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Labeling What Some Researchers Are Already Doing: Design Research Updated

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Increasingly, "research" is not being conducted in a separate group in an organization; rather, it is being integrated into the fabric of the organization. Google recently described such an integrated, "hybrid" model of software research that is characterized by cycles of short duration and small-scope activity that is ongoing and long-term. The authors argue that the practice of "Design Research" (DR) is undergoing a change in the educational technology field and becoming more a "Design Research & Development" (DRD) model, which is also characterized by ongoing and long-term partnerships, with cycles of R&D. This DRD model, then, avoids the challenges that surface when moving from a pilot done under favorable conditions to scaling the innovation in real classrooms. While, not surprisingly, DRD has its own challenges, DRD may enable positive impacts to be visible in the classroom sooner than when using the more traditional research-transfer models.

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Section 1: Introduction

Educational researchers in general and educational technology researchers in particular have always been caught in a quandary as they carry out their "research." On the one hand, in order to achieve authenticity, research needs to be classroom based. But, doing research in real classrooms/schools is exceedingly demanding:

- **Methodological Challenges:** While social science research is not physical science research, the demand for methodological rigor waxes and wanes in education. During the Bush Administration in the United States (2001 to 2009) "physics envy" was rampant, and much educational research was debunked as just fluff, with the U.S. Department of Education's Institute for Educational Sciences creating "gold standard" benchmarks for "scientifically-based research." Qualitative research was *out*; random-trial, quantitative research was *in*. Using the latter research methods, essentially all the studies of the use of computers in education showed no impact[1] of computers on student achievement.

Teachers have been conducting what they call "action research" for years. Teachers try something in their classrooms, see how it is working, and then tweak it to make it work better. But academics tend to not have high regard for such efforts. Methodologically, action research tends to be questionable, and scaling is usually not even an issue.[2]

- **Scaling Up Challenges:** One starts testing an innovation in the classroom with a "pilot study." In a pilot study, typically, researchers try to create the optimum conditions (e.g., small number of energetic, artisan teachers, first-rate equipment, a small army of graduate students to provide support in the classroom during enactment of the innovation, etc.) in order to explore the specific, theoretically-motivated, principled innovation. The university researcher's mantra has been: "we don't want to fail for the wrong reasons." Surprise—pilots tend to work fabulously!

  Then, the challenge is to recover from a successful pilot. The "wrong reasons" are precisely the issues that are endemic to schools that forever hold back innovation and change in the classroom.[3] But the university researcher's job is done; the pilot was successful; it is someone else's problem to make the innovation work in other classrooms. On to the next grant!

  Moving on is not an unreasonable strategy from a university researcher's position, since by and large every efficacy study of educational technology turns up "no effect of the technology." This is very demoralizing to the educational technology researchers when, in the end, some third-party group will swoop into a school with your innovation, provide quick professional development, assess the innovation after the first implementation, and *voila*—find it to be ineffective.

To address the need to do research that has a higher degree of authenticity, Brown (1992) put forward the notion of "Design Research." In Design Research, "design experiments," are carried out in classrooms with an attempt to "engineer innovative educational environments and simultaneously conduct experimental studies of those innovations" (p. 141). DR-style research has been a mainstay of the educational community since Brown's publication.

But it doesn't take a soothsayer to see that today is quite a bit different from yesterday. The world is going through a Great Recession, with political, social, and economic upheaval on a scale not seen in many decades. Education is under attack for a failure to properly educate our children. And implicit in that attack is an assault on educational research in general, and educational technology research in particular—after spending millions and millions of dollars, educational technology researchers have precious little evidence to show that computing technologies, for example, have led to increases in student achievement.[4] Indeed, who needs research? Throw some 10-minute videos on curricular topics up on the Internet and students will come—by the millions. Bill Gates commented that the Khan Academy was "the future of education."[5] Efficacy research be damned; full speed ahead! And so it goes.

Bill Gates notwithstanding, methodologically sound, relevant educational technology research has made and will continue to make a contribution to education, e.g., research on microcomputer-based labs (Krajcik & Layman, 2012); research on use of graphing calculators (Texas Instruments). That said, doing methodologically sound, relevant educational technology research is not easy! In the face of unrelenting, unforgiving technological disruption, and just as other industries, organizations, and individuals have done, we need to reinvent ourselves. Indeed, why should K–12 education[6] and K–12 education research be spared disruption?

Fortunately, reinvention of K–12 educational technology research is already in motion. This article is meant to put a "label" to that already existing activity (e.g., Nelson, 2013; Penuel *et al.*, 2011a; Penuel *et al.*, 2011b). By naming it, we can talk about it; by naming it, we can build on it. In addition to labeling this already existing activity, our intent here is to put some context around the label. That is, the change in educational technology research is not happening in a vacuum; other types of research are also changing in ways analogous to what is happening in educational technology research (e.g., see Section 2). Indeed, in the spirit of "building on it" our intent in providing this context is to learn from these other areas, borrowing terms and processes where appropriate.

In Section 2, we describe the fundamental change that is occurring in software research in industry. In Section 3, we then recast Design Research to more accurately capture the new type of activity that is already happening. In Section 4, we describe our educational technology research at Nan Chiau Primary School in Singapore as an example—an unfolding example—of this evolutionary change in research method.

Section 2: Learning About R&D from the Software Industry

Research in the software industry is changing—and changing dramatically, too. The traditional model, as implemented at Microsoft, is:

- **The Independent Research Group:** Microsoft, in 1991, created Microsoft Research (e.g., 1375 people, 10,112 publications). It spends 13% of its total revenue on research (Yap, 2012). In comparison, IBM spends 6%, while Apple claims to only spend 2%—but they no longer have distinct research organizations (Yap, 2012).

However, for essentially the same reasons that transfer-

ring an educational technology innovation that had a successful pilot to mainstream classrooms fails, transferring technology innovation from an independent research group to production has a poor track record of success:

- the favorable conditions that the researchers set up to test their software are not available in production settings;
- the innovation is typically one small part of a bigger system, and the issues involved in making everything else work take precedence over making that "small" innovation work; and
- the people who create the production software are not the people who invented the innovation, and thus the former folks are not necessarily invested in the innovation's success.

To address the challenges of having separate research and production groups, Google has reinvented research. On July 20, 2011[7] it announced that Google Labs, traditionally where research at Google was carried out, was being shut down and replaced with a new model, the "hybrid model," where they "integrate research and development...Research happens throughout Google" (Spector, Norvig, & Petrov, 2012).

In their own words, what Google has done is put the D (Development) back in R&D (Research & Development): "[Google is] maximally connecting research and development" (Spector *et al.*, 2012). Indeed, assuming that words have meaning, it is called Microsoft Research, not Microsoft Research & Development, for a reason.

In "maximally connecting research and development" (Spector *et al.*, 2012), Alfred Spector, Google's Vice President of Research and Special Initiatives, says that this strategy solves key issues of taking advantage of research: "Research at Google is built on the premise that connecting research with development provides teams with powerful, production-quality infrastructure and a large user base, resulting not only in innovative research, but also in valuable new commercial capabilities. By coupling research and development, our goal is to minimize or even eliminate the traditional technology transfer process, which has proven challenging at other companies" (Spector *et al.*, 2012).

Two key properties of Google's research model are:

- **Cycles of R&D using Agile Software Development practices:** "Google's entire organization is focused on rapid innovation" and thus their approach to R&D "is iterative and usually involves writing production, or near-product, code from day one" (Spector *et al.*, 2012). In contrast to the waterfall model of software development, where each phase (e.g., requirements, development, design, etc.) is completed before the next phase is started and the project is completed when the software is installed, the cycles of R&D are more akin to "Agile Software Development," a relatively new model of software development.[8]
- **Long-term, ongoing R&D:** Google has committed to integrating R&D throughout its organization; in Google's own words R&D is a "long-term engagement." That is, R&D does not end; it is an ongoing activity concurrent with the core activity of the team. The cycles of R&D continue as long as the team continues to be doing its assigned task.

Section 3: Applying Lessons from Google to K–12 Education: Extending DR to DRD

Drawing on Google's model of R&D, perhaps "Design Research" should be "Design Research & Development," or DR to DRD. The seemingly innocuous addition of a single letter to the abbreviation signals a profound change for the DR model:

- **Cycle of R&D using Agile Curriculum Development practices:** Development activities in classrooms drive the research. The observations from the classroom experiences change the design, which in turn can be tried out in the classroom. As curriculum developers and teachers learn how students use the technology, as they learn what impact the technology has on the students, and as they learn what new opportunities the technology affords, they can design and enact new curricular activities. The current method for curricular development is to create an entire unit with multiple activities that might well last for weeks, if not an entire semester. In contrast, using DRD with its "Agile Curriculum Development model"—which draws on the "Agile Software Development model"—curriculum developers only create perhaps a week or two's worth of technology-enabled activities, and then they iterate based on the feedback learned from the classroom.
- **Long-term, ongoing R&D:** If development—and the cycles of R&D that it engenders—is part-and-parcel of classroom activities, then by definition R&D is a continuous, ongoing, long-term process, since classroom activities do not end! The Action Research model that teachers have undertaken for years has this long-term character. But, unlike most Action Research, that is focused on the local area (i.e., classrooms in a school/district), DRD has a goal of trying to abstract general observations/principles and disseminate them throughout the educational community.

Section 4: An Example of DRD in Practice

Since 2008, in our efforts at trying to transform class-

rooms at Nan Chiau Primary School in Singapore from practicing traditional direct instruction pedagogy (lecture/worksheet/drill) to practicing an inquiry pedagogy consistent with the guidelines proffered by Singapore's Ministry of Education in their Masterplan 3 for Education, we have been evolving and employing—implicitly until now—a DRD strategy. We definitely have:

- **Cycles of R&D using Agile Curriculum Development practices:** As we describe below, essentially the only way we could develop curriculum materials was in small steps, iteratively, bringing all the stakeholders to the table.

- **Long term, ongoing R&D:** As will be described in "Phase 2," the principal of the school, Mr. Chun Ming Tan, was the first to realize that researchers, educators, students, parents, and for-profits and not-for-profits needed to come together as partners, in a physical space with tables and chairs, whiteboards, and even a refrigerator. That physical space signaled to us that the partnership had a *permanence* that verbal or even written agreements do not necessarily have.

Phase 1: Recovering from a Successful Pilot

The initial pilot study, in 2008, with 40 students each having a smartphone, 24/7, equipped with a Mobile Learning Environment (MLE) in a third-grade science class, couldn't have gone any better. Not only did we develop a new inquiry curriculum that leverages the affordances of the mobile devices (Looi *et al.*, 2011; Zhang *et al.*, 2010), but in a quasi-experimental study, the smartphone-using class outscored five other comparable classes on Singapore's standardized, fact-based, science test. And, because an inquiry pedagogy encourages conversation and requires writing, the smartphone-using class also outscored the five other classes on the English standardized test, too.

With sky-high expectations, in 2009 at Nan Chiau, we tried to implement the "same innovation" with all fourth-grade students (about 350) and eight teachers new to the innovation. Because of administrative issues and demands from the teachers, our curriculum developers tried to merge the inquiry curriculum with the existing direct-instruction curriculum. While there were moments and instances of successes, overall the project did not live up to expectations.[9] Exactly what factors/issues should we have transferred from the pilot study with one teacher to the scaled-up study with eight teachers? How should we have prepared the new teachers?

Phase 2: The Creation of CERA: Institutionalizing R&D

In 2009, Mr. Tan suggested that we carve out physical, permanent space in Nan Chiau and devote it to a center where the researchers could be based and that would enable the researchers and the school people to interact more easily. The Centre for Educational Research and Application (CERA) was officially inaugurated on April 29, 2009. University researchers know how difficult it is to "find" office space at the university; but to "find" "extra space" in primary schools is 10 times—at least—more difficult!

Therefore, for Mr. Tan to devote a classroom-sized room—not a "broom closet"—to CERA was a major commitment of resources, and thus he demonstrated, by that action, his serious commitment to fostering an ongoing, long-term, close partnership among researchers, educators, and students for the purpose of carrying out research and development.

Universities house centers; schools don't house centers. But having a center that deals with classrooms and schools housed at a university sends the wrong signal to the school; it says that the ownership of change is housed with the university; it says that the responsibility for carrying out meaningful research and development belongs to the *university*. Mr. Tan's insight said that *his school must own the change*; the school must be responsible for carrying out R&D.

In fact, a subtle, but powerful switch occurred: researchers no longer scheduled time to "come to Nan Chiau." Rather, the researchers scheduled time to visit the university, since they were now housed, full-time, at Nan Chiau, with essentially unlimited access to all school activities.

Phase 3: Growing a Culture of DRD

Once CERA[10] was established, we "found" funding from various sources: industry (e.g., Qualcomm, Microsoft, SingTel, Nokia), government (e.g., Ministry of Education, National Institute of Education), and foundations (e.g., Singapore Hokkien Huey Kuan, a clan formed by descendants from the Fujian (Hokkien) Province of China). Like magnetism, funding attracts funding.

Fast-forward to 2013: there are now approximately 350 P3 (third grade) students using mobile computing devices (called "handphones" in Singapore) daily for science, English, and Chinese language learning. We plan to move soon to approximately 700 students in P3 and P4 in science, English, Chinese language, and math.

During 2012, in developing the science and English curriculum, where the technology was essentially baked in, DRD—Design Research & Development—is the model we have been implicitly using. This strategy consists of short cycles of developing curriculum, working with teachers, seeing what works in the classroom, and what doesn't work. We are constantly listening to each other and constantly tweaking.

The introduction of technology itself operates on longer cycles since, frankly, it takes a good while to truly leverage all the value (or even a substantial portion of the value) that the technology affords. Thus, we introduce new tools infrequently into the mix, since everyone is working hard with the existing tools.

Transfer per se is no longer the issue; there is no separate

research group trying out the technology in a lab setting, and then moving it to the classroom. There is no lab setting; the technology is immediately used in the classroom.

But now an almost deeper challenge raises its head: convincing one or two or six to eight teachers to try an innovation for one semester is one thing; having six to eight teachers in a grade use the innovation as the *norm* is a completely different thing! What is needed in this latter case is a cultural change; getting everyone—teachers, staff, administrators, researchers, software developers, curriculum developers, funders, parents, students, etc.—to see that we are in this for the long-term and that this is an enduring change—it's not going away—is truly a challenge, one that goes beyond the scope of this article.

Section 5: Concluding Remarks

In this article, we have not invented a new educational research model. Rather, we have put a label on an existing but heterogeneous and implicit set of strategies and tactics already being practiced in the educational technology research community. Google didn't one day institute its "hybrid" model and tell its 24,000+ employees to practice it. Of course not! But rather, some thoughtful Googlers reflected on their daily activities and abstracted a common set of practices that they then labeled as "the hybrid model." Similarly, we didn't start out to create the DRD model, nor were we under the impression, until recently, that we were in fact working under a new model. However, by giving "it" a label, we can now talk about "it" as something specific, something coherent, and something that needs to be refined and evolved.

While DRD may not be the most appropriate name, or our description of DRD may not be the most illuminating, the fact is this: education research needs a new model to address the urgencies of our times. There is real danger brewing today in societies the world over. Acts of intolerance are increasingly on the rise. Education is the antidote to intolerance; education is the sure way to improve one's lot in life and address the growing anger and frustration. Computing and communications technologies have transformed—mostly for the better, it can be argued—practices the world over; it is time for these technologies to transform K–12 education.[11] □

Acknowledgment. This section could easily be longer than the entire article since, almost by definition, a DRD strategy requires the participation of just about everyone! We are pleased, however, to single out two individuals who have given tremendous time, energy, ideas, heart, and soul to change at Nan Chiau: Peter Seow and Gean Chia. We also thank Alex Wang, who recently joined the English curriculum team, for his driving energy and ideas. We thank Assistant Principal Mr. Kin Mun Wong, along with the IT department at Nan Chiau. We thank Dr. Horn Mun Cheah, Director of Technology for the Ministry of Education, Singapore, for his rock-solid, on-going support. We thank Dr. David Hung from EduLabs, Ministry of Education, Singapore, and Dr. Chee Kuen Chin, Executive Director of the Singapore Centre for Chinese Language (SCCL), for their unwavering support. We thank Ms. Erin Gavin from the Wireless Reach Project, a Qualcomm sponsored activity, for her ingenuity in working around roadblocks! We thank Ms. Horng Shya Chua, from Microsoft, for her unbroken support over the years.

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Notes

[1] We hasten to point out that lack of research or even negative research findings tends to not impact school behavior—even when schools claim that "data-directed decision making" is an important strategy. For example, McAllen, TX has dropped 25,000 iPads and iPod Touches (Sherman, 2012) into their school district. There is precious little evidence (qualitative or quantitative) that such a move will have a positive impact on student achievement.

[2] There are notable exceptions. The recent excitement around the "flipped classroom" was due to school-based experiments (e.g., *http://www.flippedhighschool.com/*). And, no surprise, there is little methodologically-rigorous research to support the efficacy of the "flipped classroom" strategy.

[3] Interestingly, innovations outside education and the classroom fail for the same reason, i.e., the ecology that supports the innovation fails to materialize (Allen, 2012).

[4] Of course, there are exceptions. Empirical, rigorous, classroom-based research on MBL—microcomputer-based labs (probeware)—has shown, over and over again, that MBL technology can have a positive impact on student achievement in science (e.g., Krajcik, 2012).

[5] *http://www.youtube.com/watch?v=gM95HHI4gLk* .

[6] Elsewhere, Norris and Soloway (2012) argue that higher education will lead primary/secondary education by two to three years in this reinventing process.

[7] *http://googleblog.blogspot.com/2011/07/more-wood-behind-fewer-arrows.html* .

[8] "**Agile Software Development** is a group of *software development methods* based on *iterative and incremental development,* where requirements and solutions evolve through collaboration between *self-organizing, cross-functional teams.* It promotes adaptive planning, evolutionary development and delivery, a *time-boxed* iterative approach, and encourages rapid and flexible response to change. It is a conceptual framework that promotes foreseen interactions throughout the development cycle" (from Wikipedia, 2012).

[9] Norris and Soloway (2013) in using MLE on PalmOS and PocketPC PDAs with upwards of 40,000 students in schools all over the United States and the UK repeatedly saw this same phenomenon; pilot studies with four artisan teachers and 100 students were widely successful with respect to increased student achievement, increased homework completion, etc. But when we scaled up to 14 everyday teachers and 400 diverse students, no such gains were observed—at best. Transfer was not easy.

[10] On October 7, 2010 an agreement was signed by Nan Chiau Primary School, National Institute of Education, Singapore Centre for Chinese Language, and Microsoft that has fostered a still growing relationship around mobile-based MyCloud, a system to support the learning of the Chinese language.

[11] It is grandiose enough to think of "fixing" primary and secondary education; we leave the fixing of higher education to others.

Web Consulting for Non-Academic Educational Missions: How Instructional Design Offers a Competitive Advantage

Ward Mitchell Cates
Paige Hawkins Mattke

Based on a recently completed study of education directors at science museums, this article addresses how design-and-development consultants might use those findings to enhance the way in which they propose and deliver Website services to non-academic organizations with either primary or complementary educational missions. After a very brief presentation of study findings, the article recommends specific techniques such consultants might employ to use their instructional design skills to gain a competitive edge over traditional IT-focused consultants.

Open Educational Resources and Why They Might Be Important

Hylen (2007) defined open educational resources (OERs) as "digitized materials offered freely and openly for educators, students, and self-learners to use and re-use for teaching, learning, and research" (p. 1).

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