australasian journal of TECHNOLOGY EDUCATION

The Australasian Journal of Technology Education is a peer refereed journal, and provides a forum for scholarly discussion on topics relating to technology education. Submissions are welcomed relating to the primary, secondary and higher education sectors, initial teacher education and continuous professional development, and general research about Technology Education. Contributions to the on-going research debate are encouraged from any country. The expectation is that the Journal will publish articles at the leading edge of development of the subject area.

The Journal seeks to publish

- reports of research,
- articles based on action research by practitioners,
- literature reviews, and
- book reviews.

Publisher: The Technology, Environmental, Mathematics and Science (TEMS) Education Research Centre, which is part of the Faculty of Education, The University of Waikato, publishes the journal.
Contact details: The Editor, AJTE, pj.williams@waikato.ac.nz
Cover Design: Roger Joyce

ISSN: 2382-2007

australasian journal of
TECHNOLOGY EDUCATION

E-portfolio environment design principles in practice: A case study of a collaborative project in technology teacher education

Richard Edwards

Abstract

The design of an e-portfolio environment is key to its effectiveness. This paper explores the usefulness of a set of guiding questions for e-portfolio design through their application to a collaborative design project in a primary technology teacher education course. The responses to the design questions highlight the importance of considering the e-portfolio in the context of the environment in which it will be used. A number of key factors affecting implementation emerged from the case study: task design, supporting infrastructure, providing appropriate support, and the nature of the students themselves.

Keywords: e-portfolio design, collaboration, assessment

Introduction

As part of an investigation into the assessment of individual performance in a group technology project, a set of questions to guide decision-making in the development of an appropriate e-portfolio environment was generated from the literature and presented at the PATT29 conference (Edwards, 2015) The questions were organised into four dimensions – technical, functional, pedagogical, and manageability – based on a framework developed and used by Kimbell (2012) and Williams and Newhouse (2013).

The questions developed for the investigation reported here were intended to provide a broad framework for decision-making, supported by theory and research, but they had not been tested in an authentic setting. A trial was therefore set up to explore how well the design question framework worked in practice and to identify any issues affecting its implementation. The context for the trial was a primary undergraduate initial teacher education degree in which a group design project was undertaken as part of a compulsory first-year technology education paper. Students worked in small self-selected groups (3-4 people) to develop a response to a design problem that they identified, and submitted a record of their project in the form of a joint group e-portfolio.

The paper begins with the conceptual framework that underpins the questions, before exploring the responses to them in the context of the group project. A number of important implications that emerged are then discussed. A justification for the questions themselves were the focus of an earlier paper (Edwards, 2015).

Theoretical background

Conceptual framework

The four dimensions used to organise the questions represent a practical framework aimed at guiding the planning and decision-making associated with setting up an e-portfolio in a given context. However, a broader conceptual framework draws together key theoretical elements

from relevant domains to underpin the concept of an e-portfolio environment as used here.

The conceptual framework (see Figure 1) brings together important concepts at the intersection of four fields: the role of context (in this case technology education), a socio-cultural view of learning with a focus on assessment, collaboration with a focus on its role in education, and the use of digital technologies in education; and applies them in the context of an e-portfolio environment. The links between the fields highlight important design considerations and provide a useful perspective on the design questions themselves. The four fields and links between them are explored below in relation to this study.

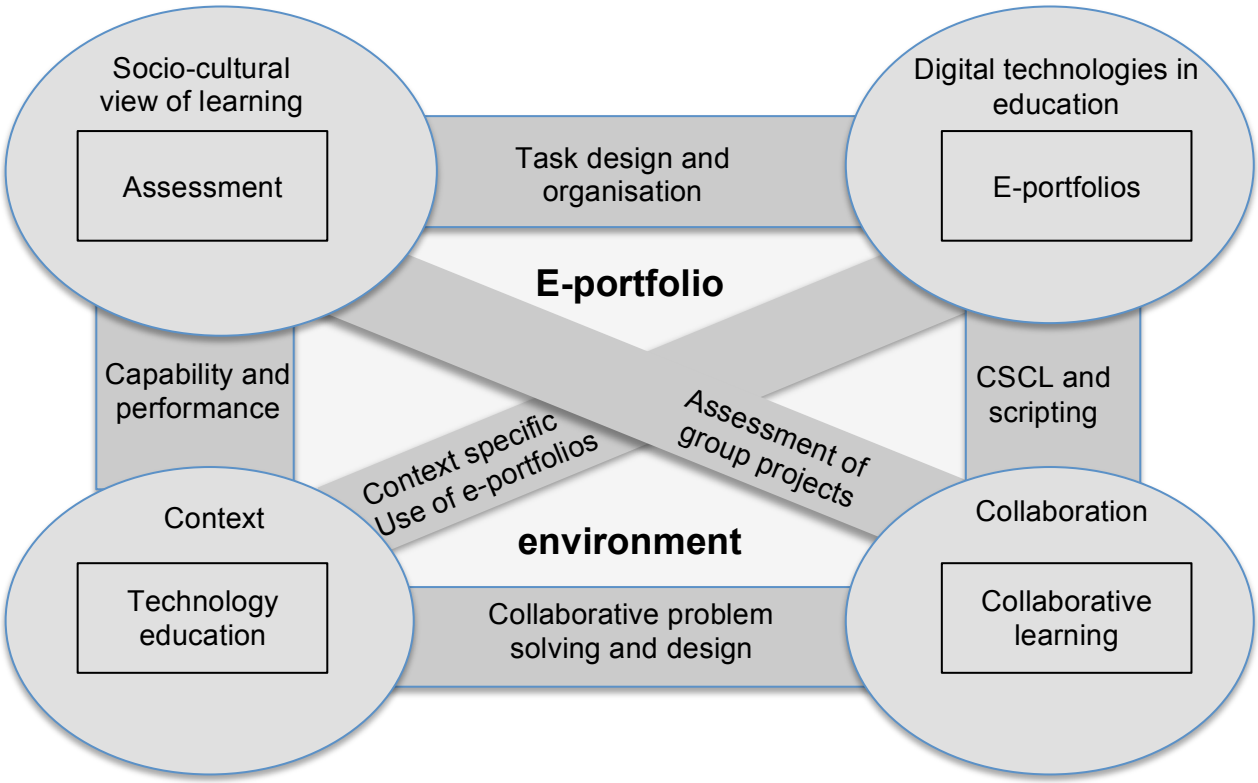

Figure 1. Conceptual framework linking key determinants of a collaborative e-portfolio environment

Digital technologies

The term e-portfolio refers to an electronic portfolio in which the artefacts presented are in digital form (Hicks et al., 2007). E-portfolios are simply one of a growing number of digital tools that take advantage of the increasing range of media types and modes of communication available with digital technologies. Effective use of e-portfolios depends on resolving a number of specific issues related to the portfolio concept and to the digital nature of the environment. Because the e-portfolio places an emphasis on the selection by students of appropriate material and on reflective commentary, the learner becomes more actively involved in the assessment process when e-portfolios are used for assessment (Barrett, 2007).

Socio-cultural view of learning

This research is informed by a socio-cultural view of learning which suggests that learning involves interaction with other people and their ideas through mediating tools such as language, and that it is influenced by the cultural setting within which it takes place (Wertsch, 1998). This is particularly useful in making sense of a group learning situation since the effective functioning of a group requires social interaction and takes place within a particular cultural

setting. A socio-cultural view has important implications for e-portfolio design as it suggests an emphasis on supporting social interaction, joint contribution, and flexibility to allow the group to make decisions about how best to present their performance on the task. It also affects the approach to assessment.

Assessment involves the collection and evaluation of evidence generated by learners and is used both to inform further teaching and learning and to indicate current levels of performance or competence (Brown, 2008). Where it allows comparison between two instances, it can be used to comment on learning. The primary focus of assessment is the student and their learning, and there is increasing recognition of the benefits of involving the student in assessment decision-making (Bain, 2012; Boud, 2007). Effective assessment has to take account of context and of domain specific requirements. In technology education where both process and outcomes are important, traditional forms of assessment have been found to be inadequate (Williams & Newhouse, 2013).

Context

There are some significant features of learning in technology education that affect its assessment. According to Kimbell and Stables (2008) these include

- a focus on learning in issue-rich, task-centred activities in which the learner is an active participant;
- recognising that learners will not necessarily each be learning the same things and may achieve the same result in different ways; and
- viewing knowledge and skills as best learnt when the learner needs to know them and to the level needed to address the problem rather than as a defined corpus that can be generically associated with any given activity.

Capability has been described as "the power to produce change and improvement in the made world" (p. 18) and imaging and modelling are seen as central to its development (Kimbell & Stables, 2008). It requires competence, skill, and knowledge but these are not sufficient. It also requires the ability to make good decisions and to bring these together in a purposeful way. Assessment of capability in technology is characterised by its focus on process as well as outcome, and by its highly contextual nature. It requires attention to aspects of student performance that are not well captured in traditional paper and pen based assessment events (Kimbell & Stables, 2008). Portfolios have been used as a way of better capturing the range of elements of performance. E-portfolios extend the portfolio concept by enabling the inclusion of a broader range of forms of digital evidence including images, video and sound files, weblinks, and files from specific software packages in a range of formats (Williams & Newhouse, 2013).

Collaboration

Technological and design practice are commonly collaborative (Poggenpohl & Sato, 2009; Snape & Fox-Turnbull, 2011). However, Poggenpohl and Sato note a lack of research theorising collaborative work. McCormick (2004), in commenting some time ago on a similar lack of research on collaboration in technology education, suggested that the use of digital technologies offers potential for both collaborating to learn and learning to collaborate in the context of design problems. Since then, there have been significant developments in digital technologies, particularly associated with mobile devices. However, few studies (e.g. Hong, Yu, & Chen, 2011) have focused on collaborative work. Most research into the use of digital technologies in design problems tends to focus on individual rather than collaborative activity (e.g. Kimbell, 2012; Williams, 2012). Although possibilities for collaboration in technology education have been identified (Hennessy & Murphy, 1999), there appears to be a need for more research that explores this with respect to the use of digital technologies.

Collaboration has been identified as a key skill in research into what people need for twenty-first century living and employment (Binkley et al., 2012; Ministry of Education, 2007). The Programme for International Student Assessment (PISA) draft framework for collaborative problem-solving (OECD, 2013) defines collaboration as "the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills, and efforts to reach that solution" (p. 6). Any consideration of collaboration therefore needs to explore the nature of the group, the nature of the activity in which they are engaged, and the nature of the interactions that contribute to completion of the activity (Dillenbourg, 1999).

In recent years, a growing interest in the ways in which information technologies can support collaboration has developed. Several themes emerge from this, including recognition of the diversity of skills and background of participants and the need for people to develop collaborative skills as well as those needed to achieve intended cognitive outcomes (Dawes & Sams, 2004; Fransen, Weinberger, & Kirschner, 2013; Montequín, Fernández, Balsera, & Nieto, 2013; Napier & Johnson, 2007). Some of this has come from analysis of failure of collaborative projects in education (Baker, Bernard, & Dumez-Féroc, 2012; Kapur & Kinzer, 2009; Pathak, Kim, Jacobson, & Zhang, 2011). There has also been a focus on the role of design of the environment, task, and supporting tools in regulating both the process and outcomes of collaboration (Fischer, Kollar, Stegmann, & Wecker, 2013; Strijbos, Martens, & Jochems, 2004).

E-portfolio environment

The concept of an e-portfolio environment extends the idea of e-portfolio design to take into account the broader range of considerations discussed above. It allows consideration of the e-portfolio itself, the context in which it is to be used, and the support materials provided. It recognises the contextual nature of any use of an e-portfolio and that its use affects, and is affected by, a range of interacting factors.

The development of a digital environment for a specific purpose can usefully be regarded as a design problem, enabling the resources and approaches of innovative design to be applied as demonstrated in a number of recent studies (An, 2013; Kirschner, Strijbos, Kreijns, & Beers, 2004; So, Seah, & Toh-Heng, 2010; Wang, 2009; Zhang, Olfman, & Ractham, 2007). The design required is complex as it needs to address a broad range of intersecting areas: the technical aspects of the technologies involved, the nature of the task(s) students are to be engaged in, and the support materials and processes that guide students in their involvement. Where engagement in the task itself requires knowledge and skills other than those the task seeks to develop or assess, these need to also be explicitly addressed in the supporting materials and processes.

Williams and Newhouse (2013) identified a framework of four specific dimensions that would need to be satisfied in order for the use of digital technologies to be effective in assessment. This was based on the proof of concept criteria used by Kimbell (2012) in his initial exploration of the feasibility of project e-scape. The four dimensions identified were technical, functional, pedagogical, and manageability (see discussion below). They were used to frame a set of questions (see findings) that could be used to guide the development of an e-portfolio environment. The justification for the choice of questions is presented and discussed in Edwards (2015).

Technical dimension

The technical dimension deals with issues about the practical implementation of the software. It addresses how the software works, where it is based, and how it is supported. It also considers administration of student accounts and access.

Functional dimension

The functional dimension relates to the way the e-portfolio environment supports the purpose for which it is being used and so is primarily concerned with how the task itself is facilitated by the software and supporting materials.

Pedagogical dimension

The pedagogical dimension provides a way of considering how the e-portfolio environment enacts the theoretical ideas about teaching, learning, and assessment, particularly in technology education, that underpin the task and its intended purpose.

Manageability dimension

Manageability addresses issues of how people might use the environment to complete the task. It considers such things as workload, timing, ease of use, and fitness for purpose.

Method

This research focused on exploring the use of a specific design tool in developing an e-portfolio environment. It is positioned as a case study reflecting its focus on a current situation in a specific context, the desire to understand how effective the set of questions is, and the complex nature of the context (Yin, 2014). An interpretive methodology was adopted.

The research sought to answer the following questions:

- How well does the design question framework work in practice?
- What factors affecting its implementation need to be considered in its future use?

In order to answer these questions, a trial was set up in which the design question framework was used to guide the development of an e-portfolio environment in the context described earlier; a collaborative design project in a first year technology education paper in a New Zealand primary initial teacher education programme.

The data used as a basis for analysis comprises:

- the decisions made in response to the questions together with the resulting elements of the e-portfolio environment itself ;
- the group portfolios submitted by students; and
- the recorded observations and reflections of the author.

Analysis involved exploring the design decisions made in developing the e-portfolio environment and aligning them with the questions in the design question framework. The broader conceptual framework was then used to identify any other relevant considerations that may not have been addressed but that should have been.

Findings

The four dimensions discussed above are used to organise the presentation of the findings as they form the organising structure for the design question framework. For each of the dimensions, the associated questions are presented followed by a collective discussion of the responses in the context of the design decisions that were actually made in developing the e-

portfolio environment. The questions themselves did not always require individual responses as in a number of instances one response answered a range of questions.

Technical dimension

Table 1: Design questions for the technical dimension

Aspect	Questions
Server location	• Will the server be located internally or externally? • How many accounts can the system cope with? • How secure is the system?
Accounts	• How are accounts set up? • How are group accounts set up?
Access	• Who controls access? • Will the software be continuously accessible? • Is it web-based or PC-based? • Does the system allow several people from the same group to access the group page simultaneously? • How do students access each other's files? • Can the site be accessed on multiple devices?
Storage	• Is there enough storage space for what we need? • How is file quality maintained?
Support	• How good is the technical support within the institution?
Flexibility	• How much scope is there to adapt the software to suit our needs? • How much scope is there for student creativity in designing their group portfolio?

With respect to most of these questions, the answers were determined by the institutional infrastructure available. The institution in which this study took place has a large and well-established information technology infrastructure that included provision for the use of e-portfolios in teaching. However, the choice was made to use the externally hosted *myportfolio*, a variant of *Mahara*, because it is widely used in schools, was well supported, and suited most of what was wanted in the task. However, it is based offsite so considerations of server location and size, security, account management, access and storage were determined by what was available and not open to negotiation. This would also have been the case if another proprietary e-portfolio had been selected, whether free or paid for, and the alternative of developing something in house was not available. Because of this, the questions proposed represent a pointer to important aspects of the e-portfolio environment that influence its nature and use. They do not really reflect a series of design decisions.

The scale and organisation of *myportfolio* has been set up to provide e-portfolio capability to New Zealand schools. As a result, server and account access, security, setting up of accounts and storage were already suited to the classroom setting that formed the context of the study. Of more interest was the ways in which students could interact with the e-portfolio both individually and as a group. The web-based nature of *myportfolio* made it useable anywhere the student(s) had Internet access and independent of the computer setup (hardware and software) they were using.

The critical element was support for group work as this was a defining aspect of the project. *Myportfolio* did enable establishment of groups and the development of a group portfolio both of which were surprisingly easily used by all groups. The ability to have all group members access the portfolio at any time, edit the portfolio, and work on it simultaneously was

particularly useful. Some aspects of the group function were not quite what we wanted including the lack of provision for tracking activity and not being specifically suited to the technology context in which we were working. However, it provided a sufficiently useful platform that it could be used for what we needed. In particular, it offered considerable scope for student creativity and ownership of the way the e-portfolio was developed.

Support was well catered for through the institution's IT infrastructure that included a team who were familiar with *myportfolio* and able to offer tutorial support for staff and students, and technical support as required. When needed, additional technical support was available through an established relationship with the external provider running *myportfolio*.

Functional dimension

Table 2: Design questions for the functional dimension

Aspect	Questions
Nature of evidence	• What evidence needs to be available?
Source of evidence	• Where can evidence come from?
Task clarity	• How will students know what is expected of them?
Authenticity	• How will authenticity be assured?
Content decisions	• How will content decisions be made and who will make them?

This dimension relates to how well the e-portfolio environment suits its intended purpose which, in this case, was to enable effective assessment of group performance in a learning activity. *Myportfolio* supported the necessary wide range of forms and sources of evidence required to allow students to record all relevant aspects of the process they went through and the outcome they produced. It also allowed students full control of what to include as representative of their process. However, there was no way to consider what they had chosen to leave out of their final portfolio.

Task clarity was achieved through supporting materials and instruction and so is a feature of the wider environment rather than the e-portfolio itself. While a more tailored e-portfolio could integrate instructions and support materials within the e-portfolio itself, this was not the case in this situation. Students appeared to be able to make good sense of task expectations as indicated by their engagement with the task and what they submitted for assessment.

Authenticity with respect to student work being their own was not an issue at the group level because the nature of the task required students to be working with a unique design problem. At an individual level though, the ability to distinguish individual contribution and performance proved difficult with *myportfolio* and would be difficult with any piece of e-portfolio software. While it is potentially possible to isolate and track individual activity with the e-portfolio, this does not clearly show individual technological capability and in fact the more collaborative a group is, the more blurred individual contribution becomes.

Pedagogical dimension

Table 3: Design questions for the pedagogical dimension

Aspect	Questions
Socio-cultural view of learning	• How does the e-portfolio environment support a socio-cultural view of learning?
Peer feedback	• Are peer and teacher feedback supported?
Reflection supported	• How is reflection supported?
Necessary learning supported	• How will the necessary learning be supported?

From the perspective of a socio-cultural view of learning, an emphasis on the active involvement of the learner, social interaction, and the setting in which the task is undertaken are important. All of these were well supported within *myportfolio* and in the way the task itself was designed. Feedback and reflection are important features of an e-portfolio (Barrett, 2007) and are supported in *myportfolio* through a feedback function and a journaling tool. The necessary learning associated with the task itself and with developing the e-portfolio was accommodated within the class programme through specific teaching and learning episodes and through self-paced web-based tutorials.

Manageability dimension

Table 4: *Design questions for the manageability dimension*

Aspect	Questions
Student workload	• Will this make more demands on student time than the current task?
Learning to use *myportfolio*	• How long will it take students to learn to use *myportfolio*? • What support will be provided for students to learn to work with *myportfolio*?
Staff workload	• Will the marking take longer than it currently does? • How long will it take for staff to learn to work with *myportfolio*?
Ease of marking	• Does the group e-portfolio provide all the necessary evidence for marking?

It was important that the shift to working with the e-portfolio did not create additional workload for staff or students. While there was some time required to become familiar with the software, this was less than expected and did not intrude on the typical process of completing the task. Staff involved found that the support required was similar to that needed with the previous paper portfolios and that marking took a similar time. Students experienced the same kinds of issues in getting the task completed as other cohorts have with the paper portfolio. They did not find that the e-portfolio posed unreasonable challenges or that it was time-consuming to work with. This surprised staff as we had anticipated more difficulties than students experienced. Students commented positively about the clarity of their presentation and about not having to print and rework what they were putting into their e-portfolio as they expected they would have needed to do had they been working with a paper version.

Discussion

This section discusses the implementation of the design question framework and issues associated with its use. As indicated in the previous section, the questions were relevant and useful in guiding the development of the e-portfolio environment. The development process

involved a combination of selection decisions (where there was little opportunity to adapt what was available) and design decisions. Using the framework was not simply a matter of answering the questions however. They tended to cluster around design decisions that were largely determined by the context. The findings suggest the design question framework acts more as a guide to decision-making than a checklist. They also indicate that the decision-making process is complex, context-dependent, and needs to consider the broader environment within which the e-portfolio will be used. In particular, it needs to consider task design, supporting infrastructure, providing appropriate support, and the students themselves. These aspects align closely with the conceptual framework outlined in Figure 1.

It quickly became apparent that in designing an appropriate e-portfolio environment for a particular context, consideration of the environment is at least as important as the choice of e-portfolio software. Such a view is consistent with the idea that design for collaborative learning needs to go beyond surface-level features (Kirschner et al., 2004). Decisions about how best to manage aspects of the task in context can be integrated with other decisions in order to provide a rich learning focused environment. For example, where the e-portfolio software works well in a general sense but does not provide context specific support, this can be designed into the broader environment. Choice of software is only part of the decision-making process.

Kirschner et al. (2004), working in the field of computer supported collaborative learning (CSCL), identify three interacting elements of the environment that should be considered: the technological, social, and pedagogical. Design should aim to develop affordances (Norman, 2009) in each of these areas. The conceptual framework suggested at the start of this paper fits reasonably well with these three elements but suggests inclusion of a fourth, the context-specific demands of the domain. In the example considered here, the unique requirements of a technology design task impose a contextual overlay that colours the responses to the questions in ways different from tasks in other subject domains. These four elements of the environment are not the same as the dimensions of the design question framework which is more focused on the e-portfolio itself. However, they are clearly related.

Decisions about choice of e-portfolio software and design of the environment inevitably involve compromise. There is no software solution that is capable of meeting all of the anticipated needs of any given context even when custom-designed to do so. This is because the needs are often in tension, highlighting the complexity of the design task (Kirschner et al., 2004). Kirschner et al. discuss the complex way in which all elements of the environment interact, especially in a collaborative setting. One preference will often be at the expense of another. For example, if priority is given to directing what can be included and how it can be presented, this will be at the expense of student ownership and creativity. Recognition of the inevitability of compromise means an emphasis on ‘best fit’ rather than ‘perfect fit’ and the creative development of other solutions through the design of the task environment. Generic tools such as Google Sites and *myportfolio* generally come with fewer bugs, have better support, and are reasonably easy to use but may lack the flexibility or specific features desired in a particular context. On the other hand, software that is specifically designed to suit a particular type of task is likely to be better suited to its use but may have more bugs, less support and may not be so easy to use.

Local infrastructure is a requirement for successful implementation. Because the use of e-portfolios and digital tools requires use of ICTs, without adequate local support for them, they cannot be used effectively. The infrastructure needs to be substantive, pervasive, robust, well-integrated, and well-supported. This includes practical support in the form of Internet access, wireless connectivity, and sufficient scale to accommodate the software and its use. It also involves personal support in the form of people who can solve technical problems as they arise and can help students and staff deal with specific problems that they have. In our case, the infrastructure support was good and the choice of e-portfolio software was relatively straightforward as what was readily available was suitable for what was required. Where the necessary infrastructure is not in place as may be the case in some schools, the preferred option

would be to have the e-portfolio software housed offsite although infrastructure issues would still affect the environment within which students interact with their e-portfolios.

The integrated nature of the design process for the e-portfolio environment means that where problems or limitations arise in one aspect they can often be resolved by thoughtful design of another aspect. As a result, the questions in the design question framework should usually be considered in relation to responses to other questions and with an awareness of the implications for designing other aspects of the environment. While this is consistent with design principles generally (McGlashan, 2010), it has not been a focus in the e-portfolio literature.

Task design emerged as a core element of the design and development process placing an emphasis on the pedagogical dimension of the question framework but going beyond it. In doing this, the focus shifts from surface features of the environment to a deeper consideration of the intended purpose. The task itself reflects underpinning beliefs about learning and teaching, assessment, the subject domain, and the use of digital technologies. As a result, task design decisions relating to task ownership, task character, and task control (Kirschner et al., 2004) should guide responses to the questions posed in the question framework discussed here.

Conclusion

This paper aimed to explore how well the design question framework worked in practice and to identify any issues affecting its implementation. In the trial, the framework questions worked well as a guide to key considerations although their usefulness was more in focusing attention on key considerations in e-portfolio environment design than acting as a checklist.

The design of an effective e-portfolio environment is clearly complex and involves a number of interacting decisions. While this is not a new idea, the study reported here highlighted the context dependent nature of the process of design and development because the relevant constraints and affordances are unique to each situation. It is also iterative. Decisions about e-portfolio software and supporting materials depend on the answers to key questions but also influence some of the answers to those questions. Choices are governed by what best meets specified needs but are also moderated by considering how what is available can be tailored to what is required. The tension between characteristics that are at times complementary and at times conflicting makes the design of effective e-portfolio environments challenging. Working with the complex array of interacting elements of the environment demands flexibility and the ability to adapt to needs as they arise. Ongoing development of the question framework should take account of this. An integrated approach is needed that recognises the need for compromise and the scope for resolving issues through thoughtful design in other aspects of the environment.

Adopting a broader perspective that takes into account the environment in which the e-portfolio is being used offers more likelihood of its use being effective. The role of task design and of local infrastructure is central in this. The conceptual framework proposed earlier (*Figure 1)* provides a useful way of understanding the complexities of this broader perspective.

Affiliation

Richard Edwards
Lecturer
Te Kura Toi Tangata Faculty of Education
The University of Waikato, Hamilton, NZ
richarde@waikato.ac.nz

References

An, Y. (2013). Systematic design of blended PBL: Exploring the design experiences and support needs of PBL novices in an online environment. *Contemporary Issues in Technology and Teacher Education*, 13(1), 61–79.

Bain, J. (2012). Negotiating the vacuum: Constructing and applying assessment criteria to focus design learning. In *Explorations of best practice in technology, design, and engineering education* (vol. 1, pp. 13–24). Gold Coast, QLD, Australia: Griffith Institute for Educational Research.

Baker, M., Bernard, F.-X., & Dumez-Féroc, I. (2012). Integrating computer-supported collaborative learning into the classroom: The anatomy of a failure. *Journal of Computer Assisted Learning*, *28*(2), 161–176. http://doi.org/10.1111/j.1365-2729.2011.00435.x

Barrett, H. C. (2007). Researching electronic portfolios and learner engagement: The REFLECT initiative. *Journal of Adolescent & Adult Literacy*, *50*(6), 436–449.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 17–66). Dordrecht, Netherlands: Springer.

Boud, D. (2007). Reframing assessment as if learning were important. In D. Boud & N. Falchikov (Eds.), *Rethinking assessment in higher education: Learning for the longer term* (pp. 15–25). Oxon, England: Routledge.

Brown, G. (2008). Conceptions of assessment: Understanding what assessment means to teachers and students. New York, NY: Nova Science.

Dawes, L., & Sams, C. (2004). Developing the capacity to collaborate. In K. F. Littleton, D. Miell, & D. Faulkner (Eds.), *Learning to collaborate, collaborating to learn* (pp. 95–109). New York, NY: Nova Science.

Dillenbourg, P. (1999). Introduction: What do you mean by "collaborative learning?". In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 1–19). Oxford, England: Elsevier Science Ltd.

Edwards, R. (2015). Designing an e-portfolio environment for assessment of a collaborative technology project. In *PATT29, Plurality and complementarity of approaches in design and technology education* (pp. 112–119). Marseilles, France: Presses Universitaire de Provence.

Fischer, F., Kollar, I., Stegmann, K., & Wecker, C. (2013). Toward a script theory of guidance in computer-supported collaborative learning. *Educational Psychologist*, *48*(1), 56–66. http://doi.org/10.1080/00461520.2012.748005

Fransen, J., Weinberger, A., & Kirschner, P. A. (2013). Team effectiveness and team development in CSCL. *Educational Psychologist*, *48*(1), 9–24. http://doi.org/10.1080/00461520.2012.747947

Hennessy, S., & Murphy, P. (1999). The potential for collaborative problem solving in design and technology. *International Journal of Technology and Design Education*, *9*(1), 1–36.

Hicks, T., Russo, A., Autrey, T., Gardner, R., Kabdian, A., & Edington, C. (2007). Rethinking the purposes and processes for designing digital portfolios. *Journal of Adolescent & Adult Literacy*, *50*(6), 450–458. doi:10.1598/JAAL.50.6.3

Hong, J., Yu, K., & Chen, M. (2011). Collaborative learning in technological project design. *International Journal of Technology and Design Education*, *21*(3), 335–347. http://doi.org/10.1007/s10798-010-9123-7

Kapur, M., & Kinzer, C. K. (2009). Productive failure in CSCL groups. *International Journal of Computer-Supported Collaborative Learning*, *4*(1), 21–46. http://doi.org/10.1007/s11412-008-9059-z

Kimbell, R. (2012). The origins and underpinning principles of e-scape. *International Journal of Technology and Design Education*, *22*(2), 123-134. http://doi.org/10.1007/s10798-011-9197-x

Kimbell, R., & Stables, K. (2008). Researching design learning: Issues and findings from two decades of research and development. Milton Keynes, England: Springer.

Kirschner, P., Strijbos, J.-W., Kreijns, K., & Beers, P. J. (2004). Designing electronic collaborative learning environments. *Educational Technology Research and Development*, *52*(3), 47–66. http://doi.org/10.1007/BF02504675

McCormick, R. (2004). Collaboration: The challenge of ICT. *International Journal of Technology and Design Education*, *14*(2), 159–176. http://doi.org/10.1023/B:ITDE.0000026495.10503.95

McGlashan, A. A. (2010). Designer stories: A commentary on the community of design practice. *International Journal of Technology and Design Education*, *21*(2), 235-260. http://doi.org/10.1007/s10798-010-9116-6

Ministry of Education. (2007). *The New Zealand curriculum*. Wellington, New Zealand: Learning Media.

Montequín, V. R., Fernández, J. M. M., Balsera, J. V., & Nieto, A. G. (2013). Using MBTI for the success assessment of engineering teams in project-based learning. *International Journal of Technology and Design Education*, *23*(4), 1127–1146. http://doi.org/10.1007/s10798-012-9229-1

Napier, N. P., & Johnson, R. D. (2007). Technical projects: Understanding teamwork satisfaction in an introductory IS course. *Journal of Information Systems Education*, *18*(1), 39–48.

Norman, D. (2009). *Design of future things*. New York, NY: Basic Books. Retrieved from http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10533389

OECD. (2013). PISA 2015: Draft collaborative problem solving framework. *OECD*. Retrieved from http://www.oecd.org/pisa/pisaproducts/Draft%20PISA%202015%20Collaborative%20Problem%20Solving%20Framework%20.pdf

Pathak, S. A., Kim, B., Jacobson, M. J., & Zhang, B. (2011). Learning the physics of electricity: A qualitative analysis of collaborative processes involved in productive failure. *International Journal of Computer-Supported Collaborative Learning*, *6*(1), 57–73. http://doi.org/10.1007/s11412-010-9099-z

Poggenpohl, S. H., & Sato, K. (Eds.). (2009). *Design integrations: Research and collaboration*. Bristol, England: Intellect Ltd. Retrieved from http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10354167

Snape, P., & Fox-Turnbull, W. (2011). Perspectives of authenticity: Implementation in technology education. *International Journal of Technology and Design Education*, *23*(1), 51–68. http://doi.org/10.1007/s10798-011-9168-2

So, H.-J., Seah, L. H., & Toh-Heng, H. L. (2010). Designing collaborative knowledge building environments accessible to all learners: Impacts and design challenges. *Computers & Education*, *54*(2), 479–490. http://doi.org/10.1016/j.compedu.2009.08.031

Strijbos, J. W., Martens, R. L., & Jochems, W. M. G. (2004). Designing for interaction: Six steps to designing computer-supported group-based learning. *Computers & Education*, *42*(4), 403–424. http://doi.org/10.1016/j.compedu.2003.10.004

Wang, Q. (2009). Design and evaluation of a collaborative learning environment. *Computers & Education*, *53*(4), 1138–1146. http://doi.org/10.1016/j.compedu.2009.05.023

Wertsch, J. V. (1998). *Mind as action: The task of socio-cultural analysis*. New York, NY: Oxford University.

Williams, P. (2012). Investigating the feasibility of using digital representations of work for performance assessment in engineering. *International Journal of Technology and Design Education*, *22*(2), 187–203. http://doi.org/10.1007/s10798-011-9192-2

Williams, P. J., & Newhouse, C. P. (Eds.). (2013). *Digital representations of student performance for assessment*. Rotterdam, The Netherlands: Sense.

Yin, R. K. (2014). *Case study research: design and methods* (5th ed.). Los Angeles, CA: Sage.

Zhang, S. X., Olfman, L., & Ractham, P. (2007). Designing ePortfolio 2.0: Integrating and coordinating Web 2.0 services with ePortfolio systems for enhancing users' learning. *Journal of Information Systems Education*, *18*(2), 203–214.