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Design of online teacher professional development in a statewide Reading First professional development system

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Abstract

This study examined the pedagogy of three online teacher professional development (oTPD) modules. Evidence of design features oriented to the *how people learn* framework was the primary research objective. An analytic framework was devised to code knowledge types, levels of cognitive demand, levels of interaction, and sensory details in the learning architecture of each module. All three online modules showed a didactic pedagogy (show and tell) rather than a constructivist one (teaching for understanding). Module content emphasized declarative types of knowledge (facts and concepts), and lower levels of cognitive demand (remember and understanding). The interaction pattern of two modules was largely passive, reflecting a limited level of learner participation, control, productivity, and creativity of experience. A third module, developed after research on the other two, provided learners with more guided and self-initiated interaction. Sensory design of the modules was the most well-developed and supportive of learner engagement. The study confirmed the need for more research on design principles and strategies to support constructivist principles in oTPD modules.

Keywords: Online teaching; Web-based instruction; Professional development; Instructional design; Pedagogy

1. Introduction

With astonishing speed, online teacher professional development has swept into the professional education arena and continues to grow at a tremendous rate (Mandinach, 2005). All around, it seems to be the right venue at the right time, offering a myriad of benefits in times of severe fiscal constraints (Brown & Green, 2003; Carter, 2004). Online teacher professional development, or oTPD, is convenient and efficient, incorporating new, emerging technologies, online learning communities, modeling, coaching — all with the added advantage of "any time, anywhere" participation geared to individual teacher work schedules and needs (Carter, 2004; Harlen & Doubler, 2004). In today's fast-paced, media saturated world, oTPD is a promising newcomer with high hopes for transforming professional

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development from “now and then” for some to an integral part of teaching practice for all — and potentially at a lower price.

Availability, however, is no guarantee of quality. Even though new technologies for robust oTPD are available, how to use them to advance teacher thinking, reasoning, and instructional skill is far less clear. Barab, Kling, and Gray (2004), for example, cite how difficult it is to build online learning communities that inform teachers and also help them to solve the tough problems of practice. So – while it may be the case that different configurations of oTPD (e.g., blended approaches) compete effectively with traditional models of professional development (Bernard et al., 2004) – whether these online venues result in improved teaching practice is a more complex matter (Brown & Green, 2003).

To help build the case for professional development as a worthwhile, long-term investment on the part of states, districts, schools, and individual teachers, oTPD must do what traditional professional development has long tried to do: help teachers learn. For this to happen, though, the online learning environment must incorporate interactive, meaningful, and thought-provoking tasks to engage and direct teacher learners; it must scaffold teachers to higher-level teaching skills; it must build communities of practice among them; and it must include rich collaborative e-learning tools and resources for them to use (King, 2002; Oliver & Herrington, 2003). Designing and building rich online learning environments, however, is not easy. It requires collaborative relationships between content specialists and instructional technologists who together explore new online pedagogies, integrate learning objects with learning principles, and use their imaginations to create new learning environments (Bonk, 2002; McCombs & Vakili, 2005).

Considerable research is still needed to ground and guide the future of oTPD, especially at the design level where the power of e-learning resources (e.g., tools, web technologies, multimedia) must connect with the scientific bases of learning for developing teacher knowledge and skill (Dede, 2005). Strong instructional designs that best represent how people learn are key for supporting optimum matches between e-learning technologies and appropriate instruction for diverse educators with different needs. A synthesis of cross-disciplinary research on human learning, the *how people learn* framework (Bransford, Brown & Cocking, 2000), proposes three principles of effective teaching: (a) engaging learners’ prior understandings as a foundation for new ones; (b) the essential role of factual knowledge and conceptual frameworks in developing understanding; and (c) the importance of self-monitoring and reflection in individual learning. Applying these principles to instruction calls for a learning environment that is:

- learner-centered, building on what learners already know;
- knowledge-centered, emphasizing authentic achievement and mastery;
- assessment-centered, offering multiple ways to monitor learning progress; and
- community-centered, encouraging social networks and collaborative teams that support learning.

Creating a richly-layered online environment that supports a *how people learn* framework is a core research problem in oTPD that poses several theoretical and methodological challenges (Larreamendy-Joerns & Leinhardt, 2006). Instructional design theory (Wiley, 2001), for example, offers guidance for learning object design, but methodological tools for testing their efficacy are lacking. Likewise, the need to assess teacher learning in online activities is widely acknowledged, yet the development of effective assessment approaches and tools is quite limited.

2. Background

2.1. Context of the research

This study was conducted under the auspices of Ohio’s Reading First Center (the Center), a three-university consortium (Cleveland State University, John Carroll University, The University of Akron) that provides professional development and technical assistance in the state’s implementation of the Reading First program (NCLB, 2001). A strategic goal of the state’s Reading First program plan is to effectively use oTPD to expand and improve scientifically-based reading instruction in kindergarten through third grade classrooms.

Over a three-year period (2003–2006), in partnership with Teachscape, Inc., a producer of online professional development programs, the Center developed three oTPD modules: Scaffolding in Action (SA), Differentiating Instruction (DI), and Fluency (F). Each module consists of three to five hours of online instruction in beginning reading instruction and related areas. The modules are incorporated into the state’s large-scale professional development program in reading for K-3 teachers.

The Center has engaged in a line of formative research (Newman, 1990; Reigeluth & Frick, 1999) to monitor the oTPD modules' design and preferability factors (e.g., participant satisfaction with the online modules) and to examine the extent to which the modules are effective, efficient, and appealing to participants. An initial series of studies focused on the content of the modules and methods of their delivery. The studies addressed questions of implementation and impact on teacher knowledge, satisfaction, and intent to implement research-based reading instruction practices (Brown et al., 2005). The results of the studies helped the Center to refine the design of the modules to yield increasingly improved knowledge gains and satisfaction among participants (Roskos et al., in press). The research studies, however, have not directly examined the pedagogy of the modules.

Representing an instructional system, a pedagogy includes instructional activities, learner tasks, and user tools arranged to meet certain learning objectives. Content to be learned (e.g., science-based reading teaching knowledge and skills) is embedded in these artifacts, which from a cultural psychology perspective (Cole, 1996) extend human capacities and mediate action. Artifacts may be physical objects, such as pencils, microscopes, and computers, and also abstractions, such as lesson plans, teacher guides, and instructional models (virtual worlds). Situated by design in the learning environment, artifacts powerfully shape the learning experience. On the one hand, they support learning activity and thereby knowledge construction because they trigger particular social and cultural understandings (learner prior knowledge) (Gibson, 1977). On the other, they constrain learning activity because their very properties simultaneously impose limits on thought and action (Burke, 1966). Artifacts, therefore, both afford and constrain the construction of knowledge. A practical example: the defining properties of a hammer afford certain nailing actions in building, but also limit them to pounding in with the head of the hammer or pulling out with its claw. In oTPD, it follows; the design of its pedagogy or learning architecture may support teachers' knowledge construction, but also constrain it — and it is this design aspect that this study addressed. Three areas are of primary interest: (a) effectiveness of design for developing understanding; (b) efficiency of design in promoting understanding or even accelerating learning; and (c) appeal of design in motivating and sustaining learner attention. Design information along these lines contributes to instructional design theory and models and lays the foundations for experimental studies that test the efficacy of oTPD toward higher student achievement.

2.2. The current study

Considerable attention has focused on usability design issues in oTPD, such as tracking, managing, and monitoring student learning, thus increasing understanding of the human–computer interaction (Clark & Mayer, 2003; Firdyiwek, 1999). Methods of designing e-learning environments that support learning for understanding, however, pose new and complex design challenges. Strategies for combining online learning objects into powerful instructional sequences, for example, are not clearly defined. Criteria related to granularity, i.e., the scope and size of a learning object, are also not well-articulated, which can restrict designs and reduce the re-usability of learning objects (Wiley, 2001).

Bonk and Wisher (2000) point out that possibilities for rich learning through electronic media exist, but that there is a lack of "pedagogically sound and exciting Web courseware tools" to take advantage of these learning objects (p. 9). Faced with a proliferation of e-learning tools fast outpacing educative ideas about how to use them, a new design problem is how to assemble pedagogically-based e-learning technologies in ways that support how people learn in virtual learning environments. The pedagogy of the instructional design, then, is both a matter of creating and assembling "smart" learning objects (re-usable digital resources) for use by instructors and students in active, knowledge-rich online learning environments.

This study focused on the pedagogy of the three oTPD modules produced by the Center (SA, DI, F). Specifically the study examined the extent to which the learning architecture of the respective modules – that is the design and arrangement of learning objects – supported a constructivist pedagogy or teaching for understanding (Bransford et al., 2000; Newman & Associates, 1996). From a constructivist perspective, the informational design of the online instructional activities, tasks, and tools should engage participants in higher levels of content knowledge (facts, concepts, principles) and demand higher order cognitive skills (analysis, evaluation, synthesis) to support learning with understanding. The instructional system should afford opportunities for active learning that help learners discern what they know and what they do not yet know. Sensory elements of the e-learning tools, multimedia presentations, text, and narration should be designed to help participants take control of their own learning and monitor their own progress toward learning goals. Three questions guided the research:

- Does the *information design* of the modules support different knowledge types and cognitive processes?
- Does the *interaction design* support an active learning environment?
- Does the *sensory design* support a motivating learning environment?

3. Method

3.1. Development of an analytic framework

The study's research goal was to examine the pedagogy of the three online modules (SA, DI, F) as represented in three dimensions of instructional design — information, interaction, and sensory design. This required a set of analytic tools for observing features of these dimensions in the learning architecture of each module. The study's analytic toolkit drew from Shedroff's unified field theory of design (1994), the *how people learn* framework (Bransford et al., 2000), and research-based instructional design principles (Clark & Mayer, 2003). Analytic tools applied to each dimension of instructional design are detailed below.

Criteria for analysis of the information design were based on Bloom's Revised Taxonomy of Educational Objectives (Anderson & Krathwhol, 2001) and included four knowledge types (factual, conceptual, procedural, meta-cognitive) and six cognitive process categories (remember, understand, apply, analyze, evaluate, create). Table 1 identifies the categories and more specific descriptions of the criteria used to code the information design element of the module.

Interaction design is related to how participants engage with activities, tasks, and tools for purposes of learning. Design can be geared to strengthening a specific skill, for example, or developing a conceptual model for use across

Table 1
Coding criteria for information design

Information design category	Coding guidelines
Knowledge type	Only the text on the screen, not the graphics, was analyzed. For each screen, the code for the highest level of *Knowledge type* was indicated.
Direction/context	Screen contained no content-specific information, only directions about how to use the technology or context about the course.
Fact	The basic elements that are required to understand or solve problems in a discipline. For example, knowledge of terminology or knowledge of specific details and elements.
Concept	Interrelationships among factual elements that enable them to function together. For example, classifications, categories, principles, theories, models.
Procedural	Methods of analysis and criteria for using skills, algorithms, techniques, and methods. For example, subject-specific skills, techniques, methods, criteria for when to use procedures.
Meta-cognitive	Awareness of cognition in general and one's own cognition. For example, strategic knowledge, knowledge about cognitive tasks, self-knowledge.
Cognitive demand of the learner	Each screen with a code in the *Knowledge type* category was analyzed to identify the highest level of *cognitive demand.*
No cognitive demand	Screen only contained directions or context, not content-specific information.
Remember	Identifying and retrieving information from memory.
Understand	Constructing meaning by interpreting, exemplifying, classifying, summarizing, inferring, comparing, or explaining information.
Apply	Executing or implementing a procedure in a given situation.
Analyze	Breaking material into constituent parts and determining how the parts relate to one another in the overall structure by differentiating, organizing, and deconstructing information.
Evaluate	Critiquing information based on criteria and standards.
Create	Generating hypotheses, planning, and producing elements to a coherent or functional whole or reorganizing elements into a new pattern or structure.

Note: Adapted from Anderson & Krathwhol (2001).

Table 2
Coding criteria for interaction type

Interaction type	Builds lessons that …	Description
Receptive	include information with limited practice opportunities	Information acquisition. Also called the show-and-tell method. Exemplifies training that primarily presents information without explicit guidance to the learner for how to process it. Examples: new hire orientation or product updates.
Directive	require frequent responses from learners with immediate feedback	Also called show-and-do method. Training that primarily asks the learner to make a response or perform a task and then provides feedback. Examples: short content statement followed by questions accompanied by corrective feedback.
Guided discovery	provide job-realistic problems and supporting resources	Knowledge construction and authentic problem solving. Training in which the learner tries to accomplish an authentic job task with guidance from the instructor about how to process the incoming information. Example: sales skills practice.

Note: Adapted from Clark & Mayer (2003).

settings. Three interaction design types were examined (Clark & Mayer, 2003): (a) receptive (viewing information with limited practice opportunities); (b) directive (learners offering frequent responses and receiving immediate feedback); and (c) guided discovery (providing job-realistic problems and supporting resources). Table 2 provides more specific descriptions of the criteria used to code the interaction design element of the module.

Sensory design elements motivate and sustain the learner's attention to the content of instructional activities, tasks, and tools. These elements (e.g., graphics, pop-ups, color, video) must coordinate not only with one another, but also with the content and learning objectives of the online course or module. From a constructivist perspective, the sensory design of the learning objects contributes to the communicative function of these mediators, which help to scaffold the learner's knowledge construction. Properties – such as graphics, procedures, and illustrations – can shape pedagogical schemas, scripts, and routines toward teaching for understanding. Recent research, in fact, has pointed to a redundancy effect in the combining of properties where concurrent narration and animation may actually split learner attention to the content, and thus hinder knowledge construction (Mayer, Heiser, & Lonn, 2001). The analytic framework for examining sensory design drew on six principles described by Clark and Mayer (2003): (a) multimedia (relevant graphics accompany printed or spoken words); (b) contiguity (words and graphics are presented in an integrated fashion); (c) modality (audio is used to explain concurrent animations or graphics); (d) redundancy (screen includes narration and identical printed text); (e) coherence (irrelevant details, pictures, sounds, and words are omitted); and (f) personalization (words are presented in a conversational style).

3.2. Sample

A total of 220 online screens from the three modules – 55 in SA, 83 in DI, and 82 in F –were examined for features of information, interaction, and sensory design. As a unit of analysis, the screen constituted what the learner experienced without using a mouse click, although in some instances scrolling may have been required to view a screen in its entirety. A new screen was signaled by a mouse click that resulted in new graphics and textual content. Screens contained both graphics and textual content, and when printed could span several printed pages. Two members of the research team identified and numbered the data set.

3.3. Coding procedures

The team developed coding rules to define the presence of each of the elements of the coding system. Each screen was coded for each of the following elements:

- One code for knowledge type to reflect the highest level of knowledge type (fact, concept, procedural, meta-cognitive, directions/context) evident on the screen.
- One code for cognitive demand to reflect the highest level of cognitive demand evident on the screen (no cognitive demand, remember, understand, apply, analyze, evaluate, and create).
- One code for interaction design to indicate whether participants received information through receptive, directive, or guided discovery methods.

- Six codes for each screen to indicate the presence of each of the six sensory design elements: multimedia, contiguity, modality, redundancy, coherence, and personalization.

The research team coded the first 10 screens together to clarify the coding categories and practice consistent coding. Subsequent coding was done in pairs, with one pair of researchers coding one-half of the screens and the other pair of researchers coding the other one-half of the screens. In the case of inconsistent ratings, the teams discussed the results until they reached consensus. Periodically during the independent coding process, the two-person teams met to compare their coding results and discuss coding questions. Inter-rater reliability improved with each module and with increased practice with the coding system. The inter-rater agreement for the DI module was 78%, for the SA module 80%, and for the F module 85%.

4. Results

4.1. Information design features

4.1.1. Knowledge type

The levels of knowledge types for the three modules are illustrated in Fig. 1.

As evident from the figure, in all three modules approximately 50% of the text in the online modules was devoted to providing directions and 50% to presenting course content. Of the text available for knowledge construction, the screens each contained a near equal amount of facts and concepts. The content of approximately 30% of the screens in the DI module, 38% in the SA module, and 50% in the F module reflected the concept level in Bloom's Revised Taxonomy. Opportunities for constructing procedural and meta-cognitive knowledge through engagement with instructional activities, tasks, and tools were, however, limited. Less than 15% of the screens in the three modules were devoted to building procedural knowledge and less than 5% for meta-cognitive knowledge.

4.1.2. Cognitive demand

Fig. 2 shows that the cognitive demand of the modules focused primarily at the levels of remembering and understanding.

In all three modules, for example, participants were asked to interpret, summarize, compare, and explain content presented in learning objects (e.g., video cases), which helped them draw on prior experiences and develop new understandings. However, participants were not offered many opportunities to extend these cognitive processes and to exercise critical thinking skills, such as applying new ideas to unfamiliar tasks, analyzing specific problems of practice,

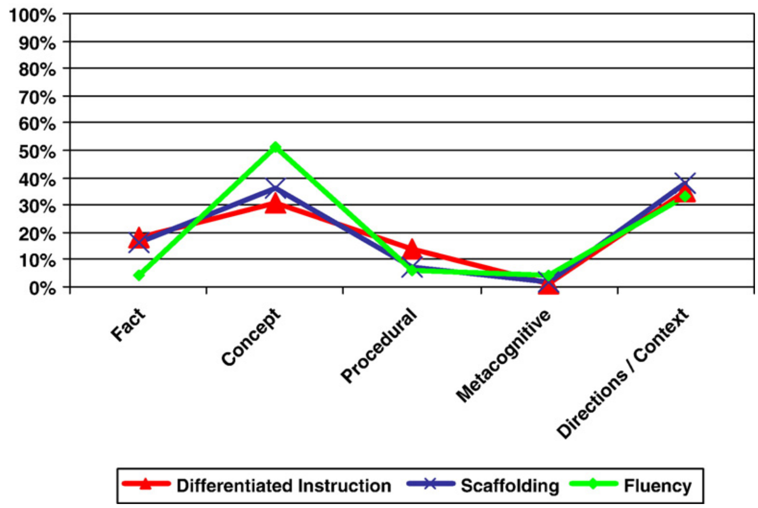

Fig. 1. Evidence of knowledge type in the online modules.

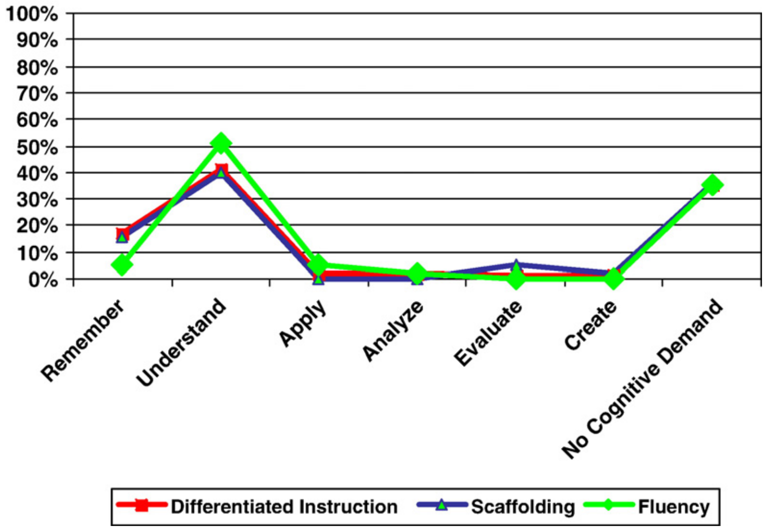

Fig. 2. Evidence of levels of cognitive demand in the online modules.

making judgments about instructional ideas or practices based on criteria, or creating new principles or structures for their own practice.

4.2. Interaction design features

Fig. 3 summarizes the interaction design features for the three categories of receptive, directive, and guided discovery.

The vast majority of slides evidenced a receptive design, with 98% of the SA screens, 90% of the DI screens, and 73% of the F screens providing information in a receptive pattern with no opportunity for participants to interact with the content. Four percent of the screens in DI offered directed interaction and 6% offered guided practice while 0% of the screens in the SA module offered directed or guided interaction with the material. In the F module, 27% of the screens offered directive interaction with the course content and 0% guided interaction.

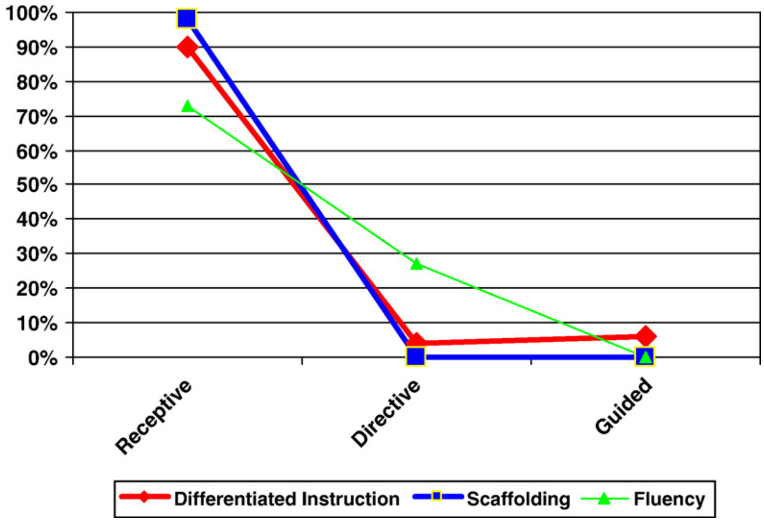

Fig. 3. Evidence of interaction type in the online modules.

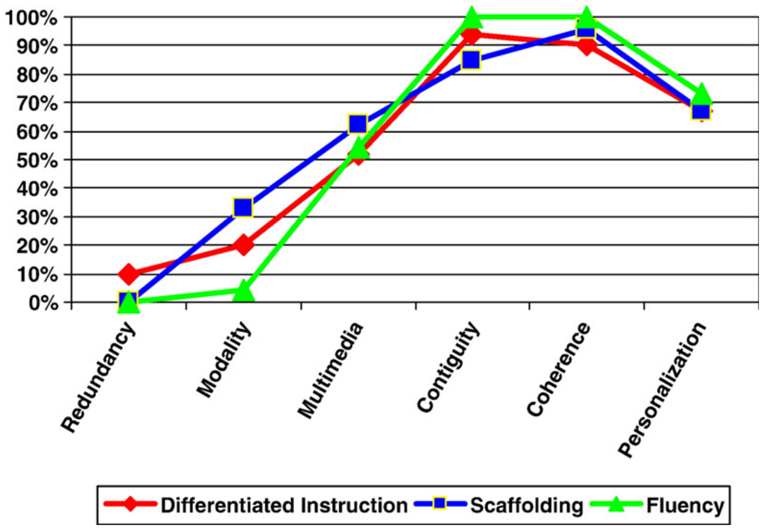

Fig. 4. Evidence of sensory elements in the online modules.

4.3. Sensory design features

The frequency of which each sensory design feature appeared in each module is summarized in Fig. 4.

All three modules demonstrated a variety of sensorial details that support an appealing and engaging online learning environment. Coherence, indicated by a lack of distracting stimuli, and contiguity, indicated by a coordination of media, were especially strong, evident in over 85% of the screens. Personalization, which helps to stimulate motivation and maintain attention to the topic, occurred in about two-thirds of the screens. Multimedia, evident in 50% to 60% of screens, served to prime and guide active cognitive processing and encourage knowledge construction. Few of the screens, however, employed audio narration to maintain interest and focus attention to the instructional message as indicated by the relatively low occurrence of the modality category. The least frequently coded element was redundancy, the concurrent use of narration and animation. Since redundancy in online learning can be distracting, the infrequent use of this element was a positive design feature. Overall, the sensorial design included fairly strong use of five of the six principles, suggesting a pattern of coordinated sensory details.

4.4. Differences among modules

In addition to examining the frequency with which the elements were represented in the three modules, the study also examined differences among the three modules for each coded element using Kruskal–Wallis tests. No significant differences were evident among the three modules in knowledge type $\chi^2(2)=2.30, p=.32$ or cognitive demand $\chi^2(2)=1.49$, $p=.48$ suggesting that all three modules had similar levels of knowledge design. In contrast, the test revealed a significant difference among the levels of interaction offered by the three modules $\chi^2(2)=20.37$, $p=.00$. Mean ranks for the test are presented in Table 3.

Mann–Whitney U analyses were used for pairwise comparisons to identify the significant differences in the amount of interaction offered by the three modules. The tests indicated that the F module (M rank$=89.46$, $N=82$) had significantly higher interaction than the DI module (M rank$=76.61$, $N=83$) $z=-2.58$, $p=.010$, effect size .20. The DI module (M rank$=72.15$, $N=83$) had significantly higher interaction than the SA module (M rank$=65.50$, $N=55$) $z=-2.36$, $p=.018$;

Table 3
Mean ranks

Category	Differentiated instruction ($N=83$)	Scaffolding ($N=55$)	Fluency ($N=82$)
Knowledge type	111.05	100.69	116.52
Demand	107.87	105.25	116.68
Interaction	106.77	95.50	124.34

effect size .20. Similarly, the F module (M rank $=76.38$, $N=82$) also had significantly higher interaction than the SA module (M rank $=58.00$, $N=55$) $z=-4.18$, $p=.000$; effect size .36. Although these differences were statistically significant, the effect sizes were small.

Differences among the modules for the multimedia element were measured through a chi-square goodness of fit test. The test showed that the three modules were not significantly different in the use of multimedia, Pearson $\chi^2=(2, N=220)=1.44$, $p=.488$, $\phi=.081$, redundancy, Pearson $\chi^2=(2, N=220)=1.66$, $p=.436$, $\phi=.087$, and personalization, Pearson $\chi^2=(2, N=220)=0.812$, $p=.666$, $\phi=.061$. Significant differences were evident in contiguity, Pearson $\chi^2=(2, N=220)=12.530$, $p=.002$, $\phi=.239$, modality, Pearson $\chi^2=(2, N=220)=20.43$, $p=.000$, $\phi=.305$, and coherence, Pearson $\chi^2=(2, N=220)=8.97$, $p=.011$, $\phi=.202$. Follow-up 2×2 chi-square analyses to identify the specific differences indicated that the F module had more frequent use of contiguity than the DI, Pearson $\chi^2=(1, N=165)=5.094$, $p=.030$, $\phi=.176$ and SA modules, Pearson $\chi^2=(1, N=137)=12.667$, $p=.000$, $\phi=.304$.

Significant differences in modality were also evident between the SA and F modules, Pearson $\chi^2=(1, N=137)=21.43$, $p=.000$, $\phi=-.396$ with the SA module having more screens with modality and the F module fewer. The F module also showed more evidence of modality than the DI module, Pearson $\chi^2=(1, N=165)=10.96$, $p=.001$, $\phi=-.258$. Finally, the F module had significantly more screens that showed coherence than did the DI module, Pearson $\chi^2=(1, N=165)=8.306$, $p=.003$, $\phi=.224$.

5. Discussion

The objective of this study was to examine the pedagogy embedded in the instructional design of three oTPD modules on scientifically-based reading instruction for kindergarten through third grade teachers. Developing rich opportunities for helping teacher learners transform knowledge into understanding and practice is a complex challenge for oTPD content specialists and technologists (Clark, 2004; King, 2002; Oliver & Herrington, 2003). Given the difficulty of successfully applying a "teaching for understanding" pedagogy that reflects the *how people learn* framework in face-to-face instruction, how successful were the oTPD elements in supporting this type of learning environment?

Drawing on instructional design principles and research, the learning architecture of each module was analyzed for specific features of information, interaction, and sensory design. Not surprising perhaps in light of prior online instruction research (Tallent-Runnels et al., 2006), all three online modules showed similar pedagogic features that profile a didactic pedagogy (show and tell) more so than a constructivist one that promotes learning with understanding. As the data indicate, the emphasis of the modules is largely on declarative types of knowledge (facts and concepts) and lower levels of cognitive demand (remember and understanding), although the fluency module did emphasize the development of concepts more often than did the other two modules. This is likely due to the cumulative feedback from the field studies, which steered design work toward the more deliberate application of constructivist principles. That this increase was not statistically significant, however – even with more intentional design – suggests the difficulty of teaching for understanding in the online environment.

Overall, the sensory design of the modules was the most diverse and well-developed, supporting learner motivation. However, although the combinations of sensory details were motivating and attention-holding they did not support high-level cognitive engagement. The design of the modules, it seemed, challenged participants to make new meanings, but at the same time limited their knowledge construction by setting the ceiling at explaining rather than more analytic processes, such as critiquing. Augmentations such as discussion boards, online journals, and face-to-face interim sessions that challenge participants' thinking may overcome this limitation in the modules' design and allow for more in-depth interaction with the course content.

The results can also be examined from another angle. The prevailing pedagogy of the modules is not all that dissimilar from most traditional professional education in college classrooms. In some respects, this may be to the learner's advantage because a familiar pedagogy might reduce the stress of negotiating the less familiar online learning environment, thus freeing learner attention (and thinking) to focus more intently on the content embedded in the activities, tasks, and tools. While "comfort level" may be of some benefit, it still falls short of supporting teacher learning with the goal of improved practice and higher student achievement. To achieve this loftier goal, oTPD must employ more rigorous instructional designs that press for learning with understanding, active learning, and meta-cognition. Increased opportunity for guided practice and coaching in the learning architecture of a module or in its augmentations (e.g., discussion boards, online tutors) would allow for a more "ambitious" online pedagogy. Given the role of oTPD in the Reading First Center's strategic goals, learning objects that support directive and guided discovery types of interaction need to be designed, built, and organized into the learning architecture of its online modules.

Current research reviews on oTPD (Bernard et al., 2004; Bonk & Wisher, 2000; Dede, 2005; Larreamendy-Joerns & Leinhardt, 2006; Tallent-Runnels et al., 2006) also offer helpful design information for strengthening the pedagogy of the modules toward a constructivist stance. Modifications of the asynchronous discussion boards by including community-building activities, such as articulating purpose, requiring contributions from each member, and inserting questions as well as activities and guidance to ensure participation, can be incorporated into the design.

Another guideline is matching design to participant needs for pedagogical content knowledge. In one respect this is an age-old curriculum design problem at work in a new, virtual learning environment (Zais, 1976). Learning is based upon the integration of factual and conceptual knowledge, and it was, perhaps, an attempt to honor this principle that brought about the high level of factual and conceptual presentations in the modules. However, an assessment-centered feature that matched participant knowledge to instructional support was less evident in the modules. More instances of immediate feedback to learners might strengthen the learning experiences.

A third design insight, and an eminently practical one, is making e-learning tools and objects transparent at the user interface. In other words, to what extent is the "how to use" dimension of the online module self-explanatory? In these three modules, a high number of screens were devoted to directions. In order to increase transparency and ease of use of learning tools, users of oTPD modules should be able to easily decipher their purpose. Effective graphics and icons should provide specific indications or cues that help learners navigate through the modules' screens and online format. However, as indicated by the large number of screens devoted to providing instructions, designing elements that instruct the user enough, but not too much, are a challenge to create in online modules.

5.1. Limitations and directions for future research

Criteria selected to examine the elements of content, interaction, and sensory demands in this research work have separately been used in other research, but this full set of constructs has not been used before to analyze online learning. Such an approach is not unique, however. Christopher, Thomas, and Tallent-Runnels (2004), for example, devised and followed a similar system to classify units of information. The coding system provided information to answer the specific research questions, but further validation of this coding scheme is needed to verify its analytic utility.

6. Conclusions

Given the study's results, future work should expand criteria or provide a more thorough examination of direction-giving screens. The screens are necessary for guiding users, but the study did not examine whether the extent of these screens was appropriate; that is, did participants benefit from the direction-giving screens, or could they navigate through the module with fewer or different directions? Identifying ways to provide directions or context through less redundant and less wordy approaches would be useful in instructional design. Finally, the study focused just on the screens of the online modules and did not examine the supporting materials such as instructor manuals, asynchronous discussion boards, and participant responses to assignments. These materials, when analyzed along with the online module, might increase the content levels, cognitive demand, and interaction elements. A more holistic examination of all course content as well as of instructors' knowledge and skills in facilitating discussions and implementing the course will be important next steps. The center's research agenda is examining these learning objects to help identify potential other resources of a constructivist learning environment in the oTPD modules.

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