DRAFT (v2)

Response to *Learning Context: Gaming, Simulations, and Science Learning in the Classroom* by Chris Dede

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In this response I suggest that if games are going to gain traction in formal learning environments, we will need to attend to lessons learned from the last thirty years of research on the integration of technology into classrooms. This research has deeply informed Dede's work with *River City*, and is reflected in its scope and complexity, and most importantly in his commitment to investigating the process of scaling up such an ambitious simulation. But I see other lessons to learn from this body of work, which suggest some rather different paths for developing successful games for formal learning environments.

I read Chris' paper in the context of almost thirty years of effort, by many collegial organizations, to learn how to create the classrooms we can imagine classrooms where students use technology frequently and for meaningful purposes, the technology supports worthwhile kinds of teaching and learning, and the teacher remains a critical participant in a collaborative, people-rich learning experience. Achieving this vision has proven to be difficult, to put it mildly. Despite enormous investments in research, design, professional development, and implementation support, it is difficult to find a classroom today in which this vision is realized and sustained.

Many organizations have been involved in this work, studying many different kinds of applications and tools in technology-rich classrooms, including a range of simulations and supports for inquiry. Most of this research does not address games specifically, because electronic games are still rare in traditional science classrooms. Much of my response is grounded in this shared experience.

<u>Lessons from prior research on the implementation of innovations in classrooms</u>

I am using this too-brief summary of prior research to contextualize two major issues where my perspective on the circumstances of effective implementation seem to differ from Dede's. I suggest that two overarching lessons could be derived from a thorough review of this literature:

1. Creating games that can be successfully implemented by teachers in everyday classrooms will require attending to a series of institutional, curricular, and social realities that are often not considered when electronic games are created as environments for research or as proof-of-concept models. Focusing more on teachers' perspectives and classroom realities during the design process would imply a different pathway for design and development than Dede's model, which seeks to protect designers' vision from being "undercut" by teachers.
2. Specific characteristics of innovations, and the conditions of their introduction, can positively influence teachers' willingness and ability to adopt those innovations and implement them well. This suggests that we can design for and support evolutionary, incremental change in classrooms, in addition to modeling more revolutionary shifts in practice such as those Dede envisions. Supporting evolutionary change will require learning more about how to design electronic games for learning that can

> thrive in the context of modest changes in the classroom, and how to sustain and leverage those incremental changes over time.

The brief review below draws on an extensive literature on the implementation of technological innovations at multiple levels of the educational system. It draws primarily from work in the learning sciences and from program evaluations, including studies of individual software tools, innovative science curricula, and systemic reform efforts.

<u>Classroom factors that impact the integration of innovative technologies</u>

Single-classroom studies of student interactions with individual pieces of software provide important evidence of the dramatic difference between the potential value of student-software interactions in isolation, and the nature of those interactions when they are embedded in the larger ecology of the classroom. Since early studies of students' use of Logo in the classroom (Sheingold, Hawkins, & Chen, 1987), researchers have sought to understand how best to design innovations in concert with, rather than in spite of, classroom realities. This issue continues to be a theme within the field of the learning sciences, where design experiments and other related approaches to design-focused research have provided extensive documentation of the challenges involved in creating technological tools that can support powerful learning outcomes while also thriving in real implementation contexts (see Sawyer, 2005, for a recent overview of the field of the learning sciences as a whole).

A second significant body of work has investigated the implementation of technology-rich science curricula.[1] These projects embed software-based scaffolding in curricular structures, often seeking to facilitate student inquiry or project-based learning. This body of work documents repeatedly the contrast between the intents of program designers and the features of actual classroom implementation. For example, SRI's long-term evaluation of the GLOBE project, an environmental science program that involves students in collecting data that is used by working scientists, has generated detailed examinations of how an inquiry-base science curriculum varies across widely varying contexts (Penuel, Korbak, Lewis, Yarnall, & Zander, 2004).

While practical constraints often play a significant role in shaping implementation (Hawkins, Culp, Gilbert, Mesa, Schwartz, 1999), and vary widely across settings (Martin, Hupert, Culp, Kanaya, & Light, 2004), gaps between teachers' and designers' perceptions of the nature of the goal to be achieved also played a significant role in shaping teachers' implementation choices. As the GLOBE project evaluation illustrates (Penuel, et al, 2004), when teachers engaged with a new project they consistently *accommodate* those elements of the program that they recognize and can match to their existing practice, rather than *adapting* their own perspectives to take on the values, goals and priorities implicitly or explicitly presented in the new curricula. This practice is largely linked to the multiplicity of pressures and inputs influencing teachers' practices, suggesting it is critical for designers to consider that the resources they are

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[1] Note that while some peer-reviewed literature on these kinds of projects exists, much of the relevant research has been conducted in the context of program evaluation, and exists as "grey literature," easily available but not part of the traditional peer-reviewed literature.

providing are only one of many influences acting on a teachers' beliefs and practices.

In additional to the pedagogical obstacles to effective implementation, teachers involved in evaluations of innovative science programs or trials of new software tools often report a range of practical obstacles to using these new resources. A range of survey studies documented these challenges during the 1990s (see for example Ronnkvist, Dexter & Andersen, 2000). The most recent Schools and Staffing Survey (administered 2007-8) has included an expanded set of questions about teachers' access to and use of technology, and will be an important source of more up to date data on teachers' views of these obstacles. Shrum and Glassett (2006) have also published a useful overview of the obstacles to implementation of technology-focused innovations.

Confronting the difficulty of spurring change in individual classrooms, researchers and developers have also embarked on ambitious projects to partner with districts and states to infuse technology into classroom and promote broad, systemic changes in curriculum and teaching. Literature on these kinds of large-scale technology integration initiatives is less directly relevant to the issues raised here, but should be considered, particularly in relation to the challenges of scale-up (see, for example, EDC's work in Union City (Carrigg, Honey & Thorpe, 2005), the LeTUS project's work with Detroit (Fishman, 2005), and the Maine Laptop Initiative (Silvernail, 2009).

Features that support teacher adoption and effective implementation

A recent strand in the learning sciences literature has drawn on new work in education policy studies (Coburn, 2006; Cohen & Hill, 2001; Honig, 2006; Honig & Hatch, 2004) to look broadly and systematically at whether and how innovations introduced within a state, district or school translate into adoption, implementation, and/or changes in practice in individual classrooms. These studies of the policy implementation process demonstrate that, classroom teachers engage in sometimes intense negotiations with other actors to determine whether and how new practices or resources will take root in their classrooms (see particularly Coburn, 2004).

Two main themes emerge from this work: first, that new initiatives often do an inadequate job of ensuring that local actors have the opportunity to fully understand the goals and intent of the newly introduced resources (see Cohen, 1990). Second, the extent to which new innovations are adapted and adopted into existing practice depends in large part on teachers' perceptions of the *local relevance* of the new initiative - their ability to find linkages between what the innovation appears to offer and the needs they can recognize among their own students, and their level of access to the associated resources that they need to make appropriate use of new resources (Cohen & Hill, 2001).

Learning sciences researchers are now beginning to build on these findings to examine the implementation of technology-rich projects in particular. One study (Penuel, Fishman, Gallagher, Korbak, & Lopez-Prado, 2008) focuses on a technology-rich innovative science curriculum that has been intensively supported in the state of California. They have found that state efforts to demonstrate the alignment of the new curriculum with state standards did little to promote take-up or implementation, because teachers instead looked for alignment of the new materials the content of the curricular materials already available to them, to their own teaching goals, and to their schools' stated goals which in turn were not necessarily aligned well with the state learning standards.

Another study offers a different perspective on the difficulty of making technological innovations take root in schools by looking critically at three technology tools that have managed to accomplish just that. Roschelle, Patton, and Tatar (2007) point out that three technological tools - graphing calculators, smartboards and probeware - have succeeded in schools, largely because they:

- Are discrete, freestanding pieces of technology. Each of these tools causes minimal disruption to the physical organization of the classroom, and each expands a function already played by another resources before their introduction.
- Address specific challenges or sticking points in the learning that teachers are very familiar with. Each of these tools addresses a common "bottleneck" that makes it difficult for teachers and students to fully engage in the conceptual work implicit in a given activity. Probeware, for instance, frees up students from the process of recording data by hand, an error-ridden and tedious process, particularly for younger students. See Zucker, Tinker, Mansfield, Metcalf, & Staudt, 2007 for an example of research on the effectiveness of probeware in middle grades science classrooms.

- Are flexible and adaptable to multiple curricular contexts. Each of these tools is essentially content-free - they can be brought into a range of activities, and used regardless of the learning standards and assessments that may dictate teachers' plans and practices. Further, teachers can begin to use them in simple ways, and gradually deepen their integration of the tool into students' learning activities.

What can we learn from this prior work?

The research discussed above suggests that teachers will need significant opportunities to explore and fully understand the intent and core principles of electronic games for learning, and that we will need their help to identify the points in their daily practice where games can play a feasible and meaningful role in supporting student learning.

This research suggests that change in schools, like change in all complex systems, can be spurred by recruiting gatekeepers to action and engagement by making the relevance of the problem, and the feasibility of the solution, evident in terms that are locally meaningful and interpretable. Below I provide two more specific illustrations of how this perspective might inform game development.

Infusing teacher perspectives into the design process

The available evidence suggests that a deep understanding of teachers' perspectives needs to be integrated into the design and development of games intended for classroom environments. This is not to suggest that all teachers must have input into the design of all of the resources introduced to their classrooms. It does mean, though, that teachers are valuable informants about a range of issues the evidence has suggested are critical to effective implementation, including:

- The specific challenges involved in supporting students' active pursuit of learning at different ages and in different social and material contexts;
- The practical and logistical constraints that complicate the introduction of innovative technologies in schools;
- The kinds of professional supports and guidance that teachers will be able to take advantage of and translate into manageable changes in practice.

With this input in mind, designers can triangulate among teachers' expert craft knowledge, the current evidence from cognitive psychology and the learning sciences, and best known practices in game design to identify what kinds of games to build in order to address needs that all parties can agree are critical to student success.

Think more broadly about what kinds of games can have an impact

If we are interested in gaining traction and influence in science classrooms, we may need to think about introducing a diverse range of games, and attending to the variations in the implementation challenges they raise. For example, given the logistical and curricular constraints of the classroom, the most comprehensive or powerful design from our perspective might not actually be the best for the job. In addition to highly veridical, complex simulations and expansive virtual worlds, we may need to create games that more like Cuisenaire rods and other resources found in Montessori classrooms games that tackle relatively specific conceptual knowledge, and that can fit comfortably into multiple curricular contexts. The history of technological innovations in classrooms suggests that teachers are most likely to recognize and adopt flexible artifacts with conceptual value built into their design, that can be used in multiple ways in the classroom and that help teachers tackle specific, difficult concepts in the context of many different possible instructional moments.

In a gloss on the writings of Thomas Merton, Lee Shulman wrote "….once ideas are put into practice they are destined to produce outcomes that extend beyond the more limited scope of interest to the planners. It is only through following an idea into practice, therefore, that one begins to appreciate the greater richness or potential of the idea. (The parallel to Dewey is striking.)" (Shulman, 1984, p. 187) Shulman was arguing for the importance of accommodating practical considerations, and not only theory, in the development of curriculum. His argument is likely to hold true for electronic games for science learning, as well.

References

Carrigg, F., Honey, M., & Thorpe, R. (2005). Moving from successful local pracice to effective state policy: Lessons from Union City. In Dede, C., Honan, J.P. & Peters, L.C. (Eds.), *Scaling Up Success: Lessons from Technology-Based Educational Improvement.* San Francisco: Jossey-Bass.

Coburn, C. E. (2004). Beyond decoupling: Rethinking the relationship between the institutional environment and the classroom. *Sociology of Education, 77*(3), 211-244.

Coburn, C.E. (2006). Framing the problem of reading instruction: Using frame analysis to uncover the micro-processes of policy implementation. *American Educational Research Journal*, *43*(3), 343–379.

Cohen, D. (1990). Revolution in one classroom: The case of Mrs. Oublier. *Educational Evaluation and Policy Analysis*, *12*(3), 311-329.

Cohen, D. K., & Hill, H. C. (2001). *Learning policy: When state education reform works*. New Haven, CT: Yale University Press.

Fishman, B., (2005) Adapting innovations to particular contexts of use: A collaborative framework. In Dede, C., Honan, J.P. & Peters, L.C. (Eds.), *Scaling up success: Lessons from technology-based educational improvement.* San Francisco: Jossey-Bass.

Hawkins, J. (1987). The interpretation of Logo in practice. In *Mirrors of minds: Patterns of experience in educational computing*. Pea, R.D., & Sheingold, K. (Eds.). Westport, CT: Ablex Publishing.

Hawkins, J., Culp, K.M., Gilbert, J, Mesa, L., & Schwartz, J. (1999). Technology integration in Chicago public elementary schools, 1997-98. New York: Center for Children and Technology. Downloaded September 19, 2009, from http://cct.edc.org.

Honig, M. (Ed.) (2006). *New directions in education policy implementation: Confronting complexity*. Albany, NY: SUNY Press.

Honig, M. I., & Hatch, T. C. (2004). Crafting coherence: How schools strategically manage multiple, external demands. *Educational Researcher, 33*(8), 16-30.

Martin, W., Hupert, N., Culp, K.M., Kanaya, T., & Light, D. (2004). Intel Teach to the Future summary of evaluation findings, 2000-2003. New York: Center for Children and Technology. Downloaded September 19, 2009, from http://cct.edc.org.

McLaughlin, M.W. (2006). Implementation research in education: Lessons learned, lingering questions and new opportunities. In M.I. Honig (Ed.), *New directions in education policy implementation: Confronting complexity* (209-228). Albany, NY: SUNY Press.

Penuel, W., Fishman, B.J., Gallagher, L.P., Korbak, C., & Lopez-Prado, B. (2008). Is alignment enough? Investigating the effects of state policies and professional development on science curriculum implementation. *Science Education 93* (4), 656-677.

Penuel, W., Korback, C., Lewis, A., Yarnall, L, & Zander, M. (2004). *Globe Year 8 evaluation: Adapting implementation to diverse contexts*. Report to The Globe Program. Menlo Park, CA: SRI Center for Technology in Learning. Downloaded Sept. 22, 2009, from http://ctl.sri.com/people/displayPerson.jsp?Nick=bpenuel#publications .

Penuel, W.R., Korbak, C., Lewis, A., Yarnall, L., Zander, M.L. (2004). GLOBE Year 8: Adapting implementation to diverse contexts. Palo Alto: SRI International Center for Technology and Learning. Downloaded September 19, 2009, from http://ctl.sri.com/people/displayPerson.jsp?Nick=bpenuel#publications .

Ronnkvist, A.M., Dexter, S.L., & Anderson, R.E. (2000). Technology support: Its depth, breadth and impact in America's schools. Center for Research on Information Technology and Organizations, University of California, Irvine And University of Minnesota. Viewed on September 20, 2009 at http://crito.uci.edu/papers/TLC/findings/technology-support/startpage.htm .

Roschelle, J., Patton, C, Tatar, D. (2007). Designing networked handheld devices to enhance school learning. In M. Zelkowitz (Ed.) *Advances in Computers* Vol 70, 1-60.

Sawyer, R.K. (Ed.) 2005. The Cambridge handbook of the learning sciences. New York: Cambridge University Press.

Schrum, L. & Glassett, K. (2006). Technology integration in K-12 schools: Challenges to implementation and impact of scientifically based research. Journal of Thought, 41(1), 41-58.

Sheingold, K., Hawkins, J., Char, C. (1984). *'I'm the thinkist, you're the typist': The interaction of technology and the social life of classrooms*. Journal of Social Issues, 40(3), 49-61.

Shulman, L.S. (1984). The practical and the eclectic: A deliberation on teaching and educational research. *Curriculum Inquiry*, (14)*2*, 183-200.

Silvernail, D. (2009). Research and evaluation fo the Maine Learning Technology Initiative Laptop Program: Impacts on Student Achievement. Center for Education Policy, Applied Research and Evaluation, University of Southern Maine. Downloaded September 20, 2009 from http://www.usm.maine.edu/cepare/.

Vahey, P., Tatar, D., & Roschelle, J. (2007). Using handheld technology to move between private and public interactions in the classroom. In M. van 't Hooft & K. Swan (Eds.). *Ubiquitous computing in education: Invisible technology, visible impact* (pp. 187-210). Mahway, NJ: Lawrence Erlbaum Associates.

Zucker, A.A., Tinker, R., Mansfield, A., Metcalf, S., & Staudt, C. (2007). *A summary of research on the TEEMSS II project*. Concord Consortium white paper. Downloaded September 17, 2009, from http://www.concord.org/publications/detail/.