriguez, 2021) and institutions (i.e., Advance HE) advocating for a hybrid and/ or blended approach to learning. Such driving forces has subsequently witnessed adaptive learning technologies being classified as one of the six most promising technologies emerging within the higher education setting worldwide (EDUCAUSE, 2020), bringing opportunities to explore new venues for T&L.

Many adaptive learning technologies can be implemented by educators in a bid to facilitate student learning. The mastery path (MP), which can be incorporated into the virtual learning environment (VLE) of Canvas, and computerised adaptive testing (CAT) are just two that have emerged within this practice. This technical paper subsequently aims to discuss and reflect on the implementation of these learning adaptive tools, citing evidence from undergraduate courses in both Vietnam and the UK. To do this, the structure of this technical paper is as follows. First, the paper offers guidance with respect to the use of adaptive learning technologies in the T&L process. Reflections and evidence from undergraduate courses in the UK and Vietnam are subsequently then put forward in a bid to further advance the use of adaptive learning as a pedagogical approach to support students' learning and experience.

Summary guidance concerning the use of adaptive learning

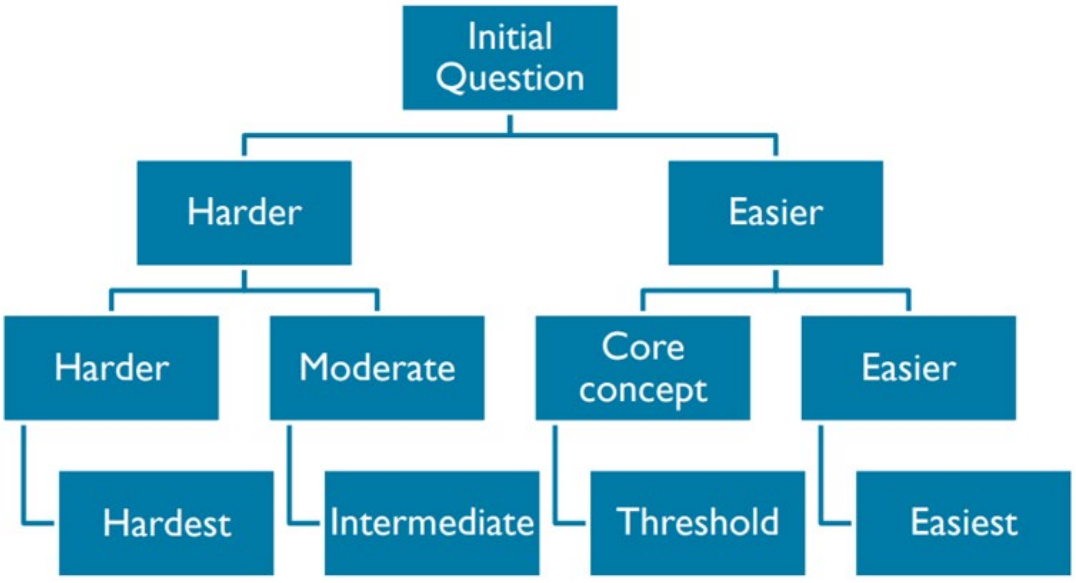
In short, an adaptive learning system is a digital learning system that assesses a learners' current skillset or knowledge before dynamically adjusting its content to the individual learner through presenting personalised feedback and content that is then monitored to enhance student learning (e.g., Educause Learning Initiative, 2017). Adaptive learning has been found to be more desirable to students as they can control elements of the learning process (Banditvilai, 2016). Whenever a learner interacts with an adaptive system, an event is triggered, followed by a sequence of actions that pushes their understanding forward. The adaptations within the system should be based on the characteristics of the learners, for example, performance on prior

exercises (Kurilovas *et al*., 2014). These features, together with a hybrid learning environment combining different learning methods, alternating distance and face-to-face teaching models, leads to the concept of asynchronous learning.

In higher education, asynchronous learning is suitable for learning to take place with a large cohort of students. A well-constructed asynchronous learning system should be based on student-centered, personalized, adaptive learning, emphasizing the importance of communication and peer-to-peer interactions. This approach combines self-study with asynchronous interactions to promote learning. It often requires a learning management system (LMS) or a VLE developed to support online interaction, allowing users to organize discussions, post and access learning materials, share multimedia contents, pose and answer questions, or simply message. This creates a mutual benefit for both students and teaching practitioners. First, students can acquire knowledge and skills in many ways, following their own path, at their own pace. Second, and with respect to teaching practitioners, the students' work can also be evaluated or automatically marked by computer systems embedded in the VLE, saving time and organisational resources. However, the use of this type of approach has little empirical evidence to support its impact on learning (Holthaus *et al.*, 2019). Moreover, some authors state that there is no evidence to support its effectiveness (Castañeda and Selwyn, 2018).

One example of adaptive learning through technology is CAT. The assessment presents a series of questions based on their level of difficulty relative to the presumed level of their subject knowledge. During the test, the system adjusts students' scores based on their answers, continuously fine-tuning the material by selecting questions from a narrower range of difficulty. The process can be seen in figure 1 below, however, there are challenges posed by using this method and more complex models (see figure 2), as the students' journeys become more bespoke. One issue is that students will not access all levels of difficulty in this model and therefore are restrained by their prior performance. Moreover, learning objectives will need to be met which could pose a challenge with such a unstandardised approach. This could pose further challenges when selecting samples for external examiners as there may be several assessments instead of the same for all students.

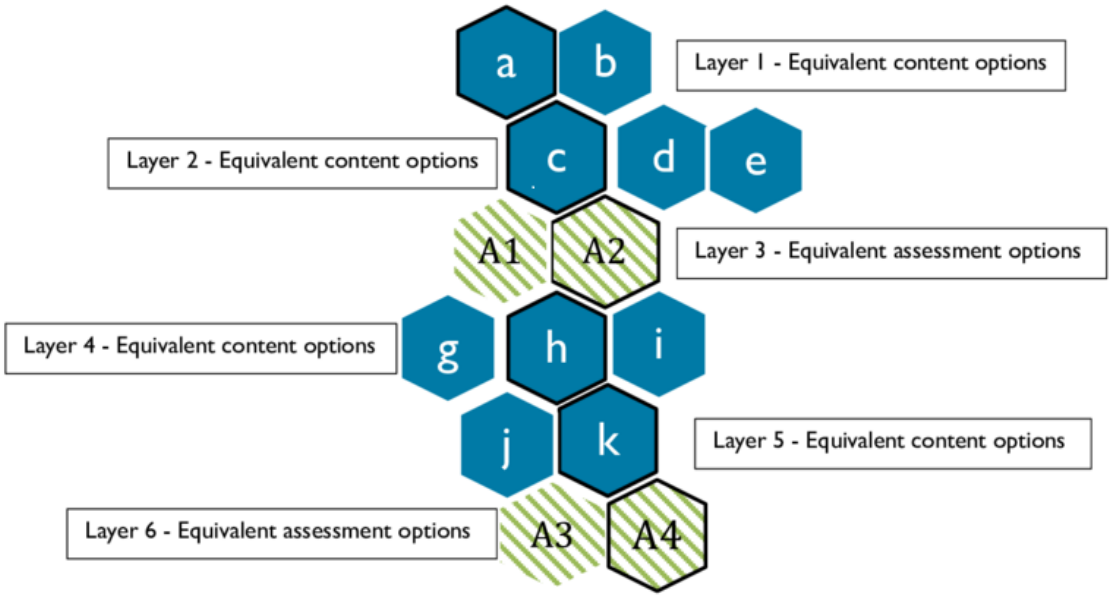
Figure 1: Learning path



Gordon (2013) p.14

In more advanced models, the assessment based on concepts requires the lessons to be organized by those concepts too. Then, the system can be designed to analyse the students' weaknesses and tailor any further material based on them. In addition, whenever a student submits incorrect answers, the system can be designed to provide hints and links to further the learning process. This process can be linear in nature or far more complex. Below in figure 2 is a learning pathway designed with multiple routes to a final assessment, which is a good example of a more complex model. In this model, students could have different learning experiences/journeys and therefore different assessments based on their performance in preceding tasks. This is similar in concept to figure 1 above, but in the second model below (figure 2), learners will have the opportunity to take an equivalent assessment. There may however be issues with using such a complex model asynchronously and online for some subjects of study (e.g., not scientific subjects that can be more descriptive in nature). Yet, with the advancement in textual questions in VLEs, it could be viable for all subjects to adopt this type of assessment in the future (Gordon, 2013). Nevertheless, this style of assessment could be used in certain aspects of all subjects, especially when utlising multiple choice questions.

Figure 2: Flexible learning pathways



Gordon (2013) p.13

MPs are a different iteration of adapted learning technologies incorporating many aspects of the previous two models. MPs differ as they are more linear in nature and students must master each concept to be able to progress to the next concept. MPs are attached to the pedagogical approach noted by Bloom (1968) of mastery learning; an approach highlighted as being more effective compared to conventional teacher-centered approaches for a myriad of reasons (Cundiff *et al*., 2020). MPs are useful in breaking down specific subject areas into manageable online learning units that students complete at their own pace, ensuring that each learner has a

thorough understanding of one topic before moving on to the next. The value of MPs thus derives from providing a systematic way to supply additional resources and activities outside the classroom, forming customised and personalised student content automatically based on their performance on a specific topic.

Regardless of the adaptive learning technologies complexity in respect of its design, as it is housed inside of the VLE student interactivity can be measured in several ways. For instance, when students interact with VLEs through their personalised devices, their clicks, navigation patterns, time on task, and information flow can be tracked and offer data for analytics (Anderson, 2008; Haythornthwaite and Andrews, 2011). These educational data analytics (DA) can include predictive and descriptive models to get hidden patterns, insights, information, and knowledge (Alblawi *et al*., 2018). DA does not only provide insight about students' activities, but also collects student feedback and can lead to future adaptations of the learning content based on students' preferences and needs. DA can also help to build learner-centered analytics and create learning strategies that could guide students to accomplish specified goals.

The following section subsequently ruminates on the implementation of the adaptive learning technologies of CAT and MPs in the Vietnamese and UK higher education context.

Reflections and Impact

Implementation of adaptive learning in the UK

With the primary intention of encouraging students to explore specific areas of the university website as well as advance their understanding of the core skills required for university, two automated MPs were created through the VLE of Canvas - one associated with referencing and the other with student systems. These MPs were summatively assessed and housed within two first-year modules that each consisted of 121 students. The total number of submissions saw 104 students complete the student systems MP (84.9%), while 108 students finished the referencing MP (89.25%). In total, there were a combined 4,833 page views for the MP quizzes aligned to the issue of referencing (3,521 if excluding summative quiz) and 5,051 page views for the student systems MP quizzes (4,182 if excluding summative quiz). Importantly, this is before even analysing the level of engagement connected to links and content that formed part of the MP that was needed to develop student understanding prior to entering the relevant stage quiz and would thus see additional page views relating to the MP. Consequently, it took students an average of 1 hour and 20 minutes to complete the student systems MP from start to finish. For the referencing MP it took students on average 2 hours and 45 minutes to complete. Table 1 presents a breakdown of student completion per stage of the MP to the final summative assessment completion. Additionally, the number of page views for each respect quiz for the stages involved in the MP are also included.

Insert Table 1: Summary of mastery path analytics

Overall, students seemed to look favourably at the implementation of the MP to support their T&L experience. For instance, in the module evaluation, 90% of students (n=51) and 78% (n=50) felt that the digital resources employed within the respective modules were (very) easy to use. This suggests that students found the MPs and associated (digital) content to be navigable and user-friendly. Qualitatively speaking, students also stressed how '*...even the*

assessments were great' while another simply stated '*referencing*' when asked what the most interesting element of the module was. That said, one student elicited that the module downplayed the role of referencing by commenting, '*If the importance of referencing was further emphasised*', therefore suggesting the referencing MP and associated discussions around this were insufficient. In this regard, we could argue that, despite its positives for most students, for some, implementing technology outside of the classroom does not necessarily affect understanding.

Overview of adaptive learning technologies in Vietnam

When COVID-19 pandemic occurred, Vietnamese education began to accelerate the use of technology applications. Private educational institutions in Vietnam started implementing adaptive forms of education during the pandemic, using creative classroom models and intelligent learning assistants through the VioEdu system or platforms like Moodle and Canvas. However, the availability of equipment for students is still limited, according to the research group of Vinh *et al*. (2022). Additionally, advanced features such as adaptive mechanisms or algorithms adapted to the needs and characteristics of individual learners, like those developed by other countries, are not yet available.

There have been some forms of adaptive education-related teaching, such as adaptive assessment technology in mathematics with Adaptive Ability Evaluation – CAT which has been tested on some small groups. For example, the Vietnam National University has created the first iteration of an adaptive testing system - UEd-CAT 1.0. It has been found that the UEd-CAT 1.0 system helps create and manage standardized question banks, organize exams, and return results of candidates evaluated according to the adaptive multiple-choice model. This system has found to increase learning interest and adapt to individual student abilities, as well as greatly supporting teachers in evaluation. However, the implementation is still at the trial level and solely focuses on the evaluation of learning outcomes.

Recommendations

From this paper there is evidence to suggest that adaptive learning technologies can be viewed favourably by students and can be used to facilitate learning both inside and outside of the learning environment.

Yet while the first iteration of the MP did display some promising results and facilitate student learning, the architecture and features could be improved to further support learning. In the current iteration, there was little in the way of feedback if a student chose an incorrect answer. Due to the nature of the MP, feedback would have to be asynchronous and automated (MCQ answers). However, as the MPs are primarily used for discovery and the students can resubmit an unlimited number of times, the feedback should be a useful tool for the students to help them advance. Unfortunately, there will always be students who try to 'game' the system regardless of geographic context. In the MP, this was mitigated by creating a question bank that would change and be randomised when reattempting the quiz. Indeed, the order of answers was also randomised to ensure students could not simply remember which numbered answer was correct if the same question was presented. Nevertheless, the use of different style questions other than MCQs, such as blank questions - whereby students are required to directly input answers - may be a prudent revision in any learning system. While this may reduce the likelihood of 'gaming' the system, it still creates practical issues in terms of students responding correctly but being viewed as being incorrect due to, spelling or letter case errors.

At this stage, it is also important to consider the accessibility of adaptive learning technologies to students, given that it is an online technology. In the UK, the Office for Students (2020) has previously strongly questioned the equality of learning for those students living in digital poverty when technology is employed, and research has compounded this by highlighting that the ability for student engagement in asynchronous learning tasks relies on access to technology (Lomer and Palmer, 2021). As facilitators of learning, we therefore need to ensure that when applying adaptive learning technologies, students cannot only access them but are also digitally literate in their usage. More time must be spent by teachers to discuss with students how to effectively use these innovative practices, bringing us to the question of whether it saves time and resources. The online learning environment also creates various challenges for teachers. It is difficult to observe, control, and adjust the learning experiences (Vozniuk *et al*., 2013).

As for the Vietnamese context, there has been some limited use of adaptive learning in higher education. However, this is an area that could be improved, not simply by investment, but by collaboration with those who have developed adaptive methods. As seen in the UK context, adaptive learning can take place in existing VLEs, but the architecture can be a little complex. Therefore, to help facilitate a more collaborative creative learning environment for educators, a cross-cultural working/learning group utilising peer-to-peer mentorship could be established to share good practice and further the use of this style of learning. Moreover, by expanding the network of educators more data can be collected to see if this approach is effective in other settings outside of the UK and challenge the existing narrative within literature (e.g., Castañeda and Selwyn, 2018).

From the above reflections the following questions should be posed to teaching teams when planning to implement adaptive learning technologies:

Does the technology facilitate learning inside the classroom?

Does the technology facilitate learning outside the classroom?

And where the above takes place;

Does it save time and resources?

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