Using VLEs to offer higher education students choice and differentiation in learning activities: Micro-pathway Learning Design implementation and opportunities

Simon Cross[1]
[1]The Open University, Milton Keynes, United Kingdom
Simon.j.cross@open.ac.uk

Abstract: Conventional models of distance e-learning course delivery are increasingly coming under pressure as course designers struggle to reconcile the diversity of learner interests, abilities, prior learning, and study demands with needing to adhere to a single linear structure pitched at the average learner. However, designers have an alternative and using technology can design and build differentiated paths, or learning micro-pathways, through sequences of learning materials and activities which have the effect of delivering a more personalised learning experience. One approach is to hide the personalisation decision-making from the student whilst a second – that explored in this paper – is to give the student agency by offering them a choice of differentiated learning pathways through a sequence of learning activities. This paper will present a small-scale pilot study intervention that spanned a week of learning activity in a postgraduate online module. This was achieved by using existing Moodle VLE functionalities associated with conditionality operators and the student options to create two, student-selectable (and re-selectable) differentiated paths through part of a learning week. The design approach will be described in relation to twelve Design Goals and a focus on the following questions: (1) Does being offered a choice increase the learners' sense of control, engagement, and perception that the course is meeting their needs? (2) What guidance do learners need to make effective decisions, and can visualisations of learning design support this? (3) Can differentiated learning be achieved within a VLE by individual teachers with appreciably low effort and resource? (4) What design skills and conceptual competencies are required to do this? Feedback from repeated use of the intervention shows that learners responded positively, found the choice-making process clear, and would support use of the technique in other modules. Learners also suggested a range of potential teaching uses. This feedback will be discussed along with consideration of learning design challenges and opportunities.

Keywords: differentiation, personalisation, learning paths, learning maps, VLEs, learner agency

1. Introduction

Teachers of distance and blended learning are increasingly expected to deliver online learning experiences that are, or at least are perceived to be, more flexible and personalised (e.g. EDATU 2016, Gordon, 2014). Flexible, personalised learning is concerned with offering students more choices for, and involvement of, students in their own learning (Boelens et al, 2017). Doing so can deliver benefits for the learner – such as greater sense of control and empowerment (Ryan and Tilbury, 2013) - but also for the teacher and the teaching institution in the form of improved learner achievement, retention and student satisfaction. This is particularly relevant in the UK context, where the number of part-time higher education distance learners is falling (Universities UK, 2018) and where the government's National Student Survey asks learners how interesting, intellectually stimulating and challenging their courses are (Office for Students, 2019).

The key challenge explored in this paper is how can greater differentiation be built into courses themselves so that it is cost effective, useful to learners, practicable for teachers, and contributes to building the perception of personalisation within the course. Creating a more nuanced learning design that better meets learner interests, abilities, level of prior learning, and study demands may not, however, fit well with current enculturated design approaches and institutional processes that are predicated on a single linear structure designed for the average learner and on the need to deliver within cost and staffing constraints (Boelens et al, 2017). This issue of cost is important and means that whilst commercial and research-funded research continue to develop, pilot and probe the potential for technologically complex solutions, lower-cost

approaches that employ technologies already integrated into university teaching such as VLEs that are should not be overlooked.

This paper reports the findings of a pilot conducted at the Open University, UK (OU) that used existing VLE functionalities associated with conditionality operators and the Student Choice tool within the student Study Planner to create two, student-selectable, differentiated paths through part of a learning week: a route for those with intermediate statistics knowledge and a route for those with little or basic knowledge. This was intended to allow the student to choose the route that they felt was more appropriate and more personal to their needs. Once the selection had been made – one which could be changed at any point – the Study Planner automatically updated and adapted to show only the activities associated with that path.

This pilot comprises part of a wider interest in the following four research questions:

- RQ1 - How does offering a choice of learning activity paths increase learner sense of personalisation, control, agency, and engagement?
- RQ2 - What information does the learner need to make effective decisions, and can visualisations of learning design support this?
- RQ3 - How much effort would be required to implement and add student choices to existing VLE-based online modules?
- RQ4 - What design skills and conceptual competencies are required to create learning activity paths?

2. Literature

Personalisation within a unit of learning will often involve some form of differentiation, be this in the content, the process or mode of learning, the product learners create during activities or assessment or the support and communications learners receive (Wanner & Palmer, 2015). It can also be manifested in the way that learners express their agency - such as deciding when, where and which learning activities to study (Carola, 2011) - and in what order to study units of learning. At the Open University, for example, learning resources are made available in a variety of formats so that students can study whilst mobile and vary the pace, place and time of learning (Cross, 2019), assessments may offer choice in topic or context, whilst the university's Open degree offers complete flexibility in choice of course modules.

However, macro-level definitions of 'flexible learning' centred around learner choice of course modules contrast with those that seek flexibility at the micro-level (EADTU, 2016). Intelligent Tutoring Systems or Adaptive course generators for example represent one alternative to the pre-authored "one-size-fits-all" courseware (Brusilovsky & Vassileva, 2003). This approach, however, can demand significant investment of time and resource and require the construction of a large instructional knowledge base or model, sufficiently granular and varied learning resources capable of being presented in multiple sequences and organised in repositories, a means of connecting and describing the metadata such as to link repositories to the software, means of generating dynamic text to allow smooth transitions between resources, and mechanism of capturing, determining and representing a learner model on which to base course generation (Ullrich & Melis, 2010). Adaptive courses may not transfer well across contexts, curriculum or learner groups and may work better for more structured subject domains such as mathematics. Furthermore, the criteria and approach used in producing and fitting the learner model raises significant issues, as do potential solutions such as the concept of an open learner model (Dimtrova & Brna, 2016).

In recent years, significant effort has also been invested in educational recommender systems and learning analytics dashboards as a means of delivering a more personalised learning experience. Learner data such as VLE usage, assessment submission and grades, and feedback can help determine 'optimal' routes through learning resources (Karampiperis 2005) or be used in recommender systems (Verbert et al, 2011). There are limitations to these approaches, however. Recommender systems may work where there is close cohort heterogeneity (where the learner is assumed to be 'similar' to previous or other learners), a sufficiently large dataset, and where course design and teaching vary little between years. Dashboards tend to be limited to personalising the process of reflection and raising learner awareness of their behaviour whilst ostensibly driven by a concern with retention (Schwendimann et al, 2017; Bodily & Verbert, 2017). Across both there is a

paucity of research into learner needs and the perceived learning benefit, as well as on how these enable learner autonomy or choice (Bodily & Verbert, 2017). Furthermore, whilst students may perceive themselves to have agency of choice, the choices and implied expectation of action may often be weighted in favour of following the 'crowd' (i.e. performing in a similar way to others or previous cohorts) and/or repeats and amplifies the expectations of the singular course design already created by the teacher.

Personalisation necessarily requires the striking of a balance between freedom and guidance where the 'learner should be offered optimal and balanced level of control and autonomy for his [sic] own learning process' (Nussbaumer et al, 2015). Learning technologies have a critical role to play (Fitzgerald et al, 2017) yet in digital systems the mechanism by which guidance is determined often remains opaque to the learner. In particular, it may be unclear what role a teacher, and more specifically 'their' teacher, had in crafting and mediating the guidance.

A central challenge to achieving meaningful personalisation is how best to capture teacher expertise and represent this to the learner. Early Learning Design research sought ways to codify past pedagogic design experience and teaching context within the IMS-LD framework (Sicilia, Sanchez-Alonso & Garcia-Barriocanal, 2006; Strobel et al 2008) whilst research into the graphical visualisation of learning design (Brasher et al, 2015) highlighted the need to not only capture but make visible and represent 'teaching intent and purpose' (Cross 2010). Presenting and explaining teaching intent is an aspect of personalisation lacking in many intelligent tutor systems or recommender systems. A learner may be told what learning activity or resources to consult next, perhaps even given some choices, but seldom is there an articulation as to *why* these choices are being presented.

3. Design and Approach

3.1 Pilot Module

The intervention described in this paper was piloted in one of the twenty teaching weeks of a postgraduate course in the OU's MA in Online and Distance Education. This course was launched in 2017 and is run annually. The pilot intervention took place midway through the module and replaced the original standard linear sequence of learning activities. The Open University is the largest distance learner provider in the UK and adopts a supported open learning model of teaching. Entry to truly open to anyone regardless of prior educational attainment and background. At present, the structure of most modules continues to follow a single path that must somehow be designed to satisfy as many students as possible with individual support provided in a variety of ways such as tutor feedback on assessments. A central component of OU teaching is the VLE which is used to deliver high-quality teaching and learning materials and provide access to digital resources and learner support. The focus of the pilot is one key element of the e-learning experience - the Study Planner. This tool provides a central place for learners to view their weekly programme of learning and assessment.

3.2 Design Goals

Twelve key design goals were developed to help guide the implementation of the pilot (Table 1). These goals underscore how the pilot was serving a dual purpose – to deliver benefits to module teaching and learning and to deliver strategic benefits to the university.

Table 1: Design Goals

Teaching and learning goals	Institutional goals
1. To increase student sense of control and ownership of their learning by allowing the student choice in their preferred pathway 2. To improve student engagement and motivation 3. To make visible aspects of the learning design	1. To help module teams better deliver differentiated learning that recognises not all students require, or want, the same learning path through a topic 2. To find a low-cost high-impact solution for delivering differentiation that can be actioned

and *teaching intention* to students 4. To allow the student to switch freely between choices at any point or re-step over the same learning with, for example, increasing difficulty, challenge or emphasis 5. To heighten student perception that modules are providing for their needs – i.e. providing more personalised learning 6. To deliver a more appropriate pedagogic fit by offering an option(s) that better fall within a students' current zone of proximal development	today within the existing system architecture without the need for further software 3. To find a teaching technique that can be retrofitted to existing modules without a costly complete module redesign. 4. To increase institutional understanding about what choices students expect and need, and how they want them presented. 5. To determine potential benefits to learner engagement, retention, sense of value for money and satisfaction 6. To find ways of making the online Study Planner in the VLE more interactive and agile such that learners use it more for organising their study

3.3 Implementing student choice of learning pathway in Moodle

The pilot sought to create an integrated user experience where learners are first given information about and asked to select one of the two learning pathways offered and then, according to this decision, are shown relevant learning resources in their online Study Planner. Each pathway consisted of three activities (4.5 hours of learning) and that re-combined for the remaining activities in the week (6 hours). The activities in each pathway differed in their assumed level of prior knowledge of statistics – the intermediate pathway assumed greater prior knowledge than the basic path.

Figure 1 is an excerpt from the week's 'Learning Map' and shows the two paths in pink (left) and purple (right). Whilst the activities may have similar titles, it is important to note that what the student is asked to do differs. The Learning Map was a second innovation piloted in the module. Each map summarises a week of learning in a graphic that fits on a single page of A4. A timeline runs from top to bottom and shows: (1) the order and length of each learning activity and linking texts, (2) resources associated with each activity (rated essential=black, optional=green and user generated=white), (3) points at which the learner needs to be connected to the internet (for V=video streaming, C=online forum and other communicative activities, S=search activities, etc.), and (4) titles and short description of each activity. The design builds on earlier research (Brasher, 2015; Cross et al, 2012; Cross, Clark & Brasher, 2009). For the purposes of the pilot, the Learning Map was intended to help learners visualise the pathway options.
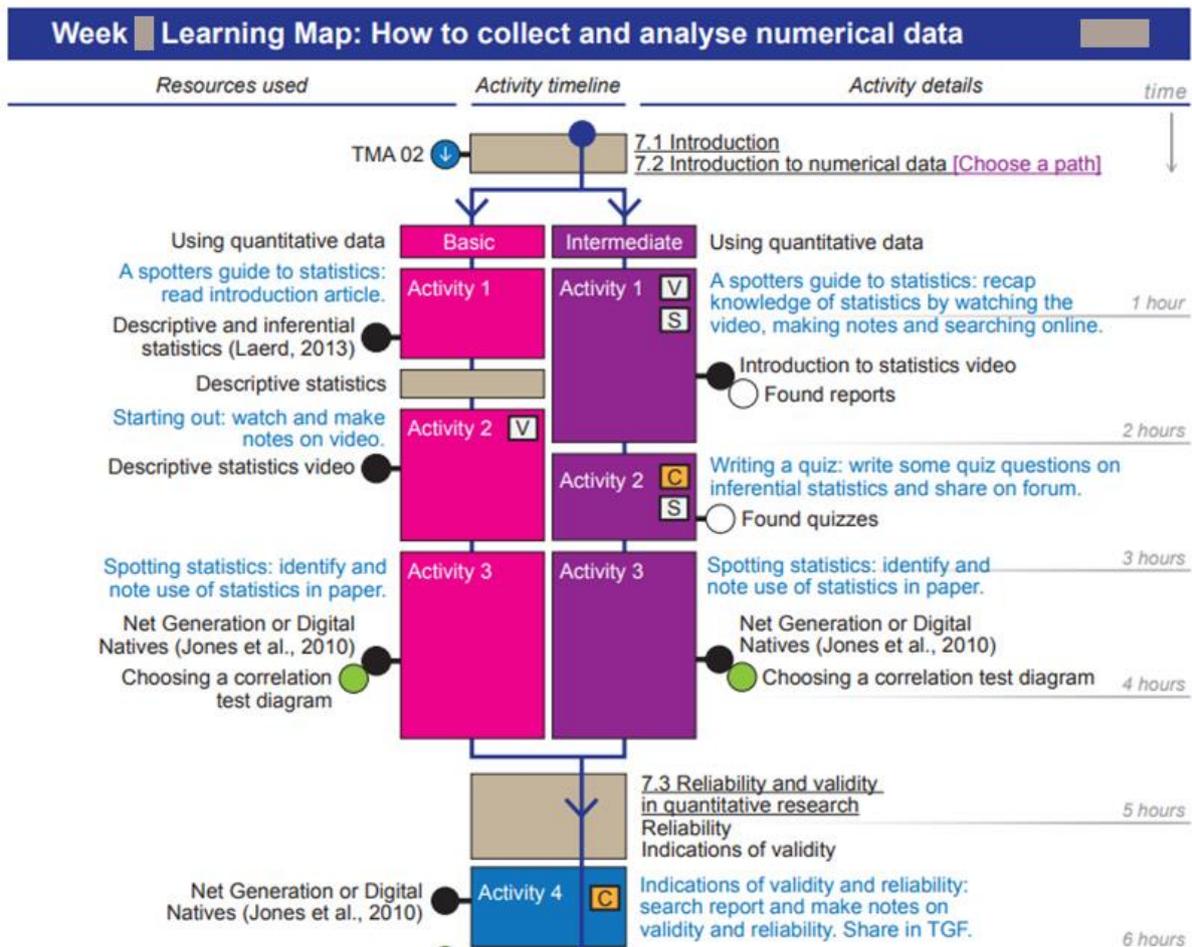
Figure 1: Excerpt from the Learning Map of relating to the week of the pilot

Building the pilot intervention in the VLE made use of the Conditional APIs in Moodle including, more specifically, functionality relating to Student Options. Experimentation in a 'sand-box' version was required to determine the most appropriate settings.

Building the 'student choice' interaction required two steps. Firstly, a Student Option item is added to the course as a separate 'page' (see tabs in Figure 2). The student choice item/page permits the learner to set one (or more) conditions and save these preferences to the system. In our design (Figure 2), condition setting was presented as a choice between condition 1 (basic path) and condition 2 (intermediate path). Several iterations of the introductory text were tested with colleagues. In particular, it was felt important to include text to reassure the learner that both paths should adequately prepare them for learning activities later in the week, that they retained control of the pathway selection and could switch at any time, the rationale for offering two paths, and a default or recommended path (for learners disinterested in or unwilling to make the choice themselves).

The second step was to add the learning resources and activities for each pathway to the Study Planner but to make their visibility conditional of the choice of the learner (the choice made in step 1). Only learning resources relating to the conditional state will be displayed and neither will be displayed *until* the learner makes a selection (sets the condition). In our case, only resources relating to one or other of the learning paths were shown, the other was hidden. Moodle will permit much more complex responses (such as selecting multiple conditions) however, as this was an initial trial of this functionality, a simple binary choice was offered.

Figure 2: The pathway choice page slots in between other pages in Week 7 on the VLE

This process used existing functionality and no system development was required. Indeed, one aim of the project was to determine whether personalised differentiated learning could be delivered effectively within the capabilities of our existing technologies. Rather than focus on technical challenges, the pilot was able to focus on the pedagogic and design related challenges instead.

3.4 Learner feedback

All learners studying the 2017 and 2018 presentations of the pilot module were invited to answer a questionnaire about the educational technologies used. This was intended to serve a dual purpose: to support student reflection on the effectiveness of the technologies and to provide feedback to the teaching team. The questionnaire asked about the Student Choice pilot and six other teaching tools used including tutor group forums, live seminars, weekly reflection points, and learning design maps (see earlier). Twenty students responded to the questionnaire over the two years. This represents a response rate of 24%.

4. Results

Students were overwhelming positive about being given a choice of learning activity pathways (Table 2). In response to four questions probing RQ1, 95% of respondents liked being given a choice between a basic and intermediate path, 90% felt this gave them a sense of control over their learning and 90% agreed that that in choosing a path they felt the materials were better tailored to their needs. Furthermore, 90% of respondents

agreed that the university should aim to use this technique in other modules. Informal feedback from one of the module tutors corroborated that the majority of students responded favourably to having a learning choice. Only one student disagreed with some of the statements (Table 2) however, even they agreed the process of choosing the path was clear, that they liked having the choice and that the university should use this elsewhere.

Table 2: Student feedback about the implementation of the Student Choice tool (n=20)

	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree
I liked having a choice between a basic and an intermediate path	85%	10%	5%	-	-
Choosing a path gives me a sense of control over my learning	60%	30%	5%	-	5%
By choosing a path I felt the materials were better tailored to my needs	65%	25%	5%	-	5%
The university should use this technique in other modules	65%	25%	10%	-	-
The process of choosing a path was clear	90%	10%	-	-	-

All respondents agreed that the process for choosing a path as implemented by the pilot was clear (100%). This helps to confirm that no learner was disadvantaged by the approach and that in general it worked well (despite a relatively basic implementation on the university's VLE). Open-comment data relating to the presentation of choice and option of pathways (RQ2) confirms this. One student wrote 'I think it was clear and easy to follow. I liked the option to switch between the basic and intermediate path – and at no point felt that I was 'trapped' with no option to return.' The freedom to take a 'step-back' – to do one pathway and then another – was mentioned by two students. One student liked the idea that 'after completing one path, [I] have the option (time permitting) to go to the other path, particularly where it is a basic – intermediate – advanced structure.' Another student explained that the learning maps were a useful companion:

> 'I chose to do both paths as I wanted to see what the difference was… and to see at [what level] my knowledge [was]. Do you remember the Steve Jackson adventure books? It's a bit like that. I thought the design maps were very useful and would appreciate having a copy of them at the beginning of each week.'

For another student, the pilot intervention helped expose the implicit assumptions regarding how differentiation is expected to occur in current learning activity design:

> 'the [intervention] is an effective way to apply differentiation and makes me realise that this is an essential teaching skill that has not been applied to all activities. Rather, [in other activities] it has been assumed [students] would all work at their own level or would [themselves] adapt the activity.'

Not all students had time to complete both paths. For example, one student reported having done some maths, but not statistics, and therefore opted for the intermediate choice which they subsequently found 'fiendishly difficult.' In this case, the student may have benefited from a greater level of guidance and perhaps also a more careful reading of the guidance (as the advice given did state that intermediate was for those 'more confident in maths *and* statistics').

Two students noted that in some cases more information, such as a preview of the pathways, may be useful to help inform the choice. This would suggest that Learning Maps could be made more prominent at the point of decision-making. Across the module in general, opinion was split with respect to the utility of Learning Map visualisations. Around half (55%) had used them, and a similar proportion (60%) agreed that they were helpful to their learning and that the university should use this technique elsewhere.

Other suggestions to make the decision-making process easier included (1) presenting or signposting the choice in good time, (2) creating overlapping activities relevant to 'pass', 'merit' and 'distinction' levels and allowing learners to join the sequence at any point, (3) providing clear pedagogic rationale, and (4) stressing that the teaching decision to offer a choice of options is a positive step so as to avoid giving the impression that "the learning designers lacked confidence in what we should be learning.'

Student comments sometimes revealed quite opposing views. For example, one student saw potential in pathways for helping them save time (by providing tailored paths for time-poor learners) whilst another student was concerned that pathways would increase their workload because they would feel compelled to study all paths so as not to 'miss anything.' In another example, whilst the majority of learners recognised the teaching and learning value in designing differentiated activities because student experience 'vary[s] quite a bit,' one student said they were concerned that providing choice, differentiation and 'allowing students to tailor content to their ability [was] a bit of a copout.'

Students also offered suggestions for how different pathways through learning activities could help improve the learning experience. This feedback gives an indication of the potential pathway design 'types' that learners may be looking for from their teachers (RQ4). Students suggestions included: (1) catering for different abilities, (2) providing a better fit with learners' previous knowledge and experience, (3) catering for different interests and level of interest in a topic, (4) offering supporting activities for those struggling to complete an activity or who lack confidence, (5) filling gaps in key areas of skills or knowledge when learners first enter study at university, (6) offering short-cuts for learners short of time, (7) testing different teaching approaches to the same content, and (8) varying questions or scenarios depending on job role or sector.

5. Conclusion

The findings of this pilot study indicate that learners are receptive to and positive about being offered a choice of learning activity paths (RQ1). Almost all learners said that they (1) liked having a choice, (2) that the approach used in the pilot had improved their sense of control, (3) that in choosing a path they felt the materials were better tailored to my needs, and (4) supported the proposal that the university use this approach more widely.

Learners felt that the implementation used in the pilot was clear and made suggestions about how to articulate and present the choices available (RQ2). One such articulation trailed in the pilot itself was a purposely designed Learning Map visualisation. Just over half the learners used the maps and found them helpful. This was expected because not all students or staff are necessarily receptive to visualisations of learning activities (Cross, Clark & Brasher, 2009) although this could be mitigated with training to build confidence and competence in the use of visual representation.

The pilot achieved its aim to find a low-cost means of delivering differentiated learning and student choice using existing VLE functionality (Moodle's conditionality APIs and associated tools). Setting this up on the VLE was relatively quick (although a reasonable amount of effort was spent initially to work out *how* to implement the approach) meaning that the majority of the effort in implementation was expended on the process of learning design (i.e. to properly design the parallel pathways) and producing learning product (the additional content and learning activities) (RQ3). Some technical improvements in the Moodle user interface would further help improve the learner experience.

The approach raises new learning design challenges such as ensuring all pathways adhere to good design practices (such as alignment with learning outcomes) and that the user experience (such as leaving and returning to the 'single' path) is handled well (RQ4). Yet designing differentiation may also be liberating. For example, saving teachers from feeling constrained to a 'one-size-fits-all' approach when they are aware this will put some learners at a disadvantage, or feeling frustrated that having to 'cover' all possible gaps in prior knowledge or skills in their main teaching will result in an experience that may seem unengaging or poor value for some learners. The pilot developed twelve design goals which, with context-specific adaption, could provide a useful framework for guiding the development of differentiated personalised learning within a VLE context.

Potential applications for offering learners a choice in learning activity pathways include: (1) parallel differentiated pathways that better challenge curious or higher ability students or that better support low ability students, (2) additional, targeted activities for learners who have insufficient prior knowledge or a skills gap without interfering with the learning paths of other students, (3) confidence-building and reinforcement such as quizzes or experiential learning activities, (4) induction pathways for multi-disciplinary students who are unfamiliar with the disciplinary approach or the particular online or distance teaching adopted by the module, (5) pathways that require less or more effort so that learners can better flex their weekly study around changing demands from personal, professional or voluntary commitments, (6) alternative teaching models where each pathway adopts a different pedagogic approach such as a path that utilising collaborative learning and a second focused on situated learning. This latter approach would also be useful for the testing and evaluating new learning designs or teaching innovation.

In summary, designing for parallel, alternative, auxiliary and challenge learning pathways – be these short micro-pathways or of greater reach across a module – continues to offer opportunities to increase the learner perception that they are receiving a more personalised learning and the ability of teachers to design and deliver learning that is better differentiated and relevant to their students.

Acknowledgements

References

Brasher, A. and Cross, S. (2015) "Reflections on developing a tool for creating visual representations of learning designs: towards a visual language for learning designs". In: Maina, Marcelo; Craft, Brock and Mor, Yishay eds. *The Art and Science of Learning Design.* Technology Enhanced Learning (9), Sense Publishers, Rotterdam, pp 169–180.

Bodily, R. and Verbert, K. (2017) "Review of Research on Student-Facing Learning Analytics Dashboards and Educational Recommender Systems", *IEEE Transactions on Learning Technologies,* Vol. 10, No. 4, pp 405–418.

Boelens, Voet and De Wever (2018) "The design of blended learning in response to student diversity in higher education: Instructors' views and use of differentiated instruction in blended learning", *Computers & Education*, Vol. 120, pp 197–212.

Brusilovsky, P. & Vassileva, J. (2003) "Course sequencing techniques for large-scale webbased education", *International Journal of Continuing Engineering Education and Lifelong Learning*, Vol. 13, No. 1/2, pp 75-94.

Carola, M. (2011) "Learner Agency", *European Educational Research Journal*. Vol. 10, No. 4, pp 559–571.

Cross, S. (2010) "Lattice Model of the Designed Learning Problem Space", webpage. Available at: https://latestendeavour.wordpress.com/lattice-model/

Cross, S., Clark, P., and Brasher, A. (2009) "Preliminary findings from a series of staff surveys on perceptions, attitudes and practices of learning design", *ALT-C 2009 Conference*, 8-10 September 2009, Manchester, UK.

Cross, S., Galley, R., Brasher, A. and Weller, M. (2012) *OULDI-JISC Project Evaluation Report: the impact of new curriculum design tools and approaches on institutional process and design cultures.* OULDI Project (Open University). Available at: http://oro.open.ac.uk/34140/

Cross, S., Sharples, M., Healing, G. and Ellis, J. (2019) "Distance Learners' Use of Handheld Technologies: Mobile Learning Activity, Changing Study Habits, and the 'Place' of Anywhere Learning", *International Review of Research in Open and Distributed Learning*, Vol. 20, No. 2, pp 224–241.

Dimtrova, V. and Brna, P. (2016) "From Interactive Open Learner Modelling to Intelligent Mentoring: STyLE-OLM and Beyond", *International Journal of Artificial Intelligence in Education*, Vol. 26, pp 332–349.

FitzGerald, E., Kucirkova, N., Jones, A., Cross, S., Ferguson, R., Herodotou, C., Hillaire, G. and Scanlon, E. (2017) "Dimensions of personalisation in technology-enhanced learning: a framework and implications for design", *British Journal of Educational Technology*, Vol. 49, No. 1, pp 165–181.

Gordon, N. (2014) *Flexible Pedagogies: technology-enhanced learning*, HEA, York.

Karampiperis, P. and Sampson, D. (2005) "Adaptive learning resources sequencing in educational hypermedia systems", *Educational Technology & Society*, Vol. 8, No. 4, pp 128-147.

Nussbaumer, A., Hillemann, C., Gütl, C. and Dietrich, A. (2015) "A Competence-based Service for Supporting Self-Regulated Learning in Virtual Environments", *Journal of Learning Analytics*, Vol. 2, No. 1, pp 101–133.

Office for Students (2019) *National Student Survey*. Accessed 1 June 2019 from: https://www.officeforstudents.org.uk/advice-and-guidance/student-information-and-data/national-student-survey-nss/

Sicilia, M.-A., Sanchez-Alonso, S., and Garcia-Barriocanal, E. (2006) "On supporting the process of learning design through planners", *Virtual Campus 2006 Post-proceedings, Selected and Extended Papers*, pp 81-89.

Strobel, J., Lowerison, G., Cote, R., Abrami, P.C., and Bethel, E.C. (2008) "Modelling Learning Units by Capturing Context with IMS-LD". In Lockyer, L., Bennett, S., Agostinho, S. and Harper, B. (Eds.) *Handbook of Research on Learning Design and Learning Objects*, ISR.

Universities UK (2018) *Higher Education Facts and Figures 2018*, Universities UK, London. Available at: https://www.universitiesuk.ac.uk/facts-and-stats/data-and-analysis/Documents/higher-education-in-facts-and-figures-2018.pdf

Verbert, K., Drachsler, H., Manouselis, N., Wolpers, M., Vuorikari, R. and Duval, E. (2011) "Dataset-driven research for improving recommender systems for learning", *Proceedings of the 1st International Conference on Learning Analytics and Knowledge*, ACM, New York, USA, pp 44-53.

Wanner, T., & Palmer, E. (2015) "Personalising learning: Exploring student and teacher perceptions about flexible learning and assessment in a flipped university course", *Computers & Education*, Vol. 88, pp 354–369.