Using design principles to improve pedagogical practice and promote student engagement

Jan Herrington
School of Education
Murdoch University

Thomas C Reeves
Professor Emeritus, Department of Educational Psychology and Instructional Technology
University of Georgia

Design principles are fundamental to the conduct of *educational design research* (or *design-based research*) studies, a research approach that is becoming more widely used in educational technology research and pedagogy. In this paper, we argue that design principles can be used to guide the design and development of learning environments in higher education that are based on sound practical and theoretical principles, and that can promote student engagement through innovative learning tasks. We review the use of design principles in educational research, and describe how these principles can be used to design and refine educational innovation and technology-based learning initiatives. The paper describes four phases of design-based research, together with examples of how existing principles can be analysed and used by teachers to inform the creation and dissemination of innovative solutions to educational problems.

Keywords: design-based research, student engagement, technology-based learning, instructional design

Introduction

In addition to the substantial challenges facing the higher education sector generally, such as global competition, socioeconomic access, the increasing need for highly skilled workers, an aging workforce, and rural and remote disadvantage (Bradley, Noonan, Nugent, & Scales, 2008), universities also face significant challenges in adopting and accommodating new technologies in their teaching and learning programs. The *2011 Horizon Report* (Johnson, Smith, Willis, Levine, & Haywood, 2011) noted that, in addition to world-wide challenges to accommodate new digital literacies and new forms of authoring (such as blogs, wikis, networked presentations. etc.) in all disciplines, individual organisational constraints are likely to be the most important factors in decisions to adopt new technologies. The report noted:

> Keeping pace with the rapid proliferation of information, software tools, and devices is challenging for students and teachers alike. New developments in technology are exciting and their potential for improving quality of life is enticing, but it can be overwhelming to attempt to keep up with even a few of the many new tools that are released. User-created content is exploding. (p. 8)

In the light of such challenges, and the need to adequately prepare students for new digital literacies, much attention has been paid to researching and implementing the means to support and improve student engagement. The area is, however, as argued by Bryson and Hand (2007), 'beset by its own complexity' (p. 351). They maintain that opportunities to improve student engagement are possible, at the course design level, through clearer curricular articulation, more attention to implementation, and strong alignment between outcomes and delivery. Others, such as Dickey (2005) argue that educators can learn much about student engagement from the design of games that present students with challenging tasks, role playing opportunities, affirmation of performance, and choice. Such recommendations for design effectively constitute design principles that enable teachers and instructional designers to use well-researched ideas as guidelines for their own efforts to enhance student engagement and learning outcomes.

The education literature is replete with design principles, although they might not always be called that. For example, the following lists from seminal works are forms of design principles because they give heuristics and guidelines for designing for particular outcomes:

Example: Bransford, Vye, Kinzer and Risko (1990) proposed that anchored instructional activities were characterised by the following design criteria:

- A single complex problem should be investigated by the students.
- Students identify and define their own questions.
- Students must have the opportunity to experience the problem from a number of different perspectives.
- Students work on the problem over a 'reasonably long period of time', that is weeks rather than days.
- Activities are logically related to the problem.

Example: Boud and Knights (1996) proposed that the following are important in introducing and establishing a productive climate for reflection:

- Articulating an educational rationale for the process
- Introducing a simple exercise to illustrate reflection
- Providing an opportunity for students to clarify their understanding of the idea
- Introducing a framework or model to aid thinking about elements of reflection
- Modelling a reflective approach in one's own presentation of the idea
- Identifying areas of the process that students can make their own
- Providing time
- Treating reflection as a normal activity.

Example: Oliver (2000) proposed guidelines for the design and development of web-based materials using new technologies:

- Choose meaningful contexts for the learning
- Choose the learning activities ahead of the content
- Choose open-ended and ill-structured tasks
- Make the resources plentiful
- Provide supports for the learning
- Use authentic assessment activities.

Example: McLoughlin and Oliver (2000) proposed ten design principles for culturally inclusive instructional design:

- Adopt an epistemology that is consistent with, and supportive of constructivist learning and multiple perspectives
- Design authentic learning activities
- Create flexible tasks and tools for knowledge sharing
- Ensure different forms of support, within and outside the community
- Establish flexible and responsive student roles and responsibilities

- Provide communication tools and social interaction for learners to co-construct knowledge
- Create tasks for self direction, ownership and collaboration
- Ensure flexible tutoring and mentoring roles that are responsive to learner needs
- Create access to varied resources to ensure multiple perspectives
- Provide flexibility in learning goals, outcomes and modes of assessment.

It is clear that such principles are useful for teachers wishing to implement improvements in their learning environments and pedagogical practice, and they exist in a range of different contexts. Van den Akker (1999) described design principles in more detail as heuristic statements in a format best illustrated as:

> If you want to design intervention X [for the purpose/function Y in context Z], then you are best advised to give that intervention the characteristics A, B, and C [substantive emphasis], and to do that via procedures K, L, and M [procedural emphasis], because of arguments P, Q, and R'. (p. 9)

Such design principles are not 'recipes for success' but are used principally 'to help others select and apply the most appropriate substantive and procedural knowledge for specific design and development tasks in their own settings' (McKenney, Nieveen, & van den Akker, 2006, p. 73).

The identification, application, testing, and refinement of design principles are infused throughout the phases of design-based research, as described in the next section.

Design principles in design-based research and evaluation

The ongoing use and development of design principles is a key defining element of design-based research (also known as *educational design research*, *design experiments*, *formative research* and *development research*) (van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). At every stage of the research process, initial and evolving design principles inform and guide the direction and shape of innovation being developed as well as its implementation and testing, until ultimately, the evolution of draft guidelines into refined design principles become a critical product of the research.

The Design-based Research Collective (2003) suggested four areas where design-based research showed much promise in improving educational practice:

(a) exploring possibilities for creating novel learning and teaching environments,
(b) developing theories of learning and instruction that are contextually based,
(c) advancing and consolidating design knowledge, and
(d) increasing our capacity for educational innovation (2003, p. 8)

In this section, we review the phases of design-based research (as portrayed by Reeves, 2006 in Figure 1 below), and how design principles evolve throughout such research, culminating in sharable design principles that can guide teachers facing problems in similar or parallel pedagogical contexts.

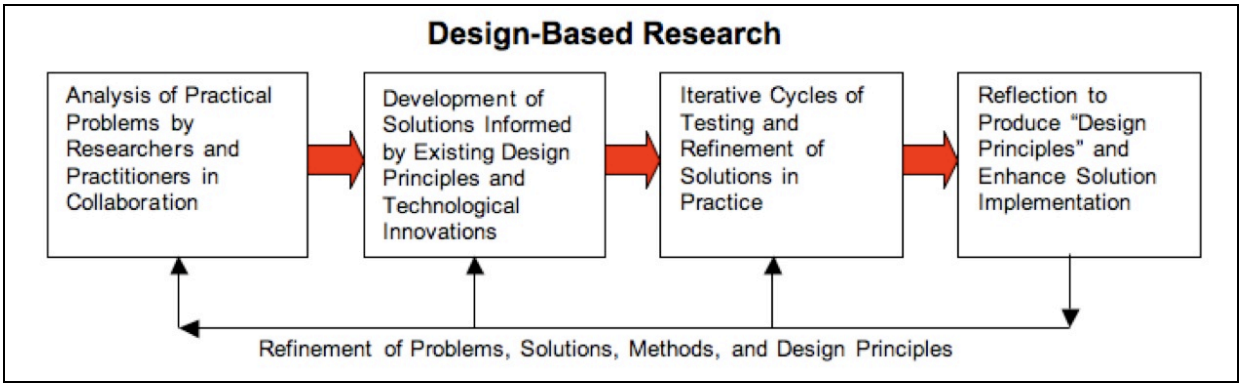

Figure 1: Design-based research (Reeves, 2006, p. 59)

PHASE 1. Analysis and exploration of a problem

In the analysis and exploration phase of design-based research, the problem under investigation is explored in an organic way by the researchers, practitioners and other stakeholders collaborating in the design research initiative. In other words, the problem is explored intensively, not solely from an academic perspective, but in the first instance, from the perspective of the people who deal with the problem on a day-to-day basis. As noted by McKenney, et al., (2006), it is only recently that practitioners have been consulted in early phases of research, whereas previously it might have been more common to consult them, for example, only at the formative evaluation phase.

In design-based research, teachers and researchers collaboratively explore the nature of an educational issue or problem facing students, and work together to create a solution (Design-Based Research Collective, 2003). It is important for teachers to be involved in this phase so that the full extent of the problem is known, rather than being interpreted solely by researchers. However, there is another key advantage to this close collaboration on the exploration of the problem—one that relates to the everyday experience of practitioners and the intimate understanding they frequently have with the problem and its potential solution.

The comparison of the everyday understanding and practice of practitioners and those of so-called 'just plain folk' has been noted by Lave and others (cf. Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). The issues faced by 'just plain folk' are generally more readily resolved by working with the resources available—those that exist within the context that produced the problem itself—rather than by reference to theoretical guidelines or algorithms. Practitioners, with their intimate knowledge of problems and their contexts and contingencies, can work with researchers to craft solutions appropriate to the context. As Brown et al. (1989) noted: 'The problem, the solution, and the cognition involved in getting between the two cannot be isolated from the context in which they are embedded' (p. 36). Consultation with practitioners who are familiar with the problem area of the research can provide rich insights into complexities inherent in a significant educational problem, because these insights are based upon their intimate and practical understanding of the issues. Practitioners may have developed their own heuristics for solving some aspects of the problem or at least coping with it. These heuristics can form the basis of draft design principles that may be used to guide the design of a solution created in the design and construction phase (i.e., Phase 2 in shown in Figure 1).

Consultations with practitioners are not always formal, and can take a variety of forms to produce different types of valuable data, such as:

- *Participant observation and conversation*: Participant observation by immersion in the setting provides an excellent opportunity to observe first hand the setting and the 'cognition involved' in exploring the parameters of the problem.
- *Interviews*: Deliberately targeting experienced practitioners for interview, together with novice professionals and students, will provide much information on the meaning that practitioners and other stakeholders hold for the everyday activities and issues that relate to the problem area.
- *Focus groups interviews*: The strength of a focus group is that ideas can be bounced off other participants, often resulting in a more robust understanding of the issues, together with potential solutions and ideas for the design of the intervention.
- *Reflective journals or blogs*: Having the agreement of 2-3 teachers who are willing to commit to this reflective recording will provide an invaluable means to explore the problem area first hand.
- *Other types of data collection* can also be used in this consultation process, but written questionnaires and surveys (even those using open-ended questions) should be avoided, as they are less likely to provide the type of in-depth reflective data that is required to fully benefit from the experiences of practitioners.

The data collected from consultations with practitioners can be analysed for themes and issues, and importantly to determine whether any practice-based advice or heuristics can be obtained to inform the design of the intervention. Such ideas can form the basis of draft principles for use in the design phase of the research.

PHASE 2. Development of solutions using existing design principles and technological innovations

The second phase of educational design-based research focuses on a solution to the problem that can be implemented in the educational setting, such as a classroom or online learning environment. While a general

literature review is conducted in the first phase to inform the exploration of the problem, in this second phase the literature is again searched to find relevant theory that can guide critical and creative thinking, as well as existing design principles that may have addressed a similar or parallel problem. These principles (similar to the examples given earlier) inform the design of the learning solution or intervention that will potentially provide a solution to the problem.

Creation of draft principles to guide the design of an intervention takes careful thought and analysis because of the need to consider relevant learning theories together with existing principles, as well as ideas from the practitioners. As suggested by van den Akker (1999), using a stem (such as *[Condition x] may best be facilitated by learning environments that*:) will help to keep the principles quite specific and naturally prompt each to start with a verb (e.g., *allow, provide opportunities for, promote, enable, support*, etc.), which ensures that each principle can be related to an action or activity in the learning situation. Once the draft principles have been created, the proposed solution is designed and developed, according to the draft principles (Joseph, 2004). The design and development of the intervention will also be informed by evaluations conducted throughout planning and development, in particular, through needs assessments that inform design, and through formative evaluations that inform development (Reeves & Hedberg, 2003).

By the end of this process, draft principles will have been created from review of theory and research literature, from consultations with practitioners, and from previous research (such as a pilot study), and they will have guided the design and development of an intervention to address a significant educational problem.

PHASE 3. Implementation and evaluation in iterative cycles

The implementation and evaluation cycles of a mature product provide further opportunities to refine design principles. After the first full implementation of the solution with the target group of students and the analysis of the data, the learning environment is refined and then implemented again, in 'continuous cycles of design, enactment, analysis, and redesign' (Design-Based Research Collective, 2003, p. 5). At this stage, further reflection is also recommended for the guiding design principles themselves, and sometimes it is necessary to edit and refine them after analysis of initial findings.

PHASE 4. Reflection to produce design principles

Once a learning environment or intervention has been implemented, evaluated and refined in cycles, design principles can be 'captured' to comprise the sharable, published output from the research in order to inform future development and implementation decisions. This is done in iterative cycles of improvement that are not concluded until 'satisfactory outcomes have been reached by all concerned' (Reeves, 2006, p. 59). Design principles can be further refined by sharing them with other researchers and practitioners, through presentations and publications. Peer review of design principles is essential for the overall enhancement of professional practice to eventually yield improved educational outcomes, such as increased student engagement.

Using design principles to guide educational practice

It is unwise to consider design principles to be 'set in stone'. Instead, they are best regarded as informed reusable guidelines for others wishing to create their own solutions to educational problems across sectors. To further the idea of reusability, Collins, Joseph, and Bielaczyc (2004) aspired to the sharing of design principles across the wider community of educators:

> Our approach to design research requires much more effort than any one human can carry out … it will take teams of researchers and accessible archives documenting design experiments … to make these dreams at all possible. (p. 33)

At least one group has taken up this challenge in the form of the *Design Principles Database* (Kali, 2008; Kali & Linn, n.d.), developed and maintained by the Technology Enhanced Learning in Science (TELS) group. The web-based database contains hundreds of design principles, searchable by subject, audience and category. The database is intended to assist researchers to connect with others working in the same areas 'enabling designers to build on the successes and failures of others rather than reinventing solutions that others have struggled to develop' (Kali & Linn, n.d., para 1). The generation of principles specific to the conduct of design-based research has also been promoted by Ma and Harmon (2009) who argue that because of 'unresolved

methodological issues' researchers can also contribute to understanding of the approach by also 'reflecting on their methodology to generate principles on how to conduct design-based research' (p. 86). Some researchers have already contributed to this understanding, such Markauskaite and Reimann (2008) who have explored the potential of e-research to solve challenges of scaling design-based research findings.

Because of its iterative and consultative nature, design-based research is unlikely to engender researcher-imposed directives on how problems should be approached, or in the words of Anderson (2006) 'those types of research that unilaterally descend for testing in a classroom and then disappear with the researcher once the experiment has been concluded' (Anderson, 2005). Reeves (2006) also cautioned against the notion of researchers mandating procedures and processes for teachers to implement: 'Our goal should not be to develop esoteric theoretical knowledge that we think practitioners should apply' (p. 61). However, when presented in the form of design principles, research findings have the potential to effectively bridge the gap between educational theory and practice (Wang & Hannafin, 2005).

Conclusion

In an educational technology class entitled *Learning Sciences*, Park, Choi, and Hong (2010) employed the use of story telling as instructional elements in higher education. Small groups of students selected existing fairy stories or cartoons as analogies to instructional and research approaches. In their presentation of this paper, Park, Choi and Hong described the investigation of design-based research by a group who chose the analogy of the Coyote and Road Runner cartoons. In the cartoon series, the Coyote tries a variety of complex and repetitive means to catch and eat the Road Runner, methods that 'invariably fail in improbable and spectacular ways' (Wile E. Coyote and Road Runner, n.d.). The lack of carefully considered design principles is characteristic of the failure of the Coyote's methods, the lesson being that design principles could assist him to avoid making the same mistakes over and over again. This very apt analogy can be extended to classroom practices, where new processes (or indeed technologies) are employed without theoretical and pedagogical foundation and are thus doomed to fail in promoting student learning and engagement.

Higher education courses, units and tasks that are based on design principles have a solid foundation in theory and practice. They are based on the ideas of practitioners (many with a wealth of experience and knowledge), on the writings of theorists, and on the findings of researchers. They are implemented and evaluated ideally until almost all the problems have been addressed, so they have significant input from students who have been part of the successively improving iterations, and the teachers who have guided them. Such learning environments have a very good chance of engaging students in meaningful and rewarding learning activities.

Design-based research has the capacity to change the ways that researchers and practitioners together investigate and solve significant educational problems in powerful ways. As noted by Anderson (2006) 'design-based research does not seek for universal solutions but rather for deep understanding of innovations and the factors that effect improvement in local contexts'. Design principles assist not only in the development of these solutions but through dissemination, provide the means to extend the results of research beyond the local context to educators in similar and parallel contexts worldwide.

References

Anderson, T. (2005). Design-based research and its application to a call centre innovation in distance education. *Canadian Journal of Learning and Technology, 31*(2).

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of the Learning Sciences, 13*(1), 1-14.

Boud, D., & Knights, S. (1996). Reflective learning for social work: Research, theory and practice In N. Gould & I. Taylor (Eds.), *Reflective learning for social work: Research, theory and practice* (pp. 23-34). Aldershot: Ashgate.

Bradley, D., Noonan, P., Nugent, H., & Scales, B. (2008). *Review of Australian higher education: Final report.* Canberra: Commonwealth of Australia.

Bransford, J. D., Vye, N., Kinzer, C., & Risko, V. (1990). Teaching thinking and content knowledge: Toward an integrated approach. In B. F. Jones & L. Idol (Eds.), *Dimensions of thinking and cognitive instruction* (pp. 381-413). Hillsdale, NJ: Lawrence Erlbaum.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational*

Researcher, 18(1), 32-42.
Bryson, C., & Hand, L. (2007). The role of engagement in inspiring teaching and learning *Innovations in Education and Teaching International, 44*(4), 349-362.
Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *Journal of the Learning Sciences, 13*(1), 15-42.
Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5-8.
Dickey, M.D. (2005). Engaging by design: How engagement strategies in popular computer and video games can inform instructional design. *Educational Technology Research and Development, 53*(2), 67-83.
Johnson, L., Smith, R., Willis, H., Levine, A., & Haywood, K. (2011). *The 2011 horizon report*. Austin, Texas: The New Media Consortium. Available http://www.nmc.org/publications/2011-horizon-report.
Joseph, D. (2004). The practice of design-based research: Uncovering the interplay between design, research, and the real-world context. *Educational Psychologist, 39*(4).
Kali, Y. (2008). The Design Principles Database as means for promoting design-based research. In A. E. Kelly, R. A. Lesh & J. Y. Baek (Eds.), *Handbook of design research methods in education: Innovations in science, technology, engineering, and mathematics learning and teaching* (pp. 423-438). New York: Routledge.
Kali, Y., & Linn, M. (n.d.). Design principles database Retrieved 17 February, 2011, from http://www.edu-design-principles.org/dp/aboutDPD.php
Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University.
Ma, Y., & Harmon, S. W. (2009). A case study of design-based research for creating a vision prototype of a technology-based innovative learning environment. *Journal of Interactive Learning Research, 20*(1), 75-93.
Markauskaite, L., & Reimann, P. (2008). *Enhancing and scaling-up design-based research: The potential of e-research.* Paper presented at the Proceedings of the 8th international conference on International conference for the learning sciences, Volume 2.
McKenney, S., Nieveen, N., & van den Akker, J. (2006). Design research from a curriculum perspective. In J. van den Akker, K. Gravemeijer, S. McKenney & N. Nieveen (Eds.), *Educational design research*. London: Routledge.
McLoughlin, C. & Oliver, R. (2000). Designing learning environments for cultural inclusivity: A case study of indigenous online learning at tertiary level. *Australian Journal of Educational Technology*, 16(1), 58-72. http://www.ascilite.org.au/ajet/ajet16/mcloughlin.html
Oliver, R. (2000). When teaching meets learning: Design principles and strategies for Web-based learning environments that support knowledge construction. In R. Sims, M. O'Reilly & S. Sawkins (Eds.) *Learning to choose. Choosing to learn. Proceedings of the Australian Society for Computers in Learning in Tertiary Education 2000 conference* (pp. 17-28), Southern Cross University, Coffs Harbour, Australia.
Park, S., Choi, H., & Hong, Y. (2010). Utilizing storytelling as an instructional element in higher education. In Z.W. Abas, I. Jung & J. Luca (Eds.), *Proceedings of the Global Learn Asia Pacific 2010 Conference* (pp. 3442-3445). Chesapeake, VA: AACE.
Reeves, T. C. (2006). Design research from a technology perspective. In J. van den Akker, K. Gravemeijer, S. McKenney & N. Nieveen (Eds.), *Educational design research* (pp. 52-66). London: Routledge.
Reeves, T. C., & Hedberg, J. G. (2003). *Interactive learning systems evaluation*. Englewood Cliffs, N.J.: ETP.
van den Akker, J. (1999). Principles and methods of development research. In J. van den Akker, N. Nieveen, R. M. Branch, K. L. Gustafson & T. Plomp (Eds.), *Design methodology and developmental research in education and training* (pp. 1-14). The Netherlands: Kluwer.
van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (Eds.). (2006). *Educational design research*. London: Routledge.
Wang, F., & Hannafin, M.J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5-23.
Wile E. Coyote and Road Runner. (n.d.). In *Wikipedia*. Retrieved June 21, 2011, from http://en.wikipedia.org/wiki/Wile_E._Coyote_and_Road_Runner.

Contact details:
Jan Herrington,
School of Education, Murdoch University,
90 South St,
Murdoch, Western Australia, 6003
Email: j.herrington@murdoch.edu.au Phone: +61 8 9360 6256
Please cite as: Herrington, J. & Reeves, T.C. (2011). Using design principles to improve pedagogical practice and promote student engagement. In G. Williams, P. Statham, N. Brown & B. Cleland (Eds.), *Changing Demands, Changing Directions. Proceedings ascilite Hobart 2011*. (pp.594-601).

http://www.ascilite.org.au/conferences/hobart11/procs/Herrington-full.pdf