Dimensions of personalisation in technology-enhanced learning: a framework and implications for design

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Abstract

Personalisation of learning is a recurring trend in our society, referred to in government speeches, popular media, conference and research papers and technological innovations. This latter aspect – of using personalisation in technology-enhanced learning (TEL) – has promised much but has not always lived up to the claims made. Personalisation is often perceived to be a positive phenomenon, but it is often difficult to know how to implement it effectively within educational technology.

In order to address this problem, we propose a framework for the analysis and creation of personalised TEL. This paper outlines and explains this framework with examples from a series of case studies. The framework serves as a valuable resource in order to change or consolidate existing practice and suggests design guidelines for effective implementations of future personalised TEL.

Keywords

Personalisation, customisation, adaptation, TEL, framework, dimensions, design.

Introduction

Personalization is a key topic of current interest in technology-oriented learning design and discussion for government policy makers, but less so in educational research. This paper develops a framework to support the design of technology-enhanced learning (TEL) resources and environment.

Key aspects of personalisation

The NMC Horizon Report Europe 2014 Schools Edition (Johnson et al., 2014) identified personalised learning as one of the emerging technologies likely to have an impact on teaching and learning in European schools within four to five years' time and the 2015 'Innovating Pedagogy' report lists personalisation as one of the six key overarching themes that are likely to make major impact on educational practice in the next ten years (Sharples et al., 2015). Core components of personalisation in education have been defined by much literature surrounding non-TEL based learning support, i.e. usually in compulsory/formal and classroom-based education. For example, the UK government's DfES (Department for Education and Skills) proposed five aspects to personalised learning: assessment for learning; teaching and learning strategies; curriculum entitlement and choice; a student-centred approach to school organisation; and a strong partnership beyond the school (Pollard & James, 2004, p. 5). Hargreaves amplified these to include nine 'gateways', which added a further four items, including new technologies; workforce development; advice and guidance; and mentoring and coaching (Hargreaves, 2004).

However, the literature offers little to suggest how personalisation might occur in strictly TEL environments. One exception is from Martinez (2002), cited in Hummel *et al.* (2004). She presents five components of personalisation achieved through TEL, in levels of increasing sophistication: name recognition; self-described personalisation; segmented personalisation; cognitive-based personalisation; and whole-person personalisation. However,

this model is fairly limited in considering the wide range of factors that impact upon learning and only really considers the individual, rather than referring to broader contextual aspects that impact upon learning such as collaboration (with peers/tutors), formal/informal/non-formal learning; resources/content, how personalisation is applied, etc. For those studying or implementing personalisation in TEL, what is needed is an understanding of how personalisation can be enacted through these different contexts, together with clear examples.

Dimensions of personalisation and framework generation

We have attempted to categorise different aspects of teaching and learning in TEL that can be implemented through personalisation. This categorisation process was carried out by two experienced TEL researchers conducting a careful scrutiny and conceptual analysis of the published literature of personalisation in TEL in the last decade and independently classifying the different aspects found, before discussing the overlap. From this, a framework was developed that classifies different dimensions of personalisation in TEL, with the aim of understanding how to apply personalisation in TEL and how it can be effective for learners and other stakeholders. This grounded approach examined carefully the published literature, resulting in a heuristic and iterative development of the dimensions through a conceptual analysis, with multiple cycles to ensure full coverage of the emerging themes and to ascertain full analysis of the literature/projects examined. These aspects are exemplified in further detail in Table 1 below. We focus upon:

- What is being personalised
- The type of learning where personalisation occurs
- What personal characteristics of the learner may be addressed
- Who/what is doing the personalisation
- How is personalisation carried out
- The impact/beneficiaries of the personalisation.

The creation of these themes were initially based upon the aforementioned work of Hargreaves (Hargreaves, 2004) and the UK government's DfES (Pollard & James, 2004, p. 5). However, since these categorisations refer only to non-TEL environments, we needed to modify and extend them in order for them to have relevance to TEL. To date, we have found almost no frameworks that reference the TEL perspective. Martinez's work (2002), cited previously, was useful but only considered one dimension, namely *how* personalisation is carried out. This emphasizes the contribution of this paper: the generation of a new framework for use primarily by, and for, the broader TEL community.

The framework itself does not imply any particular theoretical basis, but as noted by Sampson et al. 2002, the idea of personalised learning builds mainly on cognitive and constructivist theories of learning (Sampson, Karagiannidis, & Kinshuk, 2002). In describing a 'stronger' version of personalisation, Campbell et al. (2007) refer to the foundational work of Leadbetter (2003) and the aspiration to encourage children to be more involved in making decisions about what they learn and how. Following a case study of personalisation in the education of gifted and talented students, they note that it is a collective activity and that such pedagogy is not new, but is constructivist learning, derived from Vygotskian social theory (Vygotsky, 1978). These theoretical stances emphasize the social and constructivist aspects of personalisation and the need to examine learning from a number of different perspectives. The themes in the framework that follows, are briefly described below:

Dimension 1 - What is being personalised?

This refers to the resources being utilised by the learner and examines where personalisation might occur. Note that content can be personalised through learner choice or explicitly stated via the exam board syllabus being followed (i.e. it is not always teachers directing content personalisation).

Dimension 2 - Type of learning

Here, learning is viewed as formal, non-formal or informal. Formal learning occurs within institutional contexts, e.g. schools, is usually assessed, and formally taught. Non-formal learning refers to structured learning outside such institutions, such as programmes developed by organisations such as the Girl Guides, or museums, whilst informal learning is typically learner directed, under learner control and does not usually involve a teacher.

Dimension 3 - Personal characteristics of the learner

Here we look at what aspects of the learner may be utilised to provide personalisation.

Dimension 4 - Who/what is doing the personalisation

This aspect addresses the control of personalisation – who or what is ensuring that personalisation of learning occurs?

Dimension 5 - How is personalisation carried out?

This dimension considers how personalisation is enacted in the learner experience, from some fairly basic mechanisms (e.g., name recognition) to more sophisticated processes that take into account cognitive aspects and/or affective elements such as the learner's emotional states. These elements are based upon the work by Martinez (2002), cited in Hummel *et al.* (2004). *Name recognition* is when learners are acknowledged personally. *Self-described personalisation* is where a learner's preferences or attributes described by e.g. a prior questionnaire, providing the basis for options or instructional experiences. S*egmented personalisation* is where groups of people with similar attributes receive content relevant to that group. In *cognitive-based personalisation*, content or resources are presented differently based upon cognitive models or 'learner profiles' of the user that update – or are updated – as the learner progresses. These cognitive models may include how information is presented (e.g. a summary followed by the details or *vice versa*), or media formats (listening to audio information rather than reading the equivalent text). *Whole-person personalisation* explores how learner motivations and emotions combine with analytics to suggest optimal delivery of learner resources in real time. Martinez describes how the system 'learns' and adapts, based

on regular updating of a dynamic learner model, along with pattern analysis and comparison with other learner responses and data on a larger scale. Our framework focuses primarily on individual learning but we have also included ‘organisation of resources’ to suggest how this may happen at an institutional level.

Dimension 6 - Impact/beneficiaries

This aspect examines who stands to benefit from personalisation of learning and refers to different levels of impact from micro (i.e. the individual) to macro (i.e. organisational).

Table 1: Framework for modelling dimensions of personalisation in TEL

Dimension 1: What is being personalised?	**Dimension 2: Type of learning**	**Dimension 3: Personal characteristics of the learner**	**Dimension 4: Who/what is doing the personalisation**	**Dimension 5: How is personalisation carried out?**	**Dimension 6: Impact/beneficiaries**
• Content • Assessment • Teaching and learning strategy (e.g. group work; individual; peer learning) • Learner choice (e.g. of resources, topics or mode/approach of study) • Teacher choice (e.g. curriculum choices or ordering of curriculum)	• Formal (e.g. compulsory, primary, secondary etc) • Non-formal • Informal	• Demographic (e.g. age, cultural background) • Prior knowledge (e.g. based on recent assessment scores) • Self-assessed knowledge (by teacher or learner) • Demonstrated interests or personal relevance (e.g. could feed into learner profile) • Preferred mode of learning e.g. distance, online, evening classes • Level of learner commitment/motivation and self-regulation	• Learner • Teacher • Peer • Computer software and/or algorithms	• Name recognition • Self-described personalisation • Segmented personalisation • Cognitive-based personalisation • Whole-person personalisation (affective elements) • Organisation of resources	• Learners • Teachers • Trainers and training providers • School/organisation • Government (local or national level) • Commercial entities e.g. software developers

In the next section, we consider case studies of personalisation in TEL environments and use the framework both as an analysis tool and to identify the potential for further work.

Case studies: Personalisation in TEL

In this section, we apply the framework to help evaluate existing examples of TEL, We chose six case studies, based on our review of literature and our own work. The selected six examples are thus a reflection of our familiarity with the individual areas of learning and their salience in the TEL literature:

- Intelligent Tutoring Systems (ITS) and Adaptive Educational Hypermedia (AEH)
- Adaptive assessment
- Science inquiry learning
- Gaming and informal learning
- Learning analytics
- Personalised books

Intelligent Tutoring Systems (ITS) and Adaptive Educational Hypermedia (AEH)

Much work in personalisation in TEL addresses the 'cognitive-based personalisation' aspect of Martinez's model, explored through Intelligent Tutoring Systems (ITS) and Adaptive Educational Hypermedia (AEH). There are many similarities between these two types of systems, which evolved in parallel in different disciplines: ITS have arisen from psychology/AI research whereas AEH originates from computer science.

Both these systems include reference to a "learner model" or profile, containing information about the learner (Kay, 1997) which is the basis for personalisation, e.g. differentiation. For example, if a learner has not studied a particular topic, they may be classed a beginner, and only shown introductory material. Alternatively they may be provided

with more intermediate or advanced materials, depending on their existing knowledge and expertise (see e.g. Chen, 2011). The goal of such systems is to provide synchronous updating of the user model as the learner engages with the system. Thus the personalisation mechanism continuously provides the learner with resources most suited to when they are using the system. However, this synchronicity is not always achieved in real time and may require direct input from the learners through e.g. answering follow-up questionnaires (in addition to an initial one when first logging in to the system), or testing their knowledge through an online quiz.

Personalisation can occur through adaptive links (different links), adaptive content or adaptive presentation of resources (e.g. different colour schemes, designs or website navigation) (Brown, Brailsford, Fisher, & Moore, 2009). ITS and AEH fit into the following dimensions:

Table 2: Personalisation dimensions in Intelligent Tutoring Systems (ITS) and Adaptive Educational Hypermedia (AEH)

Dimension 1: What is being personalised?	Dimension 2: Type of learning	Dimension 3: Personal characteristics of the learner	Dimension 4: Who/what is doing the personalisation	Dimension 5: How is personalisation carried out?	Dimension 6: Impact/beneficiaries
Content, navigation, links and visual design	Formal	Emphasis on prior knowledge (e.g. based on recent assessment scores)	Carried out by computer software, sometimes based on information inputted by the learner e.g. response to a questionnaire	Tends to be cognitive-based personalisation	Learner (most direct impact) but could also be the teacher if savings can be made in terms of time and costs devoted to developing differentiated teaching materials

ITS/AEH systems are often implemented through computer algorithms in formal educational settings. Clear gaps in research therefore could relate to informal and non-formal settings, and/or where personalisation – to some level – could be influenced by the learners themselves.

Adaptive assessment

Computerised adaptive testing (CAT) is a form of computer-assisted assessment that uses item response theory to adapt the level of difficulty of a test to the respondent's proficiency, knowledge or skills. Questions are commonly selected from item pools and adaptive testing, adaptive grading, and adaptive self-referenced testing is used for determining achievement levels (Lord, 1980). In 2014 it was estimated that 30,000 schools in the United States use some form of adaptive tests (Kingsbury, Freeman, & Nesterak, 2014). Advocates suggest that adaptive tests are as accurate as other tests and can provide immediate information to students and teachers so as to adjust instruction. However, challenges include ensuring schools have sufficient technical infrastructure in place, item exposure, speed of selection from the pool and using the proficiency level estimates to effectively support learners' individual development (Huang, Lin, & Cheng, 2009).

Delivering adaptive feedback is another challenge for adaptive assessment. Such adaptation focuses on the feedback, or the feed-forward, delivered to the learner. This is especially important in Higher Education where learners are more autonomous and yet resources for providing detailed formative feedback may be limited. At the UK's Open University, an interactive computer marked assessment (iCMA) initiative comprised a number of projects in Science, Mathematics and Computing subjects which focussed on how to provide adaptation in the assessment questions and how to deliver adaptive feedback specific to the answer given. For example one project sought to mark free-text answers of around a sentence in length and then provide tailored feedback to students on incorrect or incomplete answers. (Jordan, Brockbank, & Butcher, 2007).

It has been suggested that the distinction between learning and assessment has become blurred because learning analytics can be used to perform assessments in real time as learners demonstrate mastery of important concepts or ideas (Long & Siemens, 2011).

Indeed, as greater emphasis is placed on assessment analytics (Ellis, 2013) and learning designs seek to better integrate assessment and learning, it may become harder to differentiate adaptive assessment from the nuances of adaptive learning more generally.

Adaptive assessment can thus be categorised according to our framework as follows:

Table 3: Personalisation dimensions in adaptive assessment:

Dimension 1: What is being personalised?	Dimension 2: Type of learning	Dimension 3: Personal characteristics of the learner	Dimension 4: Who/what is doing the personalisation	Dimension 5: How is personalisation carried out?	Dimension 6: Impact/beneficiaries
Assessment and feedback (or 'feed-forward' to students)	Formal	Adapts to the respondent's existing proficiency, knowledge or skills in a subject area	Computer software and/or algorithms	Name recognition Self-described personalisation	Learners (to aid learning and in providing immediate feedback) Teachers/instructors, as screening of students, can provide essential information to help adjust instruction

There are clear gaps in informal and non-formal situations, although as assessment tends to be linked to formal education, this is perhaps not surprising. Future adaptive assessments might take in other aspects of Dimension 5, so more sophisticated personalisation mechanisms may involve whole-person personalisation and affective/emotional elements.

Personalised science inquiry learning

The Personal Inquiry (PI) project, (http://www.pi-project.ac.uk) aimed to support *personal* student inquiry projects. The project supported children in investigating scientific issues that affect their lives, in the classroom, on field trips and in their homes and identified three aspects of personalisation: personal relevance, choice and learner responsibility (Scanlon, Anastopoulou, & Kerawalla, 2012). The children's investigations were supported by open source software called 'nQuire': a form of 'scripted inquiry learning' developed in the project, which guided the children through planning and carrying out their investigations,

collecting, analysing and presenting their data and discussing their results. The software can run on mobile devices or be downloaded onto a USB data stick – and so could support the children's inquiries wherever they were based.

Seven inquiries were conducted and carried out in the school, in the field and at other sites, with topics including heart rate and fitness, sustainability, and noise pollution. Students decided on their questions, what data to collect and how to collect it and represent it. However, in practice, student choice was limited due to practical constraints and some students did not perceive the inquiries to be personally relevant. An alternative set of inquiries, which students conducted in the less formal context of an after school club, allowed students much greater choice over the inquiry. These were rated more highly and perceived as more personally relevant. Additionally, the students' sense of responsibility also led to them checking their data and making innovative suggestions.

When reflecting on the dimensions of the framework, science inquiry learning falls under the following categories:

Dimension 1: What is being personalised?	Dimension 2: Type of learning	Dimension 3: Personal characteristics of the learner	Dimension 4: Who/what is doing the personalisation	Dimension 5: How is personalisation carried out?	Dimension 6: Impact/beneficiaries
Content Learner choice Teacher choice	Formal and non formal	Demonstrated interests or personal relevance	Learner Teacher	Organisation of resources	Learners Teachers

Personalisation here is as much human-centred as computer-based, with learners and teachers playing key roles in terms of what was being personalised and who carried it out.

However, the software was key in supporting the children in their inquiries, especially when they worked at home without access to teachers.

Gaming and informal learning

Informal learning through interaction with digital games (Iacovides, Aczel, Scanlon, Taylor, & Woods, 2011), can include learning about historical events, different cultures or simulations such as those in serious games (de Freitas & Maharg, 2011). Personalisation may take the form of content tailored to the gamers' needs or user-initiated customisation (Monk & Blom, 2007).

The personalisation agent is often the system itself, collecting certain types of learner information and delivering content according to who the learner is at a given time. In some games, the choice of content and resources is up to the user. The system creates and presents a range of potential options for play, and the user (individually or in collaboration with others) acts upon that content and decides how to play. The choice of gameplay tends to be directly related to the psychological profile of the gamer. Gamers make choices that accord with their emotion-related personality characteristics; for instance, more socially oriented individuals tend to choose highly social forms of gameplay and vice versa (Herodotou, Kambouri, & Winters, 2011).

Stealth assessment games (Shute, 2011) refer to the ongoing gathering of performance data during gaming which is used to improve instruction and self-reflection. They blur the boundaries between assessment and gaming by being seamlessly interwoven with game design so as not to disrupt immersion in gaming.

Another example is affective gaming, where the emotional states of the user is captured by physiological measurements, the situations that trigger certain emotions (e.g., winning or losing) and the users' behaviour when an emotion is experienced. Affective user

modelling can model the emotional profile of a gamer and adapt gaming accordingly in order to achieve certain behaviours (Hudlicka, 2008). One such example is the relax-to-win game (Bersak et al., 2001), where emotional information is collected from the players' galvanic skin responses (sweat) and used to control a dragon in a racing game. A winning situation is one where the gamer controls their emotions and remains relaxed. Similar approaches have been used in designing games for children with special needs such as autism (e.g. De Silva, Higashi, Lambacher, & Osano, 2007).

Informal learning through games can be exemplified thus:

Table 5: Personalisation dimensions in informal learning and gaming:

Dimension 1: What is being personalised?	Dimension 2: Type of learning	Dimension 3: Personal characteristics of the learner	Dimension 4: Who/what is doing the personalisation	Dimension 5: How is personalisation carried out?	Dimension 6: Impact/beneficiaries
Content; resources Learner choice	Mostly informal; some gaming may take place in formal settings however	Demographic (e.g. age, cultural background) Prior knowledge Demonstrated interests or personal relevance Preferred mode of learning (with others, or on an individual basis)	Learner Computer/gaming software and algorithms	Cognitive-based and whole-person personalisation	Learners Teachers/instructors Commercial entities (games developers)

Given the informal nature of gaming, teachers/instructors are less emphasised in this case study. However, where it occurs in formal settings, some game mechanics and processes can help inform teachers about the behaviour and progress of their students. This is the only case study where the impact of personalisation also influences – and is influenced by – game designers and highlights the clear need for partnerships between academia and industry.

Learning analytics

The field of learning analytics, used to provide personalised feedback and support, has been described as sitting at a crossroads between technical and social learning theory fields (Siemens & Gasevic, 2012). An example of this intersection is from Nussbaumer et al (2015), who looked at how Competence based Knowledge Space Theory (CbKST) relates to an Open Learner Model (OLM) of student understanding. CbKST states that knowledge can be mapped into a hierarchy, thus providing personalised learning paths. Nussbaumer et al. (2015) explored how exposing the Open Learner Model to the learner themselves (for the purposes of meta-cognition in learning) can provide personalised displays so that they can navigate through the learning material themselves.

Those working in personalisation know that there are many factors beyond knowledge mapping, such as learner affect, that could help create a more effective model of the learner (Baer, Norris, Hill, & Brodnick, 2013; Kolowich, 2013). At the same time, our current understanding of the dynamics of affect for learning is "impoverished" (Baker, D'Mello, Rodrigo, & Graesser, 2010). However, we are able to capture learner data and model their emotions, via methods including facial recognition, processing voice recorded data, sentiment analysis of student comments, and heart rate detection using video cameras, etc. (see e.g. Calvo & D'Mello, 2010). This would be exemplified by the 'whole person' personalisation element in Dimension 5 and have a high level of sophistication, taking into account a large number of learning characteristics (linking back also into Dimension 3).

Personalised feedback and support fits the framework as follows:

Table 6: Personalisation dimensions and learning analytics:

Dimension 1: What is being personalised?	Dimension 2: Type of learning	Dimension 3: Personal characteristics of the learner	Dimension 4: Who/what is doing the personalisation	Dimension 5: How is personalisation carried out?	Dimension 6: Impact/beneficiaries

Content Assessment Visual design/presentation of resources	Formal	Demographic (e.g. age, cultural background) Prior knowledge (e.g. based on recent assessment scores) Self-assessed knowledge (by teacher or learner) Demonstrated interests or personal relevance (e.g. could feed into learner profile) Level of learner commitment/motivation and self-regulation	Computer software and/or algorithms	Whole person personalisation (affective elements)	Learners Teachers Schools/organisations (in terms of large scale learner tracking)

Technology is necessary to provide personalised assessment, content and resources aimed at addressing a complex interplay of individual whole-person factors. However, the role of emotions and affective learning is still the subject of much current and future research and we expect ongoing research findings to provide new insights into how these might affect personalisation in TEL.

Personalised books

Personalisation is a 'rapidly growing publishing category' (Anderson, 2014) with an increasing number of children's publishers adding personalisation features to children's paper-based books, such as personalised narratives, customised book covers and personalised story characters. Personalised books can be digital or paper-based, although sophisticated technology is required for the production of both formats. For instance, buyers can choose the main character names (e.g. Jessie instead of Cinderella) or the names of subsidiary characters (e.g. the names of a child's friends). Key storyline information is replaced by the child's personal data (e.g., the names of key locations are replaced by names of local sites familiar to the child).

Digital personalised books can incorporate all these features and in addition, contain multimedia personalised elements. The personalisation process is foregrounded and is executed by the book's user, not the publisher. For instance, with story-making tablet/smartphone apps, children as young as four can create their own digital personalised books and insert their own pictures and voice-recordings into familiar stories.

From a learning perspective, this kind of personalisation adds a layer of playfulness, authenticity, and immediacy to the story (Kucirkova, 2013; Kucirkova, Messer, & Whitelock, 2010) and can be an effective way to encourage parent-child shared book reading (Kucirkova, Messer, Sheehy, & Flewitt, 2013).

In terms of our framework, personalised books are by and large, developed for the home market and hence address the 'informal learning' aspect of Dimension 1. However, some publishers are beginning to explore the development of school-oriented resources (e.g., activity sheets), designed to support the use of personalised books in conjunction with the school curriculum. Personalisation in personalised books is realised through the focus on the child's name, gender and the name of their friends or familiar locations. This information is typically supplied by a parent/caregiver or someone who knows the child well, and wants to give them a personalised book as a gift.

Similarly to learning analytics and the affective dimension, which, although perceived as important, but thus far, only minimally applied in TEL personalisation models, personalised books could contain more affective cues and provide more opportunities for affective choices (Kucirkova, 2016). For instance, books could be personalised in relation to a child's emotional state (e.g., a familiar face greeting a child feeling poorly). Also, given that most personalised books are offered as gifts to the child, the emotional link between the book giver and book recipient could be translated into the storyline (e.g. a book about a boy and his grandparent who gave the book to the child). More attention could be also paid to the

aesthetics of personalised books and the child's own preferences - an issue discussed by Oulasvirta & Blom (2008) in relation to personalisation behaviour, aesthetics and adult users embellishing their own mobile phones.

Table 7: Personalisation dimensions and personalised books

Dimension 1: What is being personalised?	Dimension 2: Type of learning	Dimension 3: Personal characteristics of the learner	Dimension 4: Who/what is doing the personalisation	Dimension 5: How is personalisation carried out?	Dimension 6: Impact/beneficiaries
Fictional content/ popular narrative	Informal and non-formal	Children of all ages, no prior knowledge required Self-assessed knowledge (by teacher or children's caregivers) Demonstrated interests or personal relevance (feeds into digital but not print books)	Computer software and/or algorithms based on the caregiver's and teacher's data	Name recognition (for paper-based as well as digital personalised books) Self-described personalisation (available for older children and digital personalised books) Segmented personalisation (different layouts for girls and boys)	Learners

This characterisation enables us to see that whole-person personalisation and dynamically-constructed cognitive-based personalisation are as yet not available for personalised books, representing an exciting future approach – and challenge – for children's publishers.

Conclusions

This paper has examined how personalisation has been modelled and realised in technology-enhanced learning. Our framework is an initial attempt at mapping the key dimensions of technology-enabled learning and at providing the language for personalised TEL approaches. Future research could expand the facets and levels of our key dimensions (e.g. , micro, meso, macro; or at a learner's individual level compared to an institutional level).

The current framework foregrounds TEL-environments, although in many cases non-TEL are closely interlinked with TEL-environments. Future research might explore this interconnection in more detail, using the framework's dimensions as key comparison points. It is also important that future work includes examples of how the framework might be applied in teaching practice and make methodological contributions (cf Mishra & Koehler, 2006).

The framework will be of use to developers of educational software, who are being urged to consider how to integrate personalisation into their new solutions (U.S. Department of Education, 2015). Other key stakeholders, e.g. teachers, are being asked to consider how to provide personal support for all their students, particularly in their online activities. We suggest that this framework could be used to support teacher professional development, to help them understand how personalisation might occur already and to see how it might be integrated more closely in the future, into their daily activities.

Statements on open data, ethics and conflict of interest

a. Not applicable – no direct empirical data created or used.

b. Not applicable – we refer only to existing published literature.

c. There is no conflict of interest from any of the authors.

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