Making Thinking Visible: Using Online Tools to Initiate Teachers' and Students' Thinking

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Abstract: This paper shares findings from a formative evaluation that explores a professional development program, Intel® Teach to the Future Workshop on Interactive Thinking Tools. The Workshop trains K-12 teachers how to use online tools with their students, which are designed to foster higher-order thinking skills, and combine technology and disciplinary content, with project-based learning activities. We found that the range in project types that were developed demonstrated that teachers, like their students, are learners in the process of understanding the higher-order thinking skills and concepts targeted by the tools. This research has implications for in-service teachers, teacher educators, and student learning.

Introduction

In the climate of standardized testing, technology is often used in ways that do not improve student understanding of content (Means, Roschelle, Penuel, Sabelli & Haertel 2003). The Intel® Teach to the Future Workshops on Interactive Thinking Tools were created as one of several professional development opportunities for K-12 teachers, intended to help teachers engage their students in higher-order thinking skills while integrating technology into their content areas. The Interactive Thinking Tools are designed to promote higher-order thinking skills that speak to standards such as cause and effect relationships, but that also help students visually represent the thinking process, which can influence their ability to show their thinking in a variety of ways. The main focus of the Workshop is for teachers to create a project that uses the Interactive Thinking Tools to depict not only what they are learning, but the process through which they are learning it and the skills they use to synthesize it. While it is useful to use the tools in projects that foreground either content or thinking skills, combining both higher-order skills and disciplinary content allows teachers a window into not just what their students are learning, but how they learn. As research has shown, in order to provide effective instruction in thinking skills they must be embedded within specific content areas and taught using concrete strategies (Brandt 2001; Resnick 1987).

Based on a suite of tools designed to support the teaching of these skills, the Workshops featured two tools: *Seeing Reason*, which focuses on causal reasoning, and *Visual Ranking*, which focuses on prioritizing information, exploring perspectives, and building consensus. These two online applications are designed to help students visualize and represent their thinking and allow users to construct causal maps with *Seeing Reason*, and manipulate interactive rank ordered lists with *Visual Ranking*, that can be applied to various

subject areas. The goal of these Workshops is to help teachers teach critical thinking with tools that support students' development of these skills across content areas. This paper is the result of findings from a formative evaluation of the Workshops on Interactive Thinking Tools, conducted by the Education Development Center, Inc.'s Center for Children and Technology (EDC/CCT).

The Workshops offer an interesting model for both effective professional development experiences for teachers and for addressing a challenging domain of student learning, particularly as educators are increasingly under pressure to provide quality instruction that is aligned to core content standards and also incorporates 21st Century skills. The interactive nature of new technologies, such as the Interactive Thinking Tools, can help learners (teachers and students alike) to visualize concepts that are difficult to understand, and allow them to actively engage in refining their current understandings in order to build new knowledge (Bransford, Brown & Cocking 2000). This paper shares how teachers met this challenge through the Workshop experience as they generated project ideas, engaged with the tools, and created projects that they could implement into their classrooms. The range in project types that were developed demonstrated that teachers, like their students, are learners in the process of understanding the higher-order thinking skills and concepts targeted by the tools. In particular, we explore how teachers (as learners) engaged in this struggle within the context of both gaining professional development around higher-order thinking skills and online technologies.

Visual Representations of Thinking

Visual representations of student learning provide teachers with a valuable window into students' thinking, which creates opportunities for both teachers and students to provide feedback, while learning is in process (Hattie 1992). As one teacher who attended the Workshop pointed out, "Thinking about thinking is difficult, and if you haven't gotten the idea, then how can you inspire students to do it?" Tools such as *Seeing Reason* and *Visual Ranking* allow teachers to see not only what students are learning, but also how they are thinking and how this process evolves over time. When students use the Interactive Thinking Tools, they can demonstrate to teachers their understanding of the class content as well as represent in a visual way the thinking that led them to this understanding. Students can represent their internal thinking process to others through external representations; making this process explicit can help to model problem solving skills that can be applied to other situations (Zhang & Norman 1994). This process of problem solving that is learned through the exercise of mapping or ranking with the Interactive Thinking Tools can strengthen students' (and teachers') higher-order thinking skills.

Similarly, when teachers learn to use these tools in the Workshops, they are modeling the process their students will undertake in the classroom. The project plans they develop during this training experience therefore, serves not only as the tangible product of the Workshop that will lead to classroom implementation of the tools, but also as a means for teachers to depict their own higher-order thinking processes. The teaching of thinking skills is a challenge that teachers confront in the classroom everyday; however, the ways in which thinking is discussed in an educational context is often vague or buried in assumptions that everyone shares the same idea of what "thinking skills" means. Within the Workshops, teachers create projects that represent their own understanding of thinking skills as they are related to their content areas. The project types discussed here reveal *what* is being made visible through using the Interactive Thinking Tools, and also *how* that understanding develops.

Methods and Data Sources

Understanding how teachers approached the Interactive Thinking Tools, generated projects for their students that drew on the tools, and decided whether and how to implement their projects into the classroom setting required the examination of multiple moments throughout the professional development experience. Borko (2004) suggests that it is important to use a situative perspective on researching teacher learning and professional development, which takes into account the multiple contexts where teachers learn (e.g. listening to a trainer during a professional development workshop, informal conversations with colleagues) and then implement what they have learned (e.g. teaching in the classroom, developing

curriculum at home). To gain a situated perspective, we observed Workshop participants during their training experience, explored teachers' reactions to the training (both immediately and over time), and investigated whether and how they used the tools after the training in their classrooms. This approach encouraged us to use a variety of data gathering methods to provide a comprehensive picture of how teachers learned to visualize thinking and then taught these techniques using the Interactive Thinking Tools, which included:

- Responses to online surveys (n=702)
- Educator interviews (n=23)
- Site visits to schools (n=8)
- Observations at Workshop trainings (n=4)
- Interactions with participants (n=7) in a focus group setting
- Email correspondences
- Document analyses of curricular materials
- Attendance at five (1-2 day) trainings and six informational meetings
- Preliminary analysis of projects generated with the tools

Types of Projects Generated During the Workshop

Project planning is the central activity of the Workshops. By creating these plans, teachers can put into practice what they have learned about the Interactive Thinking Tools and the higher-order thinking skills they are intended to support. In addition to this challenge of generating project ideas that used the tools and the thinking skills, teachers were also tasked with placing these projects within the context of their own curriculum, content area, grade level, and student learning standards. Workshop and classroom observations, interviews, and reviews of online artifacts demonstrate that teachers create a range of project plans that draw on the tools in a variety of ways – some of which align with the thinking skills the tools are intended to support, and some which do not. We discuss three types of projects here: Social Concern projects, Organizing Knowledge projects, and Gaining Perspective projects. These project types are examples of teachers' varying degrees of understanding of the specific thinking skills associated with both *Seeing Reason* and *Visual Ranking* tools, the features of the tools these projects took advantage of, and what each project helped teachers and students depict. While all of these projects made thinking visible with the help of the Interactive Thinking Tools, they did so using a variety of strategies, each of which took advantage of different capacities of the tools and fulfilled different learning objectives within the classroom.

Social Concern Projects

Teachers who generated *Social Concern* projects used the tools to focus on topic areas that were not closely tied to core content areas, but rather to social issues or "real-world problems" (e.g. bullying at school, effects of community service within a community), usually relevant to the school community or a current event. However, they were also simple and accessible in order to introduce the ways in which an Interactive Thinking Tool could be used to support a higher-order thinking skill. For example, in one Workshop, two teachers partnered to create a project on the healthfulness of cafeteria foods. This project culminated in redesigning the food pyramid based on ranking certain foods with *Visual Ranking* and mapping the effects of consuming them on the body with *Seeing Reason*. In this Social Concern project, the goals addressed included demonstrating to students how these tools can support critical thinking and engaging in discussion around a "real world" topic.

Another feature of Social Concern projects is that they do not typically involve the gathering of any new evidence, but rather asked students to articulate and summarize already-held perceptions or beliefs. For example, within the Workshop context, participants are asked to use *Seeing Reason* to map out what can affect student grades. These projects do not usually connect to core disciplinary content, but are treated as "stand-alone" projects created primarily to introduce students to the tools. Student thinking is guided by higher-order skills such as causal reasoning and list ranking, but in these projects the content is simple, so that students can see exactly how higher-order thinking skills are driving the exercise and how the tools can support this process. Students depict their thinking using the tools as well as through subsequent

discussions in Social Concern projects, but often, the projects' outcomes are focused on knowledge of the tools themselves. Many teachers designed Social Concern projects to serve as a way for students to engage with the tools and isolate higher-order skills not specific to their content area toward more complex usages of the tools in the future that would emphasize disciplinary content. Sometimes these projects were used as a "transfer task," which helped to familiarize teachers and/or students with the tools so they could then move on to create more content-focused projects.

Organizing Knowledge Projects

Other teachers created *Organizing Knowledge* projects in the Workshops that used the Interactive Thinking Tools to teach content in a project-based context, but did not necessarily ask students to use the thinking skills the tools were designed to support. Often these projects included *Seeing Reason* maps that did not depict a cause and effect relationship or *Visual Ranking* lists that could not be compared with the maps of others in a meaningful way. For example, some teachers used *Visual Ranking* as a tool to test students' content knowledge, rather than for facilitating decision-making and consensus building among students. One *Visual Ranking* project created in a Workshop asked students to arrange the steps of the scientific method in the correct order. While this project did help students to organize and review content, it did not ask them to compare lists and consider correlations among items, or engage students in discussion. What is made visible by this project is students' knowledge of the process of scientific method, but the thinking behind their ranking was driven more by the correct answer rather than the group exercise of reaching consensus. This project was designed to help reinforce how the steps of scientific method work together rather than to challenge that notion or stimulate debate over the process. In this project type, the tools are used to provide direct instruction in subject area content.

Another common type of Organizing Knowledge project involved using *Seeing Reason* as a concept-mapping tool, rather than as a causal mapping tool. These projects used the tool to visually represent other relationships among ideas rather than a cause and effect relationship. For example, a project that asked students to list and group the costs a family would incur on a road trip was a concept-mapping project, since the map might help students understand how to plan a sensible trip, but no causal reasoning was necessary to create this plan. Such projects could be useful to support discussion and organize information, but did not invite students to use the higher-order thinking skills the tools were designed to scaffold. In both of these examples, the use of the tools is correlated with disciplinary content and information is being organized through the use of the tool, but the thinking skills are not necessary to the projects at hand, as students demonstrate understanding of content-area knowledge.

Gaining Perspective Projects

A third type of project that teachers created were *Gaining Perspective* projects, which sought to teach higher-order thinking skills within a content area with the support of the Interactive Thinking Tools. Unlike the previous two project types, Gaining Perspective projects tended to integrate the tools into the context of a larger research process. For example, one teacher created a *Visual Ranking* project that asked student groups to rank the usefulness of a list of inventions according to the "lens" of career that she assigned each group (e.g. physician or chef). The lesson was part of a larger class project on inventions and patenting. This ranking list helped students gain perspective on the relative value of inventions by taking on different roles, and also framed a larger conversation about how student groups should choose what to invent themselves, in the culminating exercise of the project. By ranking, students not only depicted a list of inventions and why each would be useful or productive, but also depicted the process of how inventors come to make such decisions. The use of the tool, rank ordering, and content knowledge combined to give students a new perspective on how these choices are made and provided their teacher with a window into each team's process.

The teacher who created this project initially thought students could rank the dates of various inventions, but she realized that this ranking list would not provide meaningful comparisons, nor would it promote class discussion on why different professions value certain tools over others. As she planned this project alongside other Workshop participants and a trainer, she identified what she hoped to achieve using the tool, which was to help students discover not only what they wanted to invent and why, but also how it is

that such choices are made. By scaffolding the project in this way, the tool provided a space for students to display their ideas, manipulate and change them, and visualize this process to enhance discussion with each other and with their teacher. Decision-making skills and consensus building were also in evidence, since students gained a sense not just of their own project but of how any group would go about making a similar decision. For this teacher within the Workshop, the process of discussing her own learning objectives with others, and trying to explain exactly how ranking fit into the goals of the lesson, was critical to her project planning. Since she, too, modeled the student experience that included struggling with the content and the skills the tools support, her project promised to be one that students would also experience in these multiple ways. This project involved students using the tool to engage in critical thinking, discussion, and curriculum-relevant class project work. Students may also return to this exercise throughout their invention process and compare how their ideas have changed, or compare their thinking to other groups as a basis for discussion.

Conclusions

The *Seeing Reason* and *Visual Ranking* tools are designed to assist students (and teachers) to visualize their thinking. This quality of the tools makes them challenging to use, in part because responding to students' thinking as it develops requires a high level of mastery of the relevant conceptual material on the part of the teacher. In order to both create projects and then teach with the Interactive Thinking Tools, teachers must have an explicit concept of the higher-order skills the tools elicit. As the examples of projects that teachers generated show, teachers often struggled to both fully grasp understanding the thinking skills associated with the tools and how to then apply this understanding to their content area. Thus, we found that teachers, like their students, are learners in the process of understanding the higher-order thinking skills and concepts targeted by the tools. In order to fully engage in this learning process and create rich project plans that take full advantage of the tools' capabilities, it is critical that teachers struggle through understanding how their curricular content areas and the skills the tools are designed to support intersect. While teachers attempted to tackle this challenge, not all projects were successful in terms of accomplishing learning more about specific higher-order thinking skills and transferring this understanding to the development of project plans to be used in the classroom.

Kennedy (1999) argues that professional development that has the greatest impact on subsequent student learning focuses on helping teachers understand *how students learn*. Therefore, when teachers explore these skills themselves and pass them on to students using technology, they are helping their students think about and depict their own thinking. The continued efforts of professional development opportunities like the Workshop on Interactive Thinking Tools can help teachers to further explore and expand their knowledge of thinking skills, subject-area content, and the process they engage in as learners and educators to construct learning activities that involve their students with technology in complex ways.

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