Proceedings of the Second International Conference on eLearning: Learning Theories vs Technologies? 14–16 December 2006, Ramkhamhaeng University, Thailand

Supporting Case-based Instruction in Higher Education through Technology: What Works?

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Abstract
This paper reports findings from a two-year research project in the United States focusing on case-based instruction in higher education. The instruction incorporates the use of interactive, multimedia cases and online discussions and chats to support learning with the materials. The multimedia cases were designed as practice field cases to provide constructivist learning environments for teachers preparing to teach students with behavioral disorders. Research data were collected from 251 students in 20 different courses across four universities. Major findings support: (1) significant learning outcomes for all learners regardless of rank in school, teaching experience and discipline area; (2) case usage as anchors for related activities failed to produce equivalent levels of learning compared to other types of implementation; and (3) learning was significantly enhanced when instructors implemented forms of online discussion compared to face-to-face discussion only. Recommendations and limitations will be discussed.

Objectives for the Study
Though case-based has become popular in higher education, there are no empirical studies to date that relate instructional conditions for teaching with technology-enhanced cases to learning outcomes for pre-service and practicing teachers. This research study was designed to track what teachers using technology-enhanced case-based instruction learn from cases and investigate instructional methods that make a difference in learning outcomes. Research questions are: How are technology-enhanced multimedia cases implemented effectively in teacher education? What implementation variables influence learning outcomes?

Theoretical Framework
In re-designing teacher preparation programs to bridge the gap between what is experienced as a student and the reality of classroom teaching, teacher educators are searching for new instructional methods and materials that provide students more authentic learning experiences. The challenge is to deliver effective preparation to teachers-in-training to expand their knowledge and skill repertoires as well as enable them to 'think like a teacher' about problems of teaching (Cochran-Smith & Lytle, 1999; Wilson & Berne, 1999). Case-based instructional approaches engage students in a more authentic environment to relate theory to practice (Elskind, 2001; Shulman, 1996). The advent of newer technologies—multimedia cases, electronic performance support tools, online discussion groups—provide teacher educators promising approaches for teaching in new ways and for students to learn in new ways. Multimedia cases allow interactive linking of multiple media within a case environment to create a realistic practice field to solve problems of teaching.

Introduced within the last decade, these innovations offer problem-centered pedagogies to engage novices in thinking like professionals (Merseth & Lacey, 1993). Multimedia cases provide the means to bring dilemma-laden, complex situations of teaching into training programs. Electronic performance support tools and online discussions within learning communities provide supports for novices to apply, adapt, and evaluate

effective instructional processes. These pedagogies allow novices to develop 'case' knowledge for use in ill-defined real world situations (Fitzgerald, Semrau, & Deasy, 1997; Fitzgerald, Wilson, & Semrau, 1997).

Fitzgerald and Semrau (1993-1997; 1998-2000) produced a series of interactive, multimedia cases (Teacher Problem Solving Skills or TPSS) with embedded activities and electronic performance support tools for teacher training in EBD. The multimedia cases are designed as practice fields— a term introduced by Senge (1994). Practice fields focus mainly on situating content in authentic learner activities. In practice fields, students engage in the kinds of problems that they will encounter outside of school. The ten cases in the TPSS series include classroom videos of children; interviews with teachers, principals and parents; computerized case records; information databases; embedded interactive activities; and electronic performance support tools (see web site at http://www.coe.missouri.edu/vrcbd/)..

Research Question Clusters

1. *How are practice field cases implemented effectively in teacher education? What implementation variables influence effectiveness in multiple contexts?*

2. *How are practice field discussion groups offered effectively during training? What learner outcomes occur in face-to-face versus online implementations?*

Implementation Sites and Participants

Data were collected on 251 research participants. These research participants who represented a full range of students enrolled in teacher preparation programs both as pre-service students and teachers working on advanced degrees or certification/endorsement areas. Overall, the research participants demonstrated almost a balance between those with and without prior teaching experience: 42.8% had no teaching experience; 15.5% were novices with up to 3 years experience; and 41.6% had 3 or more years of prior teaching experience. While enrolled in the case-based courses, 58.5% were not teaching at the time and 41.5% were simultaneously teaching while enrolled in their course.

The study was carried out in four different types of courses representing a broad range of teacher education courses. These were grouped by rank (undergraduate/graduate) and discipline area (general/special education) for analyses into four groups: Undergraduate general education UGE, Undergraduate special education (USE), Graduate general education (GGE), and Graduate special education (GSE).

The instructional procedures for implementing case-based instruction varied naturalistically across course instructors. Each instructor documented instructional procedures through course syllabuses, implementation plans, and field notes. From analyses of these data, four different types of implementation emerged (Table 1). Because of the research requirement for each instructor to implement at least two cases within a course, there were seven combinations of implementation types that were used as independent variables in data analyses. They are listed in the table below (Table 2).

Table 1.
Types of Implementation for Case-based Instruction

Implementation Type		Description
A	Teaching Within the Case	Students were required to fully complete all embedded activities within the case and given points toward their course grade for quality of work.
B	Using the Case as Anchor	Students used the case information as an anchor to contextualize course assignments with no requirement to complete embedded activities.
C	Guided Application of Case Knowledge and Skills	Students were required to fully complete all embedded activities and then apply the information to simulated or real situations as transfer.
D	Teaching Within/ and as Anchor for Same Case	Students were required to fully complete all embedded activities and then use the information as an anchor to contextualize additional assignments.

Table 2.
Implementation Levels for Case-based Instruction

Level	Types	Implementation Combination	N
1	A & A	Teaching Within & Teaching Within	65
2	B & B	Anchor & Anchor	17
3	C & C	Guided Application & Guided Application	27
4	A & B	Within & Anchor	57
5	A & C	Within & Guided Application	36
6	A & D	Within & Within/Anchor	40
7	C & D	Guided Application & Within/Anchor	9

The ways in which instructors integrated discussions of cases into the courses also varied. Some courses integrated the cases into face-to-face discussions. Some used only online discussions or chat groups, while others used a combination of face-to-face and online discussions. There were 190 (75.5%) students involved in only face-to-face discussions and 61 (24.3%) students who engaged in some portion of their discussions in an online environment.

Measuring Conceptual Change of Learners: The Dependent Variables

Students constructed concept maps at the beginning and end of their courses to measure conceptual change. The maps displayed how the students conceptualized approaches for understanding children with EBD. The procedure was standardized across courses for size of paper and length of time allowed for map construction. The students had no advance notice of the concept map activity. No resources were allowed during map construction and the session was proctored.

Pre and post concept maps were scored for all participants on (a) number of unique nodes and (b) number of links between nodes using scoring procedures originally proposed by Novak and Gowin (1984) and applied in previous hypermedia research (Ayersman, 1995). To evaluate the quality of the maps, expert maps were developed and used to create a scoring rubric (Table 3). Pre and post concept maps were scored using this quality rubric by a trained map evaluator; the sample (n=98) included representatives of all the courses over the two-year duration of the study. Inter-rater reliability between experts and the map evaluator was established prior to scoring (Authors, 2003-2006) and the maps were scored blind.

Table 3.
Concept Map Quality Score Rubric

Score	Definition	Scoring Guidelines
0	None: 0-1 nodes in the concept; represents no development of concept	May have a few technical words/terms but lacks logical organization or linking
1	Minimal/little: Represents a novice/beginning level	Some terminology/terms and some logical organization
2	Fair/moderate: Represents an emerging level	Some professional/technical terminology with 3 or more of major concept components
3	A lot: Represents a great deal of development of concept between novice and expert levels	Great deal of development evidence through terminology, major concepts, and organization
4	All: Represents an expert level	Concepts developed relative to the specific cases used in course; conceptual match

Results and Conclusions

Research Cluster 1: How are practice field cases implemented effectively in teacher education? What implementation variables influence effectiveness in multiple contexts?

Conceptual Change Related to Course Type

A 2x2x2 factorial analysis of variance was conducted to examine conceptual change for students on a pre-to-post comparison of concept map nodes and links across the four course implementation. Significant pre-to-post gains were found for number of nodes with interaction effects with course type with nodes; and pre-to-post gains were found for number of links with interaction effects with course type with links (Table 4). Between-subjects analyses showed a mean increase on both nodes and links except for the UGE (undergraduate general education) group. Looking at the quality map score, all groups demonstrated growth including those in the UGE group whose mean went from .47 (no concept) to 1.16 (novice level) on a 5-point scale. For this group, students demonstrated growth in the quality of the content of their concept maps even though their numbers of nodes and links did not increase.

Table 4.
Conceptual Change Related to Course Type

Class Group	Nodes				Links			Quality Map Score			
	n	Pre $\bar{x}$	Post $\bar{x}$	Sig	Pre $\bar{x}$	Post $\bar{x}$	sig	n	Pre $\bar{x}$	Post $\bar{x}$	sig
UGE	43	31.95	30.60	.000	36.12	33.28	.001	19	.47	1.16	.000
USE	36	21.72	29.92		23.58	31.44		10	.60	1.30	
GGE	39	31.46	38.87		36.92	41.56		19	.89	2.00	
GSE	133	39.92	46.91		44.35	51.30		48	1.02	2.08	

Nodes showed significant interaction = .009. Group UGE did not show any increase.
Links showed significant interaction = .006. Group UGE did not show any increase.

Conceptual Change Related to Prior Teaching Experience

A 2x3 factorial analysis of variance was conducted to examine the relationship between prior teaching experience and learning outcomes. The analysis used one within-subjects variable (testing condition: pre and post) and one between-subjects variable (experience level: none, novice, experienced). Significant pre-to-post gains were found for all levels in number of nodes, number of links, and quality of map scores (Table 5). There were no interaction effects. Differences between the groups remained the same. However, prior teaching experience was related to higher scores at both pre and post.

Table 5.
Conceptual Change Related to Prior Teaching Experience

Experience Level	Nodes				Links			Quality Map Score			
	n	Pre $\bar{x}$	Post $\bar{x}$	sig	Pre $\bar{x}$	Post $\bar{x}$	sig	n	Pre $\bar{x}$	Post $\bar{x}$	sig
None	107	28.71	33.36	.000	32.62	36.38	.001	40	.73	1.65	.000
Novice	39	34.21	40.54		38.62	44.00		19	.84	1.79	
Experienced	104	40.84	47.63		45.19	51.26		36	.97	1.94	

Conceptual Change related to Type of Instructional Implementation

A repeated ANOVA analysis was conducted to compare learning outcomes measured by the three concept map scores (nodes, links, quality scores) across the implementation levels (Table 3). Significant pre-to-post gains (main effects) were found for all implementation levels in number of nodes, number of links, and quality of map scores (Table 6). There was an interaction effect of post test at level; for level 6, the post-test scores were less than the pretest scores for both nodes and links. At level 6, one of the cases was used primarily as an instructional anchor. All other post-test scores were significantly higher than pretest scores. Main effects of levels were significantly lower at both pre and post testing conditions for Level 2, where the cases were used primarily as instructional anchors, as compared to all other levels.

Table 6.
Conceptual Change Related to Type of Instructional Implementation

Level	Nodes				Links			Quality Map Score			
	n	Pre $\bar{x}$	Post $\bar{x}$	sig	Pre $\bar{x}$	Post $\bar{x}$	sig	n	Pre $\bar{x}$	Post $\bar{x}$	sig
1	65	33.11	40.05	.000	37.48	43.71	.000	24	.58	1.75	.000
2	17	16.29	22.06		18.06	24.00		9	.22	.44	
3	27	36.74	48.81		42.04	54.59		15	.80	1.80	
4	57	32.82	38.35		37.44	41.04		25	1.24	1.84	
5	36	42.86	50.36		46.75	52.58		5	1.80	3.40	
6	40	37.43	35.95		41.23	39.63		15	.73	1.73	
7	9	40.00	46.11		44.00	51.89		3	.76	3.67	

A repeated ANOVA analysis was also undertaken to compare learning outcomes for 96 participants measured by the quality of map scores across the implementation levels (Table 3). The highest post quality of map scores occurred in two of these groups (Levels 5 and 7).) On the post quality of map scores, students using the cases in a limited way (Level 2) demonstrated negligible change.

Research Cluster 2: How are practice field discussion groups offered effectively during training? What learner outcomes occur in face-to-face versus online implementations?

Instructors used different types of discussions of cases in their courses, offering face-to-face, online, or combinations of discussion types. A 2x2 factorial analysis of variance was conducted to compare outcomes associated with students only experiencing face-to-face discussion with those experiencing some portion of online discussions or chats. Interaction effects were found for both nodes and links.

Conceptual Change Related to Types of Discussions

Simple effects of discussion at post-test condition were significant with higher levels of change for students in the online discussion group. Significant pre-to-post gains were found between discussion type groups on all measures: nodes, links, and quality map scores (Table 7). The 4.46 nodes for the face-to-face discussion group format. The mean increase in links for participants in the online discussion group was 9.98 links compared to 3.46 links for the face-to-face discussion group

Table 7.

Conceptual Change Related to Type of Discussion

Discussion Type	Nodes				Links			Quality Map Score			
	n	Pre $\bar{x}$	Post $\bar{x}$	sig	Pre $\bar{x}$	Post $\bar{x}$	sig	n	Pre $\bar{x}$	Post $\bar{x}$	sig
Face-to-Face	190	34.39	38.85	.000	38.64	42.18	.000	71	.75	1.62	.000
Online	61	35.36	45.36		39.31	49.05		25	1.12	2.32	

Nodes showed significant interaction = .013. Online discussion showed significantly more growth.
Links showed significant interaction = .012. Online discussion showed significantly more growth.

Interpretation

Learning Outcomes: All Learn from Cases

The findings from this study support the conclusion that interactive, case-based instruction *is* an effective instructional medium for all students regardless of differences among learners. Four variables were used to examine learning outcomes for differences among learners—rank in school (undergraduate/ graduate), area of course offering (general/special education), prior experience as a teacher (none, novice, experienced), and simultaneous enrollment while teaching (yes/no). Given the significant growth in breadth of knowledge as demonstrated on the pre/post concept map nodes, the significant increase in interconnectedness of knowledge as demonstrated on the pre/post concept map links, and significant improvement in the quality of the student-constructed concept maps, it appears that case-based instruction utilizing interactive, multimedia cases is an equally-effective al method although their conceptual quality, as revealed on concept maps, did significantly move from a "none" to the "novice" level of knowledge (Table 6).

Instructional Implementation: Anchoring is Less Effective than Embedded Activities and Guided Transfer

How multimedia cases are integrated in courses appears to make a difference in case-based learning outcomes. Overall, significant learning occurred for all groups except for students who used the cases only as anchors for additional course assignments (Level 2) (Table 6). In these courses, there was no emphasis on learning the information within the case prior to using the information. Students explored the case for information and then used the information to contextualize other assignments that were the focus of the course. Although anchored instruction is a popular instructional method in situated learning theories, this approach was not as effective as other implementation methods that required in-depth casework, guided application of material mastered in casework, or combinations of these two approaches.

Instructional Implementation: Online Discussions are Superior to Face-to-Face Discussions

Important differences emerged when comparing learning outcomes related to types of case-based discussions. While all students demonstrated change on their quality of map scores, those who had opportunities to discuss and apply the case information in online environments demonstrated greater change in their breadth and interconnectedness of knowledge than those limited to face-to-face class discussions. Overall, conducting case-based discussions in online, chats, or web-assisted formats was superior to conducting case-based discussions in face-to-face formats alone. These results support the finding by Ziegler, Paulus, and Woodside that face-to-face discussion groups focused on instructor–defined tasks rarely demonstrate the depth of engagement observed in online groups involved in a process of knowledge creation (2006).

Summary

This research supports the potential of case-based instruction using interactive, multimedia cases to level the learning field for learners regardless of their differences. Factors that are related to higher levels of knowledge and its organization are graduate status, coursework in the content area, amount of prior teaching experience, and simultaneous teaching while enrolled in the course. Overall, students with these characteristics started higher and ended higher on the concept map measures than their counterparts. Another way to look at learning, however, is to consider conceptual change. The results demonstrate that equivalent learning was found on a pre-to-post basis for all learners except for the undergraduates enrolled in general education courses. These students had conceptual change for quality of content although they did not increase in the amount or organization of their knowledge.

To support learning with case-based instruction, instructors need to go beyond using the materials for anchored instruction. First of all, learning outcomes are better when students start by full engagement in the case, spending adequate time to work through the case, and by completing the embedded problem solving activities. Following a mastery of the information provided within the case, additional benefits are gained when instructors guide students in applying what they learned to simulated and real situations. In addition, there are positive benefits from offering students opportunities to discuss the cases and applications through online environments. It appears

that online discussion environments provide students opportunities for more reflection, deeper learning, and support from each other in applying the information to problems in their own preparation or teaching.

In summary, these robust multimedia cases were effectively integrated into appropriate instructional programs, supported through online discussions, and conducted over a sufficiently long treatment period to stabilize outcomes. Significant learning resulted for all students from casework. However, case usage in and of itself did not ensure learning without effective implementation and opportunities for applying knowledge and skills through extended discussion. These conclusions may be limited to multimedia case materials that are robust, based on design principles for practice fields, and implemented with technology supports.

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Author Notes

The research was funded in part by a U.S. Department of Education Steppingstones Innovation in Technology grant, Project #H327A030072.