

Assisting and assessing the development of technological fluencies: Insights from a project-based approach to teaching computer science

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ABSTRACT

University-school partnerships hold great promise for establishing innovative computer-science curricula and investigating how students learn and appropriate technologies for their own use. Here we highlight an interdisciplinary design work and describe a novel approach to the assessment of student growth.

Keywords

Design experiments, alternative assessment, teacher professional development, project-based pedagogy

INTRODUCTION

In 1997 the National Science Foundation asked the Computer Science and Telecommunications Board (CSTB) of the National Research Council to initiate a study that addressed the subject of *information technology literacy*. The study's rationale was the increasing ubiquity of information technology in daily life and the importance of beginning to define what everyone should know in order to empower all citizens to participate in this new era. Increasingly, information technology is not only an efficiency tool but is fundamentally changing academic disciplines ranging from the biological sciences to the study of history. The results of the committees' work was a report entitled *Being Fluent with Information Technology*. Rather than use the term 'literacy' the authors of the report opted for the label 'fluency' and defined it as the capacity to reformulate knowledge, express oneself creatively, adapt to change and to continually learn in order to apply technology to work and personal lives. The committee defined a tripartite approach to fluency (or "FITness") with equal attention to intellectual capabilities, domain-general information technology concepts, and contemporary information technology skills. Schools potentially play an important role in developing youths' technological fluency and in bridging gaps between youth with more or less home access to computing opportunities. However, research on the use of computing in schools shows that only a small proportion of teachers use computers in ways that might enhance various aspects of technological fluency (Becker & Riel, 2001). Long-term, university-school partnerships in which new practices, curriculum, and assessment strategies are treated as on-going design problems and approached jointly by researchers and teachers hold major promise for bridging theory-practice gaps. The design experiment we report here is based on the assumption that new teaching practices can be scaffolded in a learning-by-doing framework for integrating multiple kinds of resources for professional development and learning. This assumption is supported by research in other domains (e.g. see Barron et. al., 1998) and emphasized in new perspectives that highlight the need for teaching to be viewed as a learning profession (Hawley & Valli, 1999) and supported by participation in "communities of practice".

Interdisciplinary Design Work

Since the fall of 1998, a group of faculty and students at Stanford University has been engaged in this multi-year design experiment to create, implement, and assess a new computing curriculum for the public secondary schools in Bermuda. The project is a collaborative effort of the Computer Science Department and the School of Education and draws heavily on both knowledge domains. The computer science team provides the technical knowledge necessary to develop the curriculum content, the implementation skills needed to develop interactive computer-based teaching tools, and extensive experience in teaching computing concepts to college students with widely varying interests. The School of Education team provides expertise in the design and study of the learning environment – a process that involves learning theory, curriculum development, professional development, and assessment strategies. By working together, the two groups create a synergistic environment that has proven enormously valuable. In our work we organize our curriculum around project-based learning opportunities that allow students to learn content

in the context of creating meaningful artifacts. The design was guided by earlier work on project-based instruction and follows the design principles articulated by Barron, et al. (1998).

Assessment Strategy for Making Complex Learning Outcomes Visible

A challenge for researchers attempting to investigate the effects of innovative curriculum on student learning is to develop assessments that are sensitive to the multiplicity of outcomes that are theoretically predicted. This is particularly true for innovations that include new technologies that frequently transform the nature of tasks and what it means to know. Our systems for measuring change in knowledge and even processes such as problem solving are fairly well developed. We are less able to measure more complex yet highly valued outcomes such as changes in the ability to collaborate, manage projects, carry out research, persist in the face of difficulty, learn from social and material resources, and use tools to meet novel ends. These are the kinds of learning processes that are not only knowledge-based but involve social competence and emotional resilience.

To capture the development of these fluency-related processes we have created an approach to assessment called artifact-based interviewing. This novel method centers on eliciting learning narratives by cueing student memory and perspectives using students' project-based work. An interview protocol was developed that begins by asking students to lead the interviewer through their completed design work. The interviewer follows with a series of 45 questions in six areas. These include 1) learning of technological skills; 2) knowledge and use of design processes; 3) research skills; 4) collaborative work processes; 5) motivation and engagement; and 6) project sharing with peers, parents, teachers and other community members. These interviews yield student talk that allows us to characterize their level of fluency on multiple dimensions. We have found evidence of student growth in conceptualizations of collaboration, understanding of design and coding processes, knowledge sharing beyond the immediate community, and self-directed learning using networked resources. In addition to these interviews we measure pre to post-test change on paper and pencil measures of knowledge, motivation, perception of learning sources, breadth of technological experience, and knowledge sharing. We are also carrying out longitudinal case studies with a small number of students in order to capture their experiences, decision making and technological fluency development across the first three years of high school.

SUMMARY AND CONCLUSIONS

Our design-experiment work demonstrates the significant broadening of the content and pedagogy of traditional computing courses that can be obtained by working closely with teachers using research supported design principles. Our work has established new approaches to assessment. Traditional assessment tools are not well-designed for detecting the development of technological fluencies. They are even less suited to identifying what we might call far-transfer outcomes that are linked to school-based learning experiences but that have distal yet powerful self-perpetuating learning consequences for the student. These include self-initiated arrangements for further learning or learning that travels between the student and those in the community that the student lives within. Our findings thus far suggest that these kinds of outcomes do occur and that it is worth our while to reflect on how we might best document them in the service of creating more and better opportunities for generative learning.

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