

**Teachers' Design Knowledge of Technology-Enhanced Learning Environments in
Canada: A Knowledge Synthesis**

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Key messages

The findings from our knowledge synthesis point towards the kinds of practices that can best support teachers in their work of design. We report on five key findings from our research synthesis:

1. Design work that includes teachers takes place in a variety of contexts, including design as part of pre-service courses and professional development activities, participation in a co-design process as part of a research-driven initiative, and design work that takes place in their own classrooms.
2. Design work that includes teachers takes many forms, including customizing and modifying pre-existing curriculum documents and plans, using existing technologies to create new experiences for students, and adaptive decisions that are made during implementation.
3. Research that reports on design work tends to focus on the implementation and evaluation components of the design process. Research also looks at social processes that are part of design work, and design outcomes other than implemented curricula, such as the creation of modules or curriculum materials, and the specification of roles (e.g., pedagogical) within a learning design.
4. Teachers have access to a variety of supports, including design materials, such as exemplars, and design frameworks. Researchers provide support in various ways, including design expertise, content expertise, feedback, and pedagogical expertise. Teachers also receive support in the form of peer collaboration. Some particularly promising directions for design support include pattern language, annotations, pedagogical templates, and real-time supports in the form of visualizations and notifications of student work.
5. Research that includes the design work of teachers is focused on a few research labs, including those from the University of Toronto and Dawson College in Montreal. Much of this design work takes place in research-driven initiatives that involve teachers as co-design partners, within technology-rich environments.

Executive summary

In the field of educational research, there has been a growing interest in conceptualizing teachers as designers. This report seeks to synthesize what current research can tell us about how teachers design experiences for learning, including the context where teachers design work take place and the form that their design work takes (e.g., tailoring curriculum and technologies to their own contexts and participating in research-driven design work). Of particular interest is design work that takes place within technology-enhanced learning environments, in science, technology, engineering, and mathematics (STEM) domains. In addition, we seek to understand what supports are available to teachers as they participate in design processes, with a view towards envisioning the most effective systems for supporting teachers in the work of design. Findings will assist us in identifying (1) future areas of research and development and (2) the socio-technical infrastructures and technical supports that could be beneficial in supporting teachers' design work, specifically in a Canadian context.

We addressed these questions by systematically reviewing literature from the learning sciences, specifically from its primary international journal and the conference proceedings from its two major international conferences. We targeted papers that detailed teachers' design work, within STEM domains. In our search, we included papers that explored the role of teachers in supporting their students in design practices. We searched for four main themes: the context where teachers design work takes place, the form that the design work took, the aspect/phase of design process that the paper focuses on, and details of any supports that assist teachers in the work of design. We adopted a knowledge synthesis approach, adapted from Cooper, Hedges, and Valentine (2009). Our research team's expertise includes members who have participated alongside teachers within co-design processes over multi-year design-based research projects.

First we examined the context where teachers' design work took place and the kind of design tasks they engaged in. Pre-service teachers and in-service teachers who were enrolled in part-time university programs (8.3 %) engaged in design work as part of course requirements. In-service teachers who participated in professional development activities (20.8 %) worked to develop lessons and devise implementation strategies, sometimes tailored to address school-wide initiative. Other professional development activities included discussing curriculum activities and the use of web-based tools. Teachers who participated in co-design, research-driven partnerships (41.7 %) participated in a variety of design initiatives, including engaging in curriculum design and creating learning materials. Some partnerships resulted in specialized software that was designed to co-ordinate the flow of participants and media. In other partnerships, teachers provided design constraints and feedback on evolving designs. In another category of participation, some teachers planned, designed, and implemented lesson designs independent of researchers (14.6 %).

Next, we examined the forms of the design work that teachers engaged in. In one category, teachers customized and modified pre-existing curriculum documents and plans. In one example, teachers worked with researchers to reconceptualize an existing technology-enhanced curriculum, to infuse it with inquiry-oriented activities. In this kind of work, there was a focus on reflecting on the implementation and refining it. In a second category, teachers repurposed and adapted existing technologies. Some studies described initiatives where teachers participated in processes that added new functionality to an existing technology, usually in partnership with a research group. Many studies described how teachers used existing applications and technologies to create new learning experiences for their students. Some applications that were used were the product of previous research initiatives, productivity tools (e.g., Microsoft Word, wikis, blogs), social media tools, and visualization tools. Another category of innovation involved the use of physical technologies and devices. In a third category, teachers made decisions “on the fly” during planned activities, in response to emergent needs, constraints, and affordances (10.4 %). This form of design work allowed teachers to use their own judgment and interpretation skills to improve classroom designs and practices. Examples of this form of design work includes real-time design decisions made during collaborative activities (informed by digital activity notifications) and refining software scaffolds (in real-time) to make them more understandable to students. Another example of this form of design work is adaptive decisions that allow teachers to work towards pedagogical goals, such as moving towards principle-based approaches, rather than procedural ones.

Next, we looked at the aspect(s) or phase(s) of the design work that the paper focused on. Using our codebook, we selected all “fit in” categories of the design process that were mentioned in the papers. Our findings show that “implementation” was described the most followed by “evaluation”. The remaining categories displayed a relatively even distribution: “problem identification”, “exploring the solution space”, “multiple design iterations” and “other”. Most of the papers focused on implementation and evaluation of the designs. Some papers focused on the social processes that were part of the design work, such as negotiation, assignment and management of participants’ roles, the ways in which student designers sought help from peers, version control management, and the effects of the co-design process on teachers and students. Some papers focused on outcomes of a design process, which could include curricula or specified roles. Studies in this category did not describe the implementation in a classroom setting, but they did focus on the outcome of a design process, such as roles for students (e.g., scientific roles for an inquiry activity) or roles for teachers (e.g., pedagogical roles). Other studies focused on one iteration of a multi-year study or focus on one activity that was part of a larger curriculum design. Other studies describe two or three design cycles, describing how the outcomes of one iteration led to design decisions that influenced the next design cycle. The “other” codes revealed some interesting focus areas. (1) Provide high level overview of multiple studies; (2) Focus on the preliminary phases of the design cycle.

Finally, we searched for information on the kinds of supports that teachers had access to in their design work. In 31.8% of the studies that we reviewed, teachers had access to various design materials, including curriculum materials to inform their design activities, exemplars, manuals, and guides. Design frameworks were also included in this category. These kinds of materials were often used within the context of workshops or professional development activities. In another kind of process, teachers used role playing, as a strategy for understanding how their students might experience a learning design. In 22.9% of the studies we reviewed, teachers were provided with guidance from researchers, which took various forms. For example, one study provided teachers with a pattern language to help them articulate various components of their design work with each other. This same study also provided educators with specific notations to help them describe workspaces and workflow. In another study, researchers led teachers through Stanford University's Introduction to Design Thinking. Other forms of guidance included providing design expertise, content expertise, feedback, and pedagogical expertise (e.g., in Knowledge Building pedagogies). In 20.8% of the papers we read, some form of technological support was mentioned which helped teachers to make in situ design decisions, such as tools to visualize students' ideas and content contributions and real-time notifications of student activity. There were a number of studies that did not give a lot of detail about the design process, but did state that teachers were involved in the design process. These papers did not go into detail about any supports that teachers may have had, but they do state that teachers met regularly. From the "other" responses, the "peer collaboration" code emerged. In these studies, teachers may have collaborated on lessons, coordinated design work with other teachers, and acted as mentors during the design process. Some of the peer collaboration involved participating in the Knowledge Building Summer Institute, where teachers could elaborate on, reflect on classroom designs, and envision new ways of using technological tools.

This report details teacher design work that is specific to the Canadian context. Prevalent in this work are design research partnerships that have produced "designed from scratch" technologies for use in STEM classrooms, particularly at the University of Toronto. These partnerships have been largely successful and have produced innovative technology-enhanced learning environments.