Facilitating Teachers’ Thinking about Pedagogy and Technology with an Online Curriculum Planning Tool

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Abstract

The current study analyzed the impact of a year-long adoption of an online curriculum planning tool on teachers’ thinking about content and pedagogy, as well as their use of technology in the classroom. The online planning tool was adopted district-wide following professional development training with the purpose of supporting teachers’ development of differentiated, student-centered instruction with digital resources. Structured interviews with high school science teachers were used to determine how teachers’ thinking about key concepts and instruction changed during the course of technology adoption. Verbal protocol analysis was used to code interviews, using comprehension theory and national reform approaches in science teaching to develop a framework that coded teachers’ interview responses as more constructive (student-centered) or more directed (teacher-centered). Results showed that teachers increased their discussion of constructive pedagogical strategies and reduced the degree to which they focused on directed uses of technology. No change was seen in teachers’ domain knowledge across the adoption process, but teachers with deeper domain knowledge were more likely to spontaneously integrate technology into their discussion of domain concepts and pedagogical strategies. Overall, findings demonstrate teachers’ adoption of an online curriculum planning tool in a supported context can have important impacts on their instructional approaches.
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Introduction

Technology Integration in Classrooms

In a classroom environment, the integration of technology into instructional practice is valued by both teachers and students. Teachers readily identify important benefits to utilizing technology in instruction and students increasingly have come to expect that technology will play a significant role in their learning (Hanson & Carlson, 2005). Although teachers recognize the value of technology integration in the classroom, creating technology-supported, student-centered learning experiences is a daunting and time-consuming challenge for most educators (Project Tomorrow, 2012). Further, developing differentiated instruction that meets the specific learning needs of individuals and small groups can challenge even the most dedicated and talented educators. Broadly, differentiating instruction refers to creating instruction in which teachers adjust curricula, instructional approaches, learning materials and resources, and classroom activities to address the needs of diverse learners (Tomlinson et al., 2003). Given the varied learning materials and resources needed for effective differentiation, digital resources and online materials have strong potential to play a key role in teachers’ differentiation efforts. Some schools have strongly embraced digital personalization for effective instruction, going as far as to replace traditional textbooks with playlists of digital content that are identified and organized by teachers (e.g., Demski, 2009).

Effectively selecting and implementing technology-based instruction for diverse learners requires teachers to possess a coordinated understanding of technology, pedagogy, and domain knowledge; others have referred to this as TPACK: technological pedagogical and content
knowledge (Mishra & Koehler, 2006). Faced with the challenge of differentiating instruction to optimize individual learning for a diverse set of students, it is not surprising that teachers cite learning more about domain content, teaching students with special needs, and using technology in the classroom as three of their top four priorities for professional development (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009).

However, professional training without implementation support may not be enough to support the integration of technology into instruction in constructive ways. After participating in a training program on designing computer-based instruction, Valanides and Angeli (2008) found that 40% of the trained teachers failed to use technology as a cognitive tool to transform and customize instruction; instead, these teachers utilized technology as a delivery vehicle to present pictures or textbook content (Valanides & Angeli, 2008). Although some award-winning teachers have been found to use technology in deep, student-centered ways (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010), many classroom teachers fall back on superficial uses of technology that rely on teacher-centered activities and fail to transform instructional content or practice (Culp, Honey, & Mandinach, 2005). Thus, when considering the adoption and use of technology in the classroom, it is important to consider the nature of the instruction that is being designed and implemented.

**Constructive and Directive Pedagogical Approaches**

Recent national reform efforts, especially in science instruction, have emphasized the need for student-centered instructional approaches in which students engage in authentic and meaningful practices (e.g., National Research Council, 2012). For example, in science and engineering, students should analyze/interpret data, construct explanations, design solutions, develop arguments based on evidence, and communicate information (National Research
This paper refers to these authentic, student-centered instructional approaches as constructive, because they typically involve students developing, generating, or creating something as part of the instructional process. Constructive approaches can be contrasted with directive (also referred to as directed) approaches, in which teachers (rather than students) engage in the constructive processing to develop materials and then present content to students or direct them in learning activities that are more procedural rather than generative (e.g., looking up worksheet answers).

Examining the impact of constructive and directive pedagogical approaches has been the focus of research for many years in education (e.g., Deretchin & Contant, 1999; Klahr & Nigram, 2004; Kuhn & Dean, 2005; Prawat, 1992). Critical thinking, problem solving, and knowledge generation are critical components of constructive approaches, emphasizing the higher order skills that students are expected to apply in these learning situations (Prawat, 1992). In contrast, the directive pedagogical approach is sequenced, structured, and skill based, moving the student toward convergent thinking and skills. Accordingly, the directive approach also can be referred to as traditional, teacher-centered, didactic, shallow, and passive. Although technology integration in either pedagogical approach requires teacher training (cf., Valanides & Angeli, 2008), using technology to promote constructive pedagogical activities is most consistent with the approaches of teachers who have been recognized for high-quality, technology-enhanced instruction (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010) and with modern views of pedagogy and technology (e.g., National Research Council, 2012). Thus, when evaluating the impact of technology training and adoption, it is critical to be able to identify and analyze the nature of the resulting instruction. That is, have teachers used technology to support
their students in constructive learning activities or have teachers implemented technology as a method to present content to their students in directive ways?

Assessing Constructive versus Directive Pedagogical Approaches

As noted above, education researchers have used varied terms to define constructive and directive instructional activities. This can create difficulties in determining when training or interventions have facilitated teachers’ implementation of constructive versus directed activities, especially when attempting to analyze the quality of teachers’ technology integration. For example, Mitchem, Wells, and Wells (2003) examined the impact of a professional development program aimed at facilitating technology-based instruction with a sample of 27 K-12 teachers. As part of their analyses, these researchers analyzed teachers’ post-training lessons for examples and non-examples of “active student engagement.” They defined active student engagement as occurring anytime that students produced an observable response to an instructional prompt, including responding verbally or in writing to questions and retrieving information from a webpage. Non-examples included listening to lecture or looking at a webpage. Although this provided researchers with a consistent way to evaluate student activity, it did not capture the constructive versus directed nature of the underlying student thinking. Asking students to retrieve information from a website is more consistent with a “traditional” exercise similar to locating specific information in a printed textbook as opposed to students engaging in integration, analysis, or synthesis of the provided content. Mitchem et al. (2003) found that – after training – teachers significantly increased their use of technology and always used some form of active student engagement. However, their data showed that teachers did so without changing the basic nature of their earlier lessons. Thus, teachers appeared to focus more on the development of their technology skills (including using technology as a source of materials)
rather than as a tool with unique capabilities for constructive learning. This finding is not unique to teachers at the K-12 levels. Even university faculty in a teacher education program have been found to focus their discussion of knowledge and skills related to instructional technology on technical features of the technology itself, rather than its potential use in the classroom (Wedman & Diggs, 2001).

As illustrated in this example, evaluating the impact of technology adoption and integration on teachers’ instructional thinking requires a consistent and meaningful way to characterize the differences between constructive and directed instructional approaches. One effective method to accurately characterize the differences between constructive and directed instruction is to consider the types of cognitive processing in which a learner must engage in order to complete the instructional activity, as well as to consider the knowledge outcomes that learners should develop as the result of the instruction. Research and theory from text comprehension research provides a useful framework with which to identify these differences.

**A comprehension framework for student learning.** A well-known and widely-researched model of comprehension and learning, the Construction-Integration (CI) model, notes that knowledge can be learned and acquired at three levels: the surface level, textbase, and situation model (Kintsch, 1988). These three levels characterize the degree to which knowledge is encoded for recall and recognition versus the degree to which knowledge is constructed and integrated for meaningful application. In the CI model, *surface level* describes the specialized situation in which an exact representation is encoded from learning materials – for example, when a learner needs to memorize a poem. Because learners do not usually need to reproduce learning materials exactly (i.e., word for word), the surface level typically is not emphasized during instruction (and is not discussed further in this paper). The second level of knowledge,
the textbase representation, is formed when learners attempt to learn information by remembering its gist as faithfully as possible without transforming it themselves through analysis, synthesis, integration, or communication. As a result, learners can reproduce facts or information from studied materials, but cannot transfer or apply their knowledge in more meaningful ways. Directive instructional approaches, where teachers present or provide information to learners, typically is associated with the development of this more shallow level of knowledge. Student activities that require reproducing, recognizing, or remembering content that has been provided to them (e.g., giving the definition for a vocabulary term or finding information on a website) require only a textbase level of representation.

The third level of representation – the situation model – represents a deeper understanding of the “situation” at hand (Kintsch, 1994). It is developed when incoming information is integrated with prior knowledge, forming a new and flexible representation that can transfer to other contexts. The situation model is formed when students engage in deep-level cognitive processes, including inference, integration, and analysis (for a discussion, see Butcher & Kintsch, 2012). Students must be engaged in truly constructive instructional practices from a cognitive perspective (e.g., solving new problems, analyzing data, synthesizing information to form a new argument) in order to form this deep, flexible form of knowledge.

Using a comprehension model to analyze the constructive vs. directive quality of teachers’ pedagogical approaches offers a meaningful method to equate teachers’ activities in a way that directly considers learners’ processes and outcomes. For example, nearly all the examples of “active student learning” from Mitchem et al. (2003) are consistent with development of a textbase level of knowledge. Thus, for the purposes of the current study, those instructional activities would be categorized as more directive forms of instruction. The
exception is Mitchem et al.’s (2003) example of responding verbally or in writing to instructional prompts; in this case, categorizing the activity as constructive or directive would depend upon whether the prompts provided to the student required recall only versus integration or analysis of the previously-learned information. If integration and analysis were required, students should develop a situation model representation and the instruction could be categorized as a constructive approach.

The current study sought to determine the degree to which the adoption of a technology-based curriculum planning tool would affect teachers’ thinking about instruction and their instructional strategies. In this paper, the term “thinking” is used to refer broadly to the cognitive processes by which teachers reason about domain content, pedagogical activities, and technology integration as relevant to their instructional practices. By providing access to high quality digital materials and promoting teachers’ organization and development of instructional activities (thereby freeing cognitive resources associated with these activities), the online curriculum planning tool studied in this work was anticipated to facilitate teachers’ reasoning about more constructive forms of instructional practice. The analytical framework used in this paper builds on the CI model in order to assess constructive (situation-model) versus directive (textbase) approaches to teachers’ thinking about domain knowledge, their pedagogical approaches (in general), and their technology integration (in particular).

**Impact of Technology Adoption on Teachers’ Thinking**

Research on professional development training has found that many teachers receive training on using computers for instruction (65%), but this training typically is short term (2 days or less in 80% of cases) and the majority (57%) of teachers do not find it to be useful (Darling-Hammond, et al., 2009). More promising results have been found with intensive professional
development efforts aimed at comprehensive integration of technology in the classroom. For example, Polly (2011) studied the impact of a 30-hour professional development conducted over the course of a summer; this training focused on helping educators collaboratively develop an online curriculum map that could be used to store online educational resources associated with state standards. Results demonstrated that teachers who learned to find and construct technology-based resources for their classes reported significant gains in their content and pedagogical knowledge in addition to gains in technology skills. However, Polly (2011) relied upon teachers’ self-reported responses to an interview that directly asked teachers to reflect on their use of technology and what they learned during the training. When asked to report what they learned in three specific areas (technology, teaching strategies, and subject knowledge) following a full summer of training, teachers may feel compelled to report areas of impact that may not be central to their practices. Indeed, self-report measures have been criticized as assessing changes in confidence rather than actual knowledge (Lawless & Pellegrino, 2007). Thus, teachers’ self-reported changes in knowledge and thinking may not provide an accurate indicator of the potential for actual change in instructional practice.

Even in-depth interviews may result in misleading results when teachers are asked directly about how their practices have changed as the result of specific training or experiences. Brinkerhoff (2006) interviewed teachers about the impact of a long-term, technology-focused professional development on their thinking and perceptions (e.g., “Have your feelings concerning the integration of technology within your teaching changed during the course of the academy?”). Although all teachers reported that the training had changed their teaching practices during interviews, survey responses (in which teachers were queried about their specific technology integration practices) showed no impact of the training. Brinkerhoff noted that
teachers’ individual interpretations of technology integration may have influenced interview results and that survey questions may have to become more sensitive to capture these differences. However, another possibility is that although teachers intended to change their practices and (consciously or unconsciously) wanted to reaffirm the value of the training, their perceptions of their practices were not consistent with their specific implementation in varied instances. Thus, new methods are needed to assess changes in teachers’ thinking and practices during technology adoption. Moreover, these new methods should provide a way of objectively assessing these changes in teacher thinking and assessing technology integration as an overall part of their pedagogical practice, rather than as a separate skill that exists independently.

The Current Study and Research Questions

The current study used structured interviews to examine changes in teachers’ thinking about domain concepts, pedagogical approaches (in general), and technology integration (specifically) early and late in a technology adoption cycle. However, unlike previous studies, the current study did not directly ask teachers to describe their technology integration efforts or to self-report changes in their practice. Rather, the current study examined the impact of technology adoption on teachers’ thinking about domain content and their pedagogical approaches more holistically. Structured interviews were used to engage teachers in a discussion of their instructional approaches and strategies for several key domain concepts required by the school district curriculum. Thus, the nature of teachers’ technology integration was analyzed as it was discussed spontaneously as a part of teachers’ overall practices. Overall, this study addressed three main questions:
1. To what extent can teachers’ discussion of key domain concepts provide insight as to their constructive vs. directive thinking about domain content, pedagogy, and technology integration?

2. During adoption of an online planning tool, to what extent do teachers demonstrate significant changes in their constructive and directive thinking about (a) pedagogical practices, (b) domain content, and (c) technology integration?

3. To what extent is there an association between teachers’ thinking about content and pedagogy and the degree to which they spontaneously integrate technology into their instruction in constructive ways?

**Technology Context**

The Curriculum Customization Service (CCS) is a web-based tool that aligns digital resources from the Digital Library for Earth System Education (www.dlese.org) to key concepts in the EarthComm (Earth science) curriculum (Smith, Southard, & Crum, 2006). Teachers can use the CCS to explore online materials relevant to key instructional objectives and to save digital resources to an individual account (see Figure 1). Saved resources were connected to relevant learning goals and curriculum units/activities; teachers also were able to annotate saved resources with optional tags or free-form notes to indicate planned usage or target audiences. Additionally, the CCS provided teachers with access to publisher-provided curriculum materials, such as a digital version of the textbook and assessments, and allowed teachers to upload and share their own instructional materials (see Sumner, 2010, for a detailed description of the CCS).
Previous research has found that the CCS was used by a majority of teachers during this year-long adoption period, with about one-third of teachers reporting that they used the CCS several times per day or week (Sumner & CCS Team, 2010). Teacher responses to the CCS adoption were very positive: survey results showed that 89% of teachers reported that the CCS made it easier for them to find digital resources for instruction and 61% reported that the CCS facilitated their differentiation of instruction (Sumner & CCS Team, 2010). However, these previous evaluations relied upon teachers’ self-reported perceptions of impact. As noted earlier (Brinkerhoff, 2006; Lawless & Pellegrino, 2007), these self-report measures may not provide an accurate and consistent reflection of true changes in teachers’ thinking and practice. Thus, the current study used teachers’ discussions of instructional approaches to key domain concepts as an objective way to analyze changes in teachers’ thinking and instructional approaches.
Method

Using a qualitative approach, structured teacher interviews were used to collect teacher thinking on teaching and learning. The interviews were conducted early (interview 1) and late (interview 2) in the school year during a district-wide adoption of the CCS.

Participants

Participants were 11 practicing science teachers (average teaching experience: 7 years) from a large urban school district in the western United States. The district’s student population was ethnically diverse (77%), many students came from lower socioeconomic levels (72% qualify for free/reduced lunch programs), and approximately 40% were English language learners. Participants were recruited by an email to all high school Earth science teachers; each participant received compensation (at standard district rates) for time spent in the interviews.

Data Sources and Materials

Domain assessment items. In order to focus discussion on core concepts taught by the teachers, structured interviews were targeted to specific assessment items from the district’s standardized benchmark exams. These exams measure student progress on important Earth science concepts at the beginning and end of each school year. The benchmark exams are a secure test (i.e., items are not published), so six items were selected by the district science coordinator to cover key domain concepts from three topics required in the curriculum: plate tectonics, the water cycle, and oceans. All topics included one multiple-choice item (see Figure 2a) and one free response item (see Figure 2b). Figure 2 contains representative items, not exact items, to preserve the integrity of the secure test.
Structured interview prompts. Interview prompts were developed to help guide teachers to engage in a rich discussion surrounding the assessment items. Prompts were content-free (c.f., Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001), in that they did not refer to specific domain ideas, concepts, or item content. Prompts focused on discussion of domain content and classroom practice (see Table 1). Prompts targeted to classroom practice started out by querying teachers about general practices, then asked teachers about specific practices related to customization for small groups or individual students (see Table 1).
Table 1.

Structured interview prompts

<table>
<thead>
<tr>
<th>Prompt Type</th>
<th>Prompt(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain content (item)</td>
<td>What Earth science knowledge would a student need to answer this question correctly?</td>
</tr>
<tr>
<td>Domain content (general)</td>
<td>Okay, now we’ll transition from talking about the question itself to its associated key concepts. As you can see, the assessment objective is [read assessment objective from item]. What Earth science knowledge does a student need to understand this concept? Are there any common misunderstandings you see related to this concept? Do you consider this to be (a) central idea(s) in the domain? (i.e., is it an important concept for students to know?)</td>
</tr>
<tr>
<td>Classroom practice (general)</td>
<td>What are the most effective lessons, activities, or specific materials that you use in your class to target the idea(s) being tested by this item?</td>
</tr>
<tr>
<td>Classroom practice (customization)</td>
<td>In your experience, are there particular students or groups of students who have trouble with the concept being tested by this item? Do you have any specific materials or activities that you roll out when you sense that students need to gain a better understanding of this idea/concept?</td>
</tr>
</tbody>
</table>

Procedure

Interviews lasted 30-45 minutes and were conducted by telephone at a location where teachers also had a computer with internet access. Interview 1 took place early in the school year during the adoption period (November) and interview 2 took place late in the school year during the adoption period (April or May). The interviewer read the prompts while teachers were shown the assessment items on their computer screens, one at a time, using remote viewing technology. Interviews were audio recorded and subsequently transcribed.

Verbal protocol analysis: Segmenting and coding. Transcripts first were segmented into idea units (or “utterances”) representing a complete thought or distinct idea (Trickett & Trafton, 2007). Four research assistants segmented transcripts; a second assistant segmented
20% (randomly selected) of each transcript. Segmenting agreement was very high (Interview 1: \( M = 89\%, \text{ min } = 80\%, \text{ max } = 97\%; \) Interview 2: \( M = 86\%, \text{ min } = 79\%, \text{ max } = 96\% \)). Segmenting resulted in 4,393 utterances from interview 1 and 4,909 from interview 2. Each utterance was coded by a human rater using Atlas.ti software.

Each segmented utterance was coded at two levels. Since teachers’ discussion in response to all prompts moved naturally between content, pedagogy, and technology, Level 1 codes first identified the major focus of each utterance: domain content, pedagogical strategies, or technology. Level 2 codes divided the Level 1 codes into those reflecting more constructive vs. more directive processes, as informed by the CI model of comprehension. Table 2 provides sample utterances from Level 1 and 2 coding categories. Within the technology category, only utterances describing the integration of technology were coded into constructive and directive levels. The remainder of technology-focused utterances named types of technology without articulating how they were integrated into the classroom.

Given the large amount of data, coding was completed by splitting the transcripts across four research assistants for interview 1 and three research assistants for interview 2. Inter-rater agreement was assessed by having all raters code 20% of all transcripts (randomly-selected). Cohen’s kappa was calculated for the multi-rater sample (cf., Landis & Koch, 1977).
Table 2.

*Example utterances organized by verbal codes*

<table>
<thead>
<tr>
<th>Level 1 Code</th>
<th>Level 2 Code</th>
<th>Example Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain content</td>
<td>Constructive</td>
<td>“…and that they could figure out the focus on the epicenter through looking at the evidence and [reason about] how it has affected the ground in the surrounding…”</td>
</tr>
<tr>
<td></td>
<td>Directive</td>
<td>“…They need to know … subduction, divergent, convergent plates, transform … they have to know those definitions.”</td>
</tr>
<tr>
<td>Pedagogical Strategies</td>
<td>Constructive</td>
<td>“I mean we do the like Slinky stuff, you know, you play with Slinkys to see the difference between the waves…”</td>
</tr>
<tr>
<td></td>
<td>Directive</td>
<td>“With this concept I just drill them with it every day.”</td>
</tr>
<tr>
<td>Technology</td>
<td>Constructive</td>
<td>“… and they could have the – you know, the distributive experience… at their own workstation.”</td>
</tr>
<tr>
<td></td>
<td>Directive</td>
<td>“… I can just pull something up… I can pull up an animation and show them.”</td>
</tr>
</tbody>
</table>

**Results**

**Reliability of Coding Framework**

In order for verbal analysis of teachers’ discussions to serve as a useful methodology for understanding teachers constructive and directive thinking about domain content, pedagogy, and technology integration, there must be sufficient agreement across raters who assign codes to the verbal utterances. Agreement was measured by calculating average Cohen’s kappa across raters for level 1 and level 2 codes; as in Landis and Koch (1977), kappa values from .61-.80 were considered to reflect substantial agreement. Because level 2 codes are dependent on agreement at level 1 (i.e., level 2 codes will automatically be unmatched if raters disagree at level 1), kappa was calculated on level 2 codes for utterances upon which raters agreed at level 1. In interview 1, kappa was .76 for level 1 codes and .70 for level 2 codes. In interview 2, kappa was .73 for both
level 1 and level 2 codes. These values demonstrate that independent coders achieved substantial agreement in identifying constructive and directive forms of thinking about content knowledge, pedagogy, and technology integration. Accordingly, the current results show that analyzing teachers’ discussion of key domain concepts provides a useful way to analyze differences in teachers’ thinking.

**Constructive vs. Directive Thinking about Content, Pedagogy, and Technology**

Table 3 provides the means and standard deviations for level 1 and 2 codes. In Table 3, the percentage of total utterances shows how much of the overall conversation fell into each coded category. The percentage of level 1 codes indicates how much of the discussion about each area (content, pedagogical, or technology discussion) was coded as constructive or directive.

**Table 3.**

*Distribution of key categories across interview 1 and 2*

<table>
<thead>
<tr>
<th></th>
<th>% of All Utterances</th>
<th>% of Level 1 Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Interview 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domain content, constructive</td>
<td>12.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Domain content, directive</td>
<td>10.2</td>
<td>5.3</td>
</tr>
<tr>
<td>Pedagogical strategies, constructive</td>
<td>16.9</td>
<td>6.4</td>
</tr>
<tr>
<td>Pedagogical strategies, directive</td>
<td>4.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Technology integration, constructive*</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Technology integration, directive*</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Interview 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domain content, constructive</td>
<td>15.6</td>
<td>8.4</td>
</tr>
<tr>
<td>Domain content, directive</td>
<td>9.4</td>
<td>4.0</td>
</tr>
<tr>
<td>Pedagogical strategies, constructive</td>
<td>24.2</td>
<td>9.3</td>
</tr>
<tr>
<td>Pedagogical strategies, directive</td>
<td>4.4</td>
<td>3.7</td>
</tr>
<tr>
<td>Technology integration, constructive*</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Technology integration, directive*</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
Note: Since constructive vs. directive approaches to technology integration apply only to utterances that describe the use of technology in the classroom, percentage of constructive and directive technology integration codes are misleading as an indicator of total technology talk. Overall, technology codes accounted for about 10% of utterances in interview 1 and 2.

How Does Teachers’ Thinking Change during Technology Adoption?

An initial repeated measures analysis of variance (RM-ANOVA) was conducted to examine the distribution of content, pedagogical, and technology utterances across interviews 1 (near the beginning of the CCS adoption) and 2 (near the end of the CCS adoption). Interview time was the repeated factor and dependent measures were the percentage of total utterances coded as content, pedagogical, or technology utterances. Results showed that teachers did not differ in the amount of discussion devoted to domain content, pedagogical strategies, or technology use across the two interviews ($F$s < 1). Thus, the remaining analyses focused on the extent to which teachers’ discussion in each area was constructive or directive, using the percentage of constructive and directive utterances as the dependent measures. A repeated measures multivariate analysis of variance (RM-MANOVA) was used to analyze changes across content, pedagogy, technology, where interview time (interview 1 vs. interview 2) and instructional approach (constructive vs. directive) were the repeated factors. A standard alpha level of $p < .05$ was used for all analyses.

Discussion of Domain Knowledge across the CCS Adoption

A trend was found for instructional approach. Although the effect did not reach the level of statistical significance ($p < .05$), during both interviews teachers tended to talk about domain content more often in constructive than directive ways ($F_{(1,10)} = 4.2$, $p < .07$). There was not a main effect of interview (i.e., teachers’ talk about domain knowledge did not differ between interview 1 and interview 2; $F<1$) nor was there an interaction of interview and instructional approach (i.e., teachers’ constructive vs. directive talk about domain knowledge did not differ
across the interviews; $F<1)$. Thus, throughout the course of technology adoption, teachers were more likely to talk about domain knowledge in constructive ways.

**Discussion of Pedagogical Strategies across the CCS Adoption**

Results showed a main effect of interview time for pedagogical strategies ($F_{(1, 10)} = 6.09$, $p < .04$): teachers talked more about pedagogical strategies at interview 2 (near the end of the CCS adoption) compared to interview 1 (near the beginning of CCS adoption). Results also showed a main effect of instructional approach ($F_{(1, 10)} = 138.75$, $p < .01$): teachers were more likely to discuss constructive (rather than directive) pedagogical strategies. Main effects were subsumed by an interaction between interview time and level of knowledge ($F_{(1, 10)} = 7.85$, $p < .02$): from interview 1 (early in CCS adoption) to interview 2 (late in CCS adoption), teachers increased their discussion of constructive pedagogical strategies and slightly decreased their discussion of directive pedagogical strategies (see Table 3). Thus, across the year-long CCS adoption, results demonstrate that teachers started to think about their instruction surrounding core concepts in more constructive (student-centered) ways.

**Discussion of Technology Integration across the CCS Adoption**

Results showed a non-significant trend for interview ($F_{(1, 10)} = 4.51$, $p = .06$) and a significant effect of instructional approach ($F_{(1, 10)} = 6.78$, $p < .03$). These effects were subsumed by an interaction of interview and instructional approach ($F_{(1, 10)} = 5.63$, $p < .04$). Teachers were more likely to discuss directive uses of technology in interview 1 (near the beginning of the CCS adoption) than in interview 2 (near the end of the CCS adoption; see Table 3). Although this does not directly demonstrate that teachers’ use of technology became more meaningful during the course of the CCS adoption, it does show that directive approaches to technology use became less prevalent in teachers’ thinking as they worked with the CCS over time. It should be noted
that deep integration of technology into practice takes significant time and effort, and may require additional support beyond the initial adoption phase that was captured in this research. However, it is important to note that the current results show that teachers moved away from directive (teacher-centered) uses of technology over the course of adopting a curriculum-focused tool for classroom customization.

**Constructive approaches to Content and Pedagogy Facilitate Technology Integration**

Teachers who develop a deeper understanding of technology as related to instructional practices should be able to talk about technology in more integrated ways as they discuss domain content and pedagogy. In the current study, this possibility was assessed by using the coded transcripts to calculate the frequency with which each teacher transitioned between utterances related to technology and those related to content or pedagogy. Specifically, technology integration was calculated as the number of transitions between idea units coded as technology and idea units coded either as pedagogy or content, divided by the number of total transitions between technology and all other idea units. More frequent transitions indicated a more integrated discussion of technology within content and pedagogy.

As seen in Table 4, constructive content-based utterances at interview 1 and 2 were significantly and positively correlated to technology transitions (i.e., the degree to which technology was integrated into domain and pedagogical thinking) at interview 2. Deeper domain knowledge supported teachers in developing an integrated view of technology during the course of technology adoption. Conversely, the prevalence of utterances about directive pedagogical strategies in teachers’ protocols was significantly and negatively related to technology integration. The more teachers discussed directive (traditional, teacher-centered) strategies
during the interviews, the less likely they were to integrate technology into their discussion of instructional practice (even at the end of a technology adoption phase).

Table 4.

Correlations between verbal codes (% of total utterances) and technology transitions in teacher discussion at interview 2

<table>
<thead>
<tr>
<th></th>
<th>Correlation to technology transitions at interview 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interview 1</strong></td>
<td></td>
</tr>
<tr>
<td>Domain content, constructive</td>
<td>.85**</td>
</tr>
<tr>
<td>Domain content, directive</td>
<td>.16</td>
</tr>
<tr>
<td>Pedagogical strategies, constructive</td>
<td>-.22</td>
</tr>
<tr>
<td>Pedagogical strategies, directive</td>
<td>-.78**</td>
</tr>
<tr>
<td><strong>Interview 2</strong></td>
<td></td>
</tr>
<tr>
<td>Domain content, constructive</td>
<td>.66*</td>
</tr>
<tr>
<td>Domain content, directive</td>
<td>-.23</td>
</tr>
<tr>
<td>Pedagogical strategies, constructive</td>
<td>-.29</td>
</tr>
<tr>
<td>Pedagogical strategies, directive</td>
<td>-.60*</td>
</tr>
</tbody>
</table>

*p ≤ .05; **p ≤ .01

Discussion

Teachers’ discussion of key concepts highlights constructive vs. directive thinking

The first research question addressed by this work was “To what extent can teachers’ discussion of key domain concepts provide insight as to their constructive vs. directive thinking about domain content, pedagogy, and technology integration?” The current research demonstrates that verbal protocol analysis, used in conjunction with structured interviews and standardized assessment items, is a useful methodology to understand changes in teacher
thinking during technology adoption. Focusing teachers’ discussion on practices surrounding core concepts allowed researchers to analyze instructional approaches and technology integration in a more holistic way than methodologies that ask teachers to report specifically on their technology use or changes to their practice. Indeed, current findings show that only about 10% of teachers’ overall discussion about instructional practices spontaneously focused on technology.

Consistent with other research (Mitchem et al., 2003; Wedman & Diggs, 2001), teachers were more likely to talk about technology skills or tools than to engage in discussion about how different technologies can be integrated into classroom activities. However, observed results also demonstrated the importance of distinguishing between constructive and directed instruction when evaluating technology integration. Although the overall percentage of teachers’ technology-focused discussion did not change across the course of technology adoption, the nature of teachers’ technology-focused thinking about integration did change. Across our sample, teachers reduced their discussion of directive uses of technology over the course of CCS adoption. The current methodology showed strong potential value in using a well-known model of comprehension (the CI model) to categorize the instructional approaches of teachers based upon the cognitive processes required by learners. This approach to analyzing changes in teachers’ thinking is a promising method for assessing the impact of technology adoption and/or professional development training in a rich and objective way.

**Using an online planning tool promoted constructive approaches to pedagogy**

The second research question addressed by this research was “During adoption of an online planning tool, to what extent do teachers demonstrate significant changes in their constructive and directive thinking about (a) pedagogical practices, (b) domain content, and (c) technology integration?” Overall, findings demonstrate that providing teachers with an online tool that aligns
digital resources to a classroom curriculum had significant benefits that extended beyond their confidence in technology use. Following the year-long period of CCS adoption, teachers were more likely to discuss constructive pedagogical strategies surrounding key domain concepts. Teachers also decreased the frequency with which they discussed directive, teacher-focused uses of technology in their instruction. Facilitating teachers’ thinking about instruction in constructive ways may be especially important for supporting future technology integration – the current results showed that teachers’ discussions of directive pedagogical strategies (those focused on factual learning and memory) were negatively associated with discussions where technology, domain concepts, and pedagogy were tightly interwoven in teachers’ thinking. Future teacher education efforts focused on technology integration may need to include training on constructive pedagogy and development of domain knowledge in order to maximize potential impact.

**Constructive thinking about domain ideas facilitated technology integration**

The third research question addressed by this research was “To what extent is there an association between teachers’ thinking about content and pedagogy and the degree to which they spontaneously integrate technology into their instruction in constructive ways?” The current results demonstrated that teachers who discussed domain content in constructive ways (for example, focusing on concepts that should be integrated by students or inferences that students should make) engaged in more fluid discussion of technology as they talked about domain concepts and their specific pedagogical strategies in the classroom. From a practical standpoint, this suggests that technology adoption may be facilitated by professional development that supports student-centered thinking about domain content. Future efforts at teacher education should examine whether facilitating deep domain knowledge can leverage the impact of professional development training about technology integration. Future research also is needed to
determine the extent to which teachers’ discussions of pedagogical approaches and technology integration match their observed classroom practices.

**Limitations of the current study**

It should be noted that the current study sampled teacher thinking at two time points: early and late during technology adoption. Although findings indicated a change in thinking across the intervening time period, it cannot attribute those changes directly to the adoption of the online curriculum customization tool. Because of the intensive nature of the collected data, the current study also sampled less than a dozen teachers from a specific grade level (high school), a specific content area (Earth science), and a single district. Additional research is needed to determine the extent to which observed results may transfer to teachers at other grade levels, in other content areas, and in other districts.

In the current research, the online curriculum customization tool (the CCS) was designed specifically for the purpose of supporting teachers’ integration of high-quality digital resources into classroom instruction. The CCS included a range of planning features and was aligned specifically to key domain concepts from the curriculum used by the district. Although the current results demonstrate that well-designed technology tools can have meaningful impact on teacher thinking, the nature and strength of this impact likely depends upon the types of support available in the technology tool. Findings from this research offer an important foundation for identifying and measuring potential changes in teachers’ thinking and instructional practices during technology adoption. However, additional research is necessary to identify the key features of instructional technologies that may result in changes to teachers’ thinking, especially when considering constructive practices. Overall, the current work demonstrated that technology adoption can have important and measureable impacts on teachers’ thinking about instructional
approaches and the ways in which technology is integrated into their classrooms. Results indicate that teachers’ adoption of a well-designed online tool that supports curriculum planning with digital content can facilitate meaningful thinking about constructive practices and effective forms of technology integration.

**Implications for Practice and Teacher Education**

The current work has several implications for educational practice as well as for teacher education. With regard to educational practice, the current work provided a successful example for the adoption of an online curriculum planning tool. Key features of the adoption phase included district-wide support for attendance at professional development meetings (online and face-to-face), close alignment between the district curriculum and the online planning tool, teacher involvement in the design of the online tool (to ensure close connections with teacher practices), and buy-in at multiple levels (district teachers, science coordinators, and administrators). Thus, this work highlights the importance of professional development and local customization when districts seek to implement new educational technologies. The current work also suggests that alignment to teachers’ existing instructional practices is vital: teachers did not report drastic disruption or changes to their instructional practices. Rather, teachers were able to modify their existing instructional practices to move from directed to constructive approaches during the course of technology adoption.

When considering teacher education, the current work demonstrates the need to directly address the differences between directive and constructive approaches in instructional thinking. The current findings demonstrate that even experienced teachers need support in moving away from directed uses of technology in the classroom and may need additional time and experience to develop student-centered uses of technology in the classroom. Pre-service teachers may need
to see successful examples of student-centered technology lessons in order to develop a vision of constructive technology integration. Moreover, the current work suggests that teacher education should provide pre-service and practicing teachers with practice in using technology to offload lower-level tasks associated with digital materials (e.g., finding and organizing content) so that these educators can focus their cognitive resources on differentiating and deepening the use of digital materials in the classroom. Current results showing a negative relationship between directive uses of technology and constructive forms of content and pedagogical knowledge also suggest that professional development training for technology integration cannot ignore these concurrent forms of knowledge. Technology-focused training should be integrated into contextual examples of constructive pedagogy in order to facilitate meaningful implementation.

The current research also demonstrates that assessing teacher thinking can be facilitated by objective analysis of verbal discussion related to key concepts in a curriculum. This methodology provides a sensitive way to measure and track teachers’ progress toward developing meaningful thinking about domain content, pedagogical approaches, and technology integration as they prepare to teach a population of increasingly diverse and technology-focused students in their future classrooms. Future work should continue to evaluate and explore this methodology as a rich and sensitive method for assessing change in teachers’ instructional thinking and practices.

Conclusion

Overall, the current work demonstrated that technology adoption can have important and measureable impacts on teachers’ thinking about instructional approaches and the ways in which technology is integrated into their classrooms. Results indicate that teachers’ adoption of a well-designed online tool that supports curriculum planning with digital content can facilitate meaningful thinking about constructive practices and effective forms of technology integration.
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