Using a design-based research paradigm to develop an online course aimed at disseminating research findings and informing practice

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Publication Details
This conference paper was originally published as Hood, G, Using a design-based research paradigm to develop an online course aimed at disseminating research findings and informing practice, Proceedings of the Emerging Technologies Conference, University of Wollongong, 18-21 June 2008.
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Between 1999 and 2003 the TIMSS Video Study (Mathematics) analyzed 638 eighth-grade classes from seven countries. Findings are published in two written reports and a set of twenty-eight public release lessons. This paper examines the development of an online course aimed at disseminating the study’s research findings to educators to inform their practice. The development was guided by design-based research. Solutions to three components, content and pedagogy, technology and implementation, were developed independently with the overall solution relying on their smooth integration. The paper discusses the process including the selection of guiding principles and the iterative cycles of testing and refinements.

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This conference paper is available at Research Online: http://ro.uow.edu.au/etc08/11
Using a design-based research paradigm to develop an online course aimed at disseminating research findings and informing practice

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Abstract:
Between 1999 and 2003 the TIMSS Video Study (Mathematics) analyzed 638 eighth-grade classes from seven countries. Findings are published in two written reports and a set of twenty-eight public release lessons. This paper examines the development of an online course aimed at disseminating the study’s research findings to educators to inform their practice. The development was guided by design-based research. Solutions to three components, content and pedagogy, technology and implementation, were developed independently with the overall solution relying on their smooth integration. The paper discusses the process including the selection of guiding principles and the iterative cycles of testing and refinements.

Background
The TIMSS, Trends in International Mathematics and Science Study measures trends in students’ achievement in mathematics and science. The study is conducted on a 4-year cycle and involves approximately 40 countries with students from levels 4, 8 or 12. In 1995 and 1999 the TIMSS Video Studies were conducted as part of TIMSS. The TIMSS 1995 Video Study videotaped and analyzed mathematics’ classrooms from three countries, the United States, Japan and Germany, while the TIMSS 1999 Video Study videotaped and analyzed mathematics and science classrooms in seven and five countries respectively.

One of the most important findings in the first study was that teaching is a cultural activity, that is, teaching varies far more across cultures than within cultures. However, since Japan was the only high achieving country in this study, an unwarranted conclusion was that emulating Japanese teaching must be the key to raising the achievement of students in the United States. From the TIMSS 1999 Video Study (Mathematics) report (Hiebert, Gallimore et al. 2003):

The TIMSS 1995 Video Study included only one country with a relatively high score in eighth-grade mathematics as measured by TIMSS - Japan. It was tempting for some audiences to prematurely conclude that high mathematics achievement is possible only by adopting teaching practices like those observed in Japan. The TIMSS 1999 Video Study addressed this issue by sampling eighth-grade mathematics lessons in more countries—both Asian and non-Asian countries—where students performed well relative to the United States on the TIMSS 1995 mathematics assessments.

The 1999 TIMSS Video Study (Mathematics) analyzed videotaped lessons and artifacts from 638 eighth-grades in the seven participating countries - Australia, Czech Republic, Hong Kong SAR, Japan, Netherlands, Switzerland and United States. The videotaping commenced in 1999, and following extensive analyses, the results were published in 2003. These consisted of a 236 page report.
(Hiebert, Gallimore et al. 2003), a technical report of 533 pages (Jacobs, Garnier et al. 2003), and a set of twenty-eight public release lessons representative of the findings for each country. One of the objectives of the Study, (Hiebert, Gallimore et al. 2003, p.15) was:

To develop methods for communicating the results of the study, through written reports and video cases, for both research and professional development purposes.

This paper is about the development of one such method for teacher professional development. In this case, the objective was to design an online course that would enable participants to understand the research and some of its outcomes, to see what these looked like by analyzing lessons from the study and to be able to transfer acquired insights to the participants’ own practice where applicable. The outcome was a ten-hour interactive online course TIMSS Video Studies: Explorations of Algebra Teaching (Hiebert, Hood et al. 2003).

The research framework

A design-based research paradigm was used to develop, implement and evaluate the online algebra course. Many terms have been used to describe this paradigm including formative research, design experiments, development research and design research, prior to the term, design-based research, becoming more widely adopted (Reeves 2000; The Design-Based Research Collective 2003; Peterson and Herrington 2005, p.3; Reeves 2006; van den Akker, Gravemeijer et al. 2006). Central to designed-based research is the development of plausible solutions, informed by known and hypothetical design principles, to complex problems by practitioners, researchers and technologists working in collaboration. The stages of design-based research, its cyclic nature and the essential role of design principles to inform the development of solutions to the problem being solved, are illustrated in Figure 1 from Reeves. After the cycles of testing and refining the solutions in practice, the solutions along with their design principles are produced.

Figure 1 Design research approach in educational technology research (Reeves 2006)

Stage 1: Collaborative analysis of the problem

Stage 1 of this project occurred at an initial design meeting when the stakeholders met for the first time to start the analysis process. Stakeholders were LessonLab, the company responsible for the TIMSS 1999 Video Study and developers of the online software to be used for the course; Intel® Corporation’s Innovations in Education
Foundation; and the University of California Los Angeles (UCLA). Each stakeholder’s team members provided expertise in one or more areas needed for this project – research in education, teacher professional development both face-to-face and online, mathematics content and pedagogy and technology development and application – a real “collaboration among practitioners, researchers, and technologists” (Reeves 2000, p.10).

Participants in the initial planning meeting in Stage 1 agreed that the course should address the broad question “What does mathematics teaching look like in high-achieving countries?” with the focus being on algebra teaching. After extensive viewings and discussions, the group selected eight public release lessons to be used in the course and designated which of these would play major (3) or minor (5) roles. It was agreed that individual video-case studies would be built in the course around the major lessons and suggestions were made about the research findings to be included.

**Guiding Principles**

Design principles to inform the development process were discussed at this time. Educational philosophy from Dewey to the present day, and the years of educational experience of the research group provided a rich source from which to draw the principles. Dewey emphasized the importance of constructing knowledge in an article in *Science*, 1910, as he talked about the difference between knowledge and information. “Only by taking a hand in the making of knowledge, by transferring guess and opinion into belief authorized by inquiry, does one ever get a knowledge of the method of knowing.” The research group strongly believed that the course should provide participants with the experience of constructing their own knowledge about the research and lessons in the course.

On the knowledge needed by teachers, Dewey, in the *National Society for the Scientific Study of Education, Third Yearbook, 1904*, identified two distinct areas: content (“Mastery of subject-matter from the standpoint of its educational value and use”) and pedagogical knowledge (“…mastery of the technique of class management”), and acknowledged their inter-connectedness (“… the mastery of educational principles in their application to that subject-matter …”) (Dewey 1974). In the early 1980s Shulman identified the inter-connectedness of content and pedagogical knowledge using the term pedagogical content knowledge (Shulman 1986; Shulman 1987). It is “the key to distinguishing the knowledge base of teaching” and is “the intersection of content and pedagogy, in the capacity of a teacher to transform content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background of the students” (Shulman 1987, p.15). Shulman suggests four sources for the teaching knowledge base: scholarship in content, educational research, the wisdom of practice (an understanding of “the maxims that guide” … “the practices of able teachers”), and, materials and settings. The first three of these are central to the course. It was agreed that the course would focus on the mathematical content of the lessons, would link the research findings selected for the course to the lessons where practicable and, through video, would give participants the experience of analyzing aspects of lessons hence promoting the wisdom of practice.
Ball and Cohen suggest that teachers need opportunities to “become serious learners in and around their practice”. Teacher learning is often expected to just happen and, without access to a means of expanding their knowledge on teaching, teachers use their own teaching experience as the basis for change and ideas. Over time, practices of experienced teachers can become deeply embedded and new ideas or unfamiliar practices can be very challenging. Experience does not necessarily equate with expertise and in many cases this, and pre-service experiences, can work against the improvement of teaching (Ball and Cohen 1999; Stigler and Hiebert 1999; Elmore 2002). Effective teacher professional development must provide the means for teachers to expand their professional knowledge of teaching and then to apply this new knowledge to their practice.

The use of video is one way to do this. Video brings the classroom to the participants providing the opportunity to see within, without being there. It can be stopped, replayed, and different segments or moments selected as a focus (or foci) within the professional development domain (Brophy 2004; Le Fevre 2004; Borko, Jacobs et al. 2008). The TIMSS public-release lessons were selected to be representative of the research findings for each country and thus provide a database for analysis, comparison and contrast of teaching in other cultures. The lessons take teachers into unfamiliar territory and require them to rethink their experiences in many ways such as curriculum, student thinking, the pedagogy of the classroom and the evidence of learning. It opens the way for teachers to expand their professional knowledge of teaching by moving “them beyond their own personal and educational experience” providing “positive disequilibrium” and a “new terrain for learning” (Ball and Cohen 1999). The challenge for the design group was to make this a positive experience with participants developing an understanding that both expands, and transfers to, their own practice.

Another advantage of using video is that, according to McLellan (1993), it satisfies the authentic activity basis of situated learning (cited in Herrington, Herrington et al. 1998, p.93). Collins (1988) defines situated learning as “the notion of learning knowledge and skills in contexts that reflect the way the knowledge will be useful in real life”. A list of nine critical characteristics for designers of situated learning environments developed by Herrington and Oliver (1995) succinctly cover the features of situated learning and were used to inform the project (Herrington and Oliver 1995; Herrington, Herrington et al. 1998).

Within the situated learning framework three video-cases were designed to develop teachers’ analytical skills. Each case uses one lesson as a focus and provides activities and expert input to scaffold participants through the content and pedagogy of the lesson. “While each teacher will interpret the case in his or her own terms and focus on different aspects of the case, the case itself offers a common reference point and a shared experience.”(Clarke and Hollingsworth 2000) The second and third cases build on the previous one(s) promoting wider analyses.

The scaffolding model to support the use of the online technology was based on the work of Salmon from the book, E-Moderating: The Key to Teaching and Learning OnLine (Salmon 2000). Salmon acknowledges that online learning can lead to very rich discussions...
and learning taking place but, as in all learning situations, this doesn’t happen automatically. Salmon’s model identifies five stages in successful online learning. For participants to reach each stage and progress to the next, they must have the opportunity to acquire the necessary technical skills, be given the right amount of facilitation and be provided with appropriate activities in the online course. The interactive components of the software, support materials and processes were designed with these stages in mind.

The main design principles informing the development of the online course were to provide opportunities for participants to construct their own knowledge; to increase content understanding; to focus on pedagogical content knowledge; to develop lesson analysis skills; and to transfer gained knowledge to participants’ own practice. To support flexible delivery options, other design principles included providing expert input on subject content and pedagogy; and scaffolding participants through the online learning environment with the aim for them to reach stage 5 of Salmon’s model (‘Development’) and become independent learners.

Stage 2: Development of the solutions

After the overall analysis of the problem, the group split into three for Stage 2 - course content and pedagogy, technology, and planning for implementation (Figure 2).

![Adaptation of Reeves diagram](image)

While each component of stage 2 addressed complex problems, and solutions were developed independently by teams drawn from the stakeholders, the overall solution depended on the smooth integration of the individual solutions. Overlap ensured that teams had insight into progress and possible problems of each component during the development phase. The author of this paper, based at LessonLab, was a member of each team and had overall responsibility for the project.
Stage 3: Iterative cycles of testing and refinement

Four pilots were conducted during stage 3 of the design-based research. These covered the range of proposed delivery options – the first was totally face-to-face with optional online exploration between sessions; the second had face-to-face sessions to start and finish, with facilitated online work between; the third was totally online and non-facilitated; and the fourth was totally online with facilitation (summary details in Figure 4). The pilots tested the three areas of content and pedagogy, technology and implementation, and refinements were made after each and tested in the next iterative cycle.

<table>
<thead>
<tr>
<th>Stage 3 Testing and refinement</th>
<th>Pilot 1</th>
<th>Pilot 2A</th>
<th>Pilot 2B</th>
<th>Pilot 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>34</td>
</tr>
<tr>
<td>Face-to-face (F2F) meetings (hours)</td>
<td>3 + 3 + 2</td>
<td>2 + 1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Online work (hours)</td>
<td>2</td>
<td>7</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Online facilitation (Yes/No)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Registration (F2F guidance or remote)</td>
<td>F2F</td>
<td>F2F</td>
<td>Remote</td>
<td>Remote</td>
</tr>
<tr>
<td>Order course online</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Course materials (Guide and CD)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Video consent forms</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>TIMSS confidentiality forms</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Research consent forms</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Evaluation 1 - Demographics</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Evaluation 2 - Post course</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Evaluation 3 - online experience</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>F2F debrief feedback session (hours)</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Journals collected</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Session videotaped</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Pre and Post-online testing</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Phone &amp; online tech support</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Participant stipend (IDC=Intel Digital Camera)</td>
<td>$300+IDC</td>
<td>IDC</td>
<td>IDC</td>
<td>$80</td>
</tr>
</tbody>
</table>
Facilitation training and materials were developed, piloted and refined after the course design had been completed. This is beyond the scope of this paper but is important as some changes were made to the course as a result of this experience.

**Stage 4: Reflection on the solution and design principles**

The outcome of the design-based research was a coherent online course and implementation model informed by the iterative cycles of testing and refinement. The discussion below will focus on the course content and its development.

The course software is structured around topics and it is expected that, in general, participants will progress linearly from the *Introduction* through to *Reflections*. However each topic in this course is designed to be standalone and can be used in different ways to cater for a variety of implementation modes. The topics were designed to move participants through the process of first understanding research methodology; then to exploring some of the research findings; onto developing lesson analysis skills; and finally, to applying insights gained to their own teaching.

Since it was expected that, for many participants, this would be their first experience of online professional development and, hence, of sharing ideas online, the order and make-up of the topics were designed to scaffold this experience. For example in the *Introduction*, as well as learning about the course and software, the participants experience constructing, posting and reading responses online by completing their first interactive task *Tell us about yourself*. Reaching this point is an indication they have moved through Salmon’s first two stages (‘Access and motivation’ and ‘Online socialization’) and should be ready for stage 3 (‘Information exchange’) and then the more active learning of stage 4 (‘Knowledge construction’). This scaffolding was found to be very successful and was adopted.
EMERGING TECHNOLOGIES CONFERENCE: Supporting a learning community

The online task in the next topic Initial Explorations shows the opening sequence of the four minor lessons and asks participants to comment on what they can infer about each teacher’s goal(s) and emphasis (Figure 6). For many participants this will be their first experience of viewing classrooms from other countries. This task simulates the process the TIMSS Video Studies researchers used thus satisfying the authentic task component of the design principles. It links to the next course topic; sets the scene for the more formal analyses of teaching in the cases that follow; and continues to scaffold through Salmon’s model. Throughout the course, the online tasks encourage participants to move to a higher level of thinking as they share their own ideas and then read and reflect on responses from other participants. Strategically placed forums further support this process.

The first cycle of testing resulted in a change to this task. LessonLab’s philosophy at the time was that videotaped lessons should be presented unedited and clips to be watched accessed by linked time-markers. In the first pilot, participants quickly ‘discovered’ (both deliberately or accidentally) that by clicking the play button on the embedded video player they could watch beyond the set clip. Some participants became so involved watching the first lesson, that they completed only one question in the time allocated at the face-to-face pilot, rather than the four expected. As a result, video clips were made to use in the questions, and the full lessons were made available separately in the course resources.

A discussion on the research methodology and selected findings of TIMSS Video Studies in the topic TIMSS 1999 Video Study Up Close links topics by referencing the videos the participants have already seen and provides foci for the case studies that follow (Figure 7).
After the first pilot it was decided that classroom examples of one of the findings (problem type ‘Making connections’), a focus of the course, needed to be added. A task, Reflecting on Mathematical Thinking, applying some of the research findings to a US lesson clip, was originally placed at the end of the research topic. For pilot 4 it was decided to use this task as a pre and post test to see if there was a measurable difference in participants’ understanding after completing the course. It was during this exercise that the realization came that this was the wrong place for the task as participants had not worked through the cases aimed at developing their analytical skills. The task was shifted to the Reflections topic at the end of the course.

The other change to the research topic was the addition of a forum where participants could discuss the research. This was added at the request of facilitators after a facilitator training session and, thus, was not a refinement from the initial iterative cycles.

The three video case studies follow the same format: general information on the lesson and class; content exploration; lesson exploration; expert content commentary; lesson analysis; and expert viewpoints on the lesson. Each case starts with participants solving and posting solutions to the problem of the lesson before they explore the videotaped lesson.

During the first pilot, this task was completed face-to-face with participants being given a copy of the problem and then sharing their solutions publicly with the group. Unfortunately several participants misunderstood the question and gave an incorrect solution causing some embarrassment. After they had watched the teacher present the problem to the class, they understood their misunderstandings. As a result, the online task was changed so that participants work the problem but then watch the teacher presentation before submitting their solutions. This also reinforces the importance of the way problems are presented in the mathematics classroom.
The lesson exploration is guided, due to the course time constraints, and provides participants with an overall feel for the lesson and a chance to form their own opinions before the analysis stage (Figure 8). To ensure that participants have a comprehensive understanding of the content, and to cater for different implementation models, expert discussion of the content is provided before the lesson analysis. Like the exploration, the analysis is guided by the task questions and links to selected sections of the lesson. It aims to develop a deeper pedagogical understanding of the classroom. The analysis task is followed by an online forum where participants have the chance to discuss the lessons in more detail. The forum for each case references its own and the preceding case(s). Viewpoints: Thoughts on the lesson concludes each case and provides an expert overview of the lesson focusing on pertinent aspects of the mathematics and pedagogy.
The final topic, Reflections, is where participants have the opportunity to reflect on what they have learnt in the course, transfer insights to their own teaching, reflect on the experience and report back to the group (Figure 9). The importance of this topic was reinforced during the first pilot when, after completing Case One: Japan, a participant returned the next week proudly carrying a video-tape of himself teaching a lesson in the Japanese style.

**Conclusion**

At the end of the design-based research, the course was made available to individuals and groups. An anonymous online evaluation (Zoomerang 1999) was added for all users. Some results are included here.

### Question 12: Did you learn anything new about mathematics?

<table>
<thead>
<tr>
<th>Response</th>
<th>Number of Responses</th>
<th>Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>140</td>
<td>55%</td>
</tr>
<tr>
<td>No</td>
<td>119</td>
<td>45%</td>
</tr>
<tr>
<td>Total</td>
<td>259</td>
<td>100%</td>
</tr>
</tbody>
</table>

Question 12 indicates that fifty-five percent of the 265 respondents learnt something new about mathematics. Since the majority of participants are mathematics’ educators and the lessons in the course focus on grade 8 mathematics, this may be quite surprising. Ninety percent of the 260 respondents to Q13 learnt something new about teaching – a clear indicator for the design team that the course has successfully expanded the participants’ knowledge of teaching (Shulman 1987; Ball and Cohen 1999).
In response to whether or not their teaching may change as a result of the course, eighty-five percent of the 266 respondents thought that it would somewhat (50%) or significantly (32%). Only one percent thought it would not change at all. Question 15 shows the flexibility of delivery methods experienced by respondents.

The principles used, tested and refined during the development of the TIMSS Video Studies: Explorations of Algebra Teaching course continue to inform the design of courses at LessonLab. The opportunities for participants to construct and share their own knowledge; the guided development of lesson analysis skills; the emphasis on content understanding; the focus on pedagogical content knowledge and the transfer of knowledge to participants’ own practice are all an integral part of LessonLab online courses designed for teacher professional development. Expert input on content and pedagogy are provided either in video or text form and tasks are designed to scaffold participants through the online learning environment with the aim for them to become independent learners by moving through the five stages of Salmon’s model (Salmon 2000).

Acknowledgments

This paper is based on the thesis I am writing as a Doctor of Education student in the Faculty of Education at the University of Wollongong. For the development of ideas in the thesis, I am indebted to my two supervisors, Professor Barry Harper and Associate Professor Tony Herrington.

References


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