Some Reactions of a Design Researcher

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In reading the contributions to this section, I am impressed by their diversity. These pages offer analyses of classroom resources (U.S. textbooks, digital media, Mesopotamian clay tablets); professional development resources; and a number of theoretical frameworks and tools. These artifacts and constructs have arisen from different cultures at different times and have been used in different ways. This is a fascinating collection.

Remillard’s chapter notes that each reader enters a particular relationship with the ideas in a text and adopts a particular mode of engagement. In my own case, I read these texts as an educational designer and design-researcher. My area is in the design and development of classroom and professional development resources that equip teachers to transform the experiences of students so that they become more active, creative, and reasoning participants in the learning process. These include multimedia professional development resources and lesson descriptions that enable teachers to become aware of the pedagogical challenges. This has led me to adopt a research approach that belongs to an emerging family of related approaches, known variously as formative research, engineering research (Swan, 2006), developmental research (Gravemeijer, 1998), design experiments (Schoenfeld, 2004), and design research (van den Akker, 1999; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). From this standpoint, I read these chapters with two questions in mind: What intentions and values are apparent in the materials and tools presented? How can I use these tools to improve my analysis of the ways in which designs are transformed in the hands of teachers and thus improve my own design process?

The chapters by Schmidt and Proust both, in different ways, attempt to infer the teachers’ and pupils’ activity and experience of mathematics from an analysis of artifacts. Unlike the remaining chapters, neither calls on direct classroom observation. Schmidt considers the current situation of current mathematical textbooks in the United States, while Proust takes us back 4000 years to school materials used in ancient Mesopotamia.

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The U.S. educational system is perhaps more textbook dependent than most other cultures. Textbook production is a huge commercial business and its products are weighty tomes (Schmidt notes that the eighth-grade textbooks average 700 pages) that attempt to contain the union of content required by different state and school district adoption systems. Schmidt takes as his starting point the assumption that “textbooks are a particularly accurate reflection of the implemented curriculum in the US” and that they provide a measure of “the curricular experience of individual students”. He then uses weighted page counts to analyze the mathematical content to which students at different grade levels are “exposed”, where these weightings are based on content difficulty. He finds that the number of pages increases to a peak in Grade 10 and declines thereafter; that the content is demanding and repetitive: “a mile wide and an inch deep”; and that the long-term cumulative effect of tracking widens inequities in terms of “exposure to more challenging mathematics”. Unlike other authors in this section, Schmidt makes no allowance for the qualitatively different ways in which the same textbooks may be interrogated and used. His assumptions, whatever their validity in the United States, would not apply to other cultural situations, such as England, where there is no textbook adoption process and where experienced teachers use them only selectively. In England, schools’ inspectors criticize textbooks for focusing too much on providing practice for examination questions and for failing to promote understanding, connections, and enquiry. They note how effective teachers compensate for this (like Ms. Jordan in Remillard’s chapter) but “in less confident hands” the subject is reduced to “techniques for passing examinations” (Ofsted, 2006). Exposure to textbooks does not correlate with “experiencing mathematics” in my view.

In contrast, Proust takes us back 4000 years to school materials in ancient Mesopotamia. The artifacts she considers are clay tablets used in scribal schools – institutions where discipline was harsh. She shows how the tablets produced by students enable her to reconstruct a “fairly accurate picture” of the curriculum, pedagogy, and concepts taught. The activities involved reproducing, memorizing, and practicing measure systems, calculations, and lexical lists. One design feature that I found interesting was the organization of the memorization exercises. Counter-intuitively, the difficult exercises came earlier, presumably so that they were practiced more frequently and students would not miss them.

Mathematics curricula have always valued the memorization of facts and fluency in calculation. Internationally, there is a widespread view among educationists that such aspects are over-valued at the expense of understanding concepts and representations, developing strategies for investigation and problem solving, and appreciating the power of mathematics in society (Swan & Lacey, 2008). In the United States, for example, the widely adopted Common Core State Standards for Mathematics (NGA & CCSSO, 2010) include specific references to the importance of developing “Mathematical practices”; in the UK the most recent national curriculum documents emphasize the importance of “Key” mathematical processes (QCA, 2007); across the EU there are calls to include an increased emphasis on “inquiry based learning” (Rocard, 2007). Such aspects, however, remain separated and marginalized in teachers’ practices and textbooks continue to assume a
pedagogy of the “teacher explanation, demonstration, then student practice” kind where exercises progress gradually from the easier to the harder. There is a considerable mismatch between the values and the content presented in most resources and the aspirations articulated in such national documents. These aspirations cannot become reality without well-designed products and processes that exemplify how they may be interpreted in classrooms and examinations.

The chapters by Remillard, Ruthven, and Pepin each considers resources that have a transformational agenda: to replace “traditional” didactic transmission approaches with problem-solving approaches. While Remillard considers the U.S. context, with its agenda of reform through the *NCTM Standards* (*NCTM*, 2001), Ruthven and Pepin consider the UK context. The difficulty for designers, as these authors ably show, is that teachers interpret and mutate even the most carefully designed materials in unintended ways. In addition, these authors propose analytical tools that may help us to better understand and anticipate these mutations.

As Remillard describes, every curriculum designer has in mind an audience and seeks to enlist a particular kind of participation through a *mode of address*. Many textbook authors and educational designers prepare materials as if they were writing for themselves, tacitly assuming that teachers will share their values and pedagogical assumptions. Some abdicate from all responsibility for how their materials are used, claiming that teachers must use their own “professional judgment”. Others take their responsibility more seriously and include lesson plans, teaching guides, and resources that attempt to explain the theories that underpin the material. This creates additional complexity, and the materials can become less accessible. Of course it is impossible to create materials that are “teacher proof”, as Ruthven notes, but it is possible to systematically research the range of “interpretative flexibility” that is employed through careful, iterative phases of classroom trialing, observation, and redesign. Classroom trialing is not there to simply “fix” mistakes and omissions in the materials, but it is also intended to evaluate the range of ways in which teachers make use of the materials and to incorporate their wisdom and experience in succeeding versions. In our own materials, we also collect students’ work during trials and then use samples of these as stimulus student material in the next revision. Students are encouraged to analyze alternative approaches, critique and correct the work, and refine their own arguments. This careful process of iterative analysis and redesign is slow and difficult and requires a close interplay of research and development.

The value in Remillard’s chapter for me is that she offers a taxonomy for analyzing the structure and form of classroom material and ways of describing the teachers’ engagement with it. This could form a valuable part of the design-research process and alert a designer to aspects that are often ignored. For example, the final *form and look* of materials is often left to a commercial publisher, yet this is a crucial aspect of task design. In my own work, for example, I found empirically (*Swan*, 2006) that when I wanted students to discuss and debate some aspect of mathematics, then I needed to design resources to be shared. This required resources in a larger format, making use of posters and cards that could be cut out and moved around, so that students could more easily see them, share ideas and collaborate. We
learned from trials that teachers were much less likely to use discussion in learning if we restricted the resources to textbooks.

Ruthven’s chapter similarly draws attention to often neglected aspects of the context that influence the ways in which teachers use digital resources, in particular dynamic geometry software. Although this software was designed without an explicit pedagogical model in mind, it quickly became valued as a tool for promoting collaborative, “discovery” learning in geometry. When digital resources are observed in use, however, it quickly becomes apparent that well-designed software in the hands of experienced teachers does not necessarily result in mathematical activity. Computer feedback, for example, often encourages trial and improvement rather than the formulation, testing and validation of hypotheses (Joubert Gibbs, 2007). Ruthven examines the appropriation of dynamic geometry software by one teacher using a broad analytical framework that outlines some of the tensions and difficulties that arise. This includes: the working environment (e.g., changing rooms), the resources available (e.g., making links between manual geometrical constructions and computer-based ones), teachers’ patterns of classroom behavior (the tension between individual exploration and productive discussion), the “curriculum script” (the potential actions within the teachers’ repertoire, particularly when surprises occur) and the pressures of time (the tension between covering the curriculum and securing student learning). This framework is very helpful to the design-researcher. It is sobering to realize that dynamic geometry software is now used only rarely in England, and then often as only a demonstration device. This again underlines the importance of designing experiences rather than products. By this, I mean that the typical end-user should be observed using prototypes in realistic circumstances throughout the design process.¹ Far from ignoring or abdicating the responsibility for the way our materials are used, we should begin to analyze and describe how they have been used effectively and incorporate these descriptions into the materials themselves.

This brings us to the issue of professional development. Pepin notes how new mathematical materials are beginning to recognize the importance of building opportunities for teacher learning into their design (DfES, 2005). Pepin describes her own work with teachers and reflects on the nature of the conceptual tools that teachers need in order to make sense of classroom tasks. The specific tools she describes – her “task analysis tools” – are similar to tools I have also used with teachers (see for example MARS (1999, 2000) and Swan & Crust (1992)). These are powerful in focusing attention on the purpose of classroom tasks and the potential for learning that a task provides. As Pepin notes, they can also serve to enable teachers to audit their curriculum and assessment provision and create tasks for themselves. The context in which Pepin uses these tools is that of a collaborative, mediated, professional development “course”. In my own work we are currently seeking to develop professional development tools for other contexts – the lone

¹ As Steve Jobs told his staff at Apple, back in 1997: ‘You’ve got to start with the customer experience and work back to the technology – not the other way around’ (Arthur, 2010, p. 27).
teacher and the teacher working in school-based groups with no external mediation. The design considerations here are similar to those confronting the designer of classroom materials, but this context is clearly more difficult to observe and is currently under-researched. Such materials equip teachers with a framework and language to critique classroom materials and reflect on their own values for education. This is particularly true if they are presented in a way which they can modify and make their own, as Pepin does.

One reason why educational research is generally regarded as neither influential nor useful is that the importance of systematic research-based design is undervalued and its difficulty underestimated (Burkhardt, 2006; Burkhardt & Schoenfeld, 2003). All too often, designers marginalize teachers in the creation of materials and researchers regard classroom contexts and teachers’ practices as so intractable and individual that materials appear almost irrelevant. Educational interventions are (of course) context sensitive and we need more research to understand which contextual factors are critical and which are not and more observational data of materials in action so that we can improve them by building in the productive adaptations made by teachers (Burkhardt & Schoenfeld, 2003). This is labour intensive and requires a collection of well-engineered tools for analysis. I am grateful to these authors, for providing suggestions for tools that will help me to analyze the impact of my own educational designs in a more systematic manner.

References


