Case-based Instruction through Technology: Does Implementation Affect Outcomes?

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Abstract

This paper reports findings from a two-year, federally funded multi-site, multi-method research project focusing on case-based instruction in higher education. The study incorporated the use of technology-enhanced, multimedia cases to prepare teachers in the area of emotional/behavioral disorders across four universities with 251 teacher education students as research participants. Instructional methods varied naturalistically across venues and instructors. Independent variables included testing condition (pre vs. post), course type (rank and major), focus of course content (specialization of content), prior teaching experience, and type of instructional implementation in the course. Dependent variables included quality of concept maps and quantity of concept map nodes and links. Mixed ANOVAs were used for statistical procedures. There were significant main effects of pre-to-post conceptual change for all independent measures. Interaction simple effects were found suggesting case-based learning was less effective on one of the measures for undergraduate general education majors, in introductory courses, and when instructional implementations were limited to cases being used only to provide context to course learning activities and assignments.

Case-based Instruction through Technology: Does Implementation Affect Outcomes?

Though case-based instruction has become popular in higher education, little is known about effective practices for teaching and learning with cases. To date, there are no known empirical studies in education that relate instructional conditions for teaching with technology-enhanced, multimedia cases to learning outcomes for pre-service and practicing teachers. This multi-site, multi-method research study was designed to track what teacher education students, using technology-enhanced case-based instruction, learn from cases and investigate instructional methods that make a difference in learning outcomes.

Theoretical Framework/ Literature

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 can engage students in a realistic environment to relate theory to practice (Elskind, 2001; Shulman, 1992). The advent of newer technologies—hypermedia, video cases, interactive 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, in particular, provide rich environments that allow interactive linking of multiple media such as images, videos, and sound with domain knowledge and student (child) education and clinical case files that can create a realistic practice field to solve problems of teaching.

Introduced within the last decade, these technology-enhanced teaching innovations provide problem-centered pedagogies to engage novices in thinking like professionals (Boling, 2007; Merseth & Lacey, 1993, Utley, 2006). 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).

Case-based instruction is a recent, popular alternative to traditional, teacher-directed instruction in special education teacher preparation (Anderson & Baker, 1999; Goor & Santos, 2002; McNaughton, Hall, & Maccini, 2001; Utley, 2006). A survey of the members of the Council for Exceptional Children TED Division found that 78% of respondents had used case methods within the previous two years (Elksnin, 1998). A recent summary of current practice in the use of case methods in special education teacher preparation programs stated that the greatest advantages to case methods of instruction are bridging the gap between theory and practice and developing students' problem-solving skills (Elksnin, 2001).

In special education, educators must learn to use problem-solving approaches for working with children with emotional and behavioral problems/disorders. These skills are difficult to learn and practice without supervised direct contact with children, parents, teachers, and other care providers. By learning and reflecting on these skills during the pre-professional training period, future educators are more likely to possess the knowledge, attitudes, and skills necessary for teaching these children. Case-based learning approaches can provide a bridge between learning as a student and professional practice.

Many national leaders in special education have produced a variety of case formats for use in teacher education over the last five years. Epanchin and Colucci (1999) led the development of a web-based case library filled with case dilemmas faced by teachers in school settings. Gerber and colleagues (1999) developed CASELINK, a problem-based learning environment consisting of multimedia cases and learning supports. They described changes that occur when integrating their form of problem-based learning into teacher education. Results indicated that more time was spent on the problem than direct instruction in classes; more time was spent in group engagement; and learners engaged in a more constructive self-managed learning process. They concluded that multimedia and distance learning technologies offer excellent supports for learning**.**

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 emotional/behavioral disorders (EBD) (see web site at http://www.coe.missouri.edu/vrcbd/). These 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, learners define and solve ill-structured problems, develop domain-related information, receive coaching and modeling of thinking skills, and have opportunities for reflection (Barab & Duffy, 2000). The ten cases in the TPSS series include classroom videos of children; interviews with teachers, principals and parents and other service providers; computerized case records; information databases; embedded interactive problem-solving activities; and electronic performance support tools.

The design of computer-based learning systems to support knowledge construction, skill development, problem solving, and transfer is extremely complex. Practice fields provide authentic learning experiences where users come to "know about problems and practices" faced in real professional practice. By dealing with multiple scenarios from multiple perspectives, learners move closer to thinking like experts: they learn to extract pertinent information, generate problem solutions in flexible ways, and transfer knowledge and skills to new contexts. Most of the design principles for creating practice fields can be achieved technologically through interactive multimedia case-based systems. However, virtual learning experiences are not the same as real ones. Hence, research is needed in identifying the contexts and implementation strategies that are effective for producing transfer of new knowledge and skills to professional practice in real environments.

To date, case developers in special education have described case methods, design strategies for producing cases, descriptions of usage, and evidence of learner satisfaction with case-based instruction. However, there have been no known empirical studies in the field of education that relate conditions of course implementation to learning outcomes or the extent to which knowledge and skills transfer to professional usage. As interactive, multimedia cases are far more complex and rich than paper-based or simple video-based cases, teacher educators need to investigate the types of scaffolding and support that best facilitate learning and how these might provide differing outcomes for differences among individuals (Boling, 2007).

Purpose of the Study

This study attempts to provide answers to critical questions of how to scaffold and facilitate learning of knowledge and skills from technology-enhanced multimedia cases for teacher education students. Research questions in this study are:

1. How are technology-enhanced multimedia cases implemented effectively in teacher education?
2. What implementation variables influence learning outcomes?

Methods

This study integrated the TPSS multimedia cases into undergraduate and graduate coursework and provided electronic supports and case-based discussion groups related to the cases. The technology-enhanced case-based instruction was implemented in 20 different higher education courses with varying instructional modes involving 251 pre-service and practicing teacher education students from 4 different universities. Each researcher implemented a minimum of two multimedia cases into one course per semester over a two-year duration.

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. Only the center node was provided to them and the students had no restrictions for terminology or concepts. 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.

Measures

Independent: Information collected on the participants included type of course enrollment (rank/major), course content (introductory, generic special education, specialized emotional/behavioral disorders), and years of prior teaching experience. The instructional implementations of the cases in courses were documented by researcher field notes and course syllabuses and categorized into four different implementation types as explained below.

Dependent: Pre and post concept maps were scored for (a) number of unique nodes representing the amount of knowledge and (b) number of links between nodes representing the interconnectedness of knowledge using repeated measures for the 251 research participants. These scoring procedures were originally proposed by Novak and Gowin (1984) and applied in previous hypermedia research (Ayersman, 1995). To evaluate the quality of the content in the maps, expert maps were developed by the research team and used to create a scoring rubric (Table 1). A sample of pre and post concept maps was scored using this quality rubric by a trained map evaluator; the sample 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 quality scoring of the maps (Fitzgerald, Hollingsead, Koury, Miller, & Mitchem, 2003-2006) and the maps were scored blind.

Table 1.
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

Data Sources

Data were collected on 251 research participants. Demographic data were compiled to describe the 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. The research pool demonstrated a balance of students with and without teaching experience while enrolled in the courses: 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. In respect to access to classrooms for application of knowledge and skills during training, 58.5% were not teaching while enrolled and 41.5% were simultaneously teaching while enrolled in their course.

Implementation

The instructional procedures for teaching with the cases were allowed to vary naturalistically across course instructors. Each instructor documented instructional procedures through course syllabuses, implementation plans, and field notes. From analyses of these data, four different implementation types emerged (Table 2).

Table 2.
Types of Implementation for Case-based Instruction

Implementation Type		Description
A	Learning 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 Context	Students used the case information to contextualize course learning activities and assignments with no requirement to complete activities embedded within the case.
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	Learning Within/ and As Context (combination approach)	Students were required to fully complete all embedded activities and then use the information to contextualize learning activities and assignments.

The research project agreement required each instructor to implement at least two cases within a course resulting in seven combinations of implementation types that were used as independent variables in data analyses. These seven combinations were placed into a levels hierarchy and they are listed as implementation levels and numbers of students in each condition (Table 3).

Table 3.
Implementation Levels for Case-based Instruction

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

Results and Conclusions

Conceptual Change Related to Course Type

A 2x4 factorial analysis of variance with one within-subjects variable, Testing Condition (pre vs. post) and one between-subjects variable Course Type (undergraduate general education (UGE) vs. undergraduate special education (USE) vs. graduate general education (GGE) vs. graduate special education (GSE)) was conducted to examine conceptual change for learners. Data were collected using dependent variable pre and post measures of concept map nodes, links, and quality scores for each course implementation. Regarding number of nodes; there was a significant interaction with simple effects of UGE at posttest. The UGE group did not make gains where all others had significant pre to post gains. In addition, significant main effects of testing condition pre-to-post gains were found for number of nodes (Table 4).

Regarding number of links, there was a significant interaction with simple effects of UGE at posttest. The UGE group did not make gains where all others had significant improvement pre to post. There were main effects of testing condition as significant pre-to-post gains were found for number of links (Table 4).

Regarding the quality map score, there was a main effect of Testing Condition where all groups improved from pre to post testing. Thus, all groups demonstrated growth as measured on the Quality of Concept Score, 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, learners 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 Course Content

A 2x3 factorial analysis of variance with one within-subjects variable Testing Condition (pre vs. post) and one between-subjects variable Course Content (Introduction (Intro) vs. Generic Special Education (Generic) vs. Specialized Special Education (EBD)) was conducted to examine conceptual change for learners. The independent variable was determined using cases that were implemented in 20 courses and grouped into three clusters based on depth of course content: 1) introductory courses with some special education content (Intro), 2) generic special education content focused on multiple disability areas, (Generic SPED) and 3) specialized courses focused on the emotional/behavioral disability area (Specialized EBD). Results indicate a significant interaction with simple effects of Intro at Post Testing as measured on number of Links. Intro courses gains were lower and post hoc testing shows a significant difference between Intro and EBD. Main effects were noted in significant pre-to-post gains for number of nodes and for number of links. Finally, there were main effects of testing condition as measured by quality of map score with significant pre-to-post gains (Table 5).

Table 5.
Conceptual Change Related to Course Content

Content Cluster	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
Introductory	82	32.72	34.54	.000	36.50	37.22	.001	38	.68	1.58	.000
Generic SPED	127	35.37	42.58		38.96	45.98		34	1.09	1.91	
Specialized EBD	43	34.67	45.51		42.91	50.33		25	.88	2.04	

Links showed significant interaction = .017. Introductory was significantly lower than specialized EBD.

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 vs. post) and one between-subjects variable Experience Level (none vs. novice vs. experienced). Results showed there were no interaction effects. There were main effects of Testing Condition with significant pre-to-post gains were for all levels in number of nodes, number of links, and quality of map scores (Table 6).

Table 6.
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 measures 2x7 factorial analysis of variance with one within-subjects variable Testing Condition (pre vs. post) and one between-subjects variable Implementation Level (level 1 vs. level 2 vs. level 3 vs. level 4 vs. level 5 vs. level 6 vs. level 7) was undertaken to compare learning outcomes as measured by number of nodes, number of links, and quality map scores across the seven implementation levels (Table 3). The repeated ANOVA was also undertaken to compare learning outcomes for 96 participants measured by the quality of map scores across the implementation levels (Table 3). Overall there were significant main effects of testing condition with pre-to-post improvement in number of nodes, number of links, and quality of map scores (Table 7).

Table 7.
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	

- Nodes scores showed significant interaction = .023. On the Bonferroni, interactions occurred for the following post comparisons: Level 2 was significantly less than all other intervention levels; Level 4 was significantly less than Level 5.
- Links scores showed significant interaction = .044. On the Bonferroni, interactions occurred for the following post comparisons: Level 2 was significantly less than all other intervention levels.
- Quality Map Scores showed significant interaction = .027. On the Bonferroni, interactions occurred for the following post comparisons: Level 2 was significantly less than Levels 4 & 5 and Level 1 was significantly less than Level 5.

Results for the nodes and links scores showed a significant interaction with simple effects of Level at Posttest. At Level 6, the posttest scores were lower than the pretest scores for both nodes and links. All other post-test scores were significantly higher than pretest scores. Main effects of levels were significantly lower at both pre and posttest conditions for Level 2 on all measures.

Figure 1 displays in graphical form the results for the quality map scores at pre and post. 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 as context (Level 2) demonstrated negligible change.

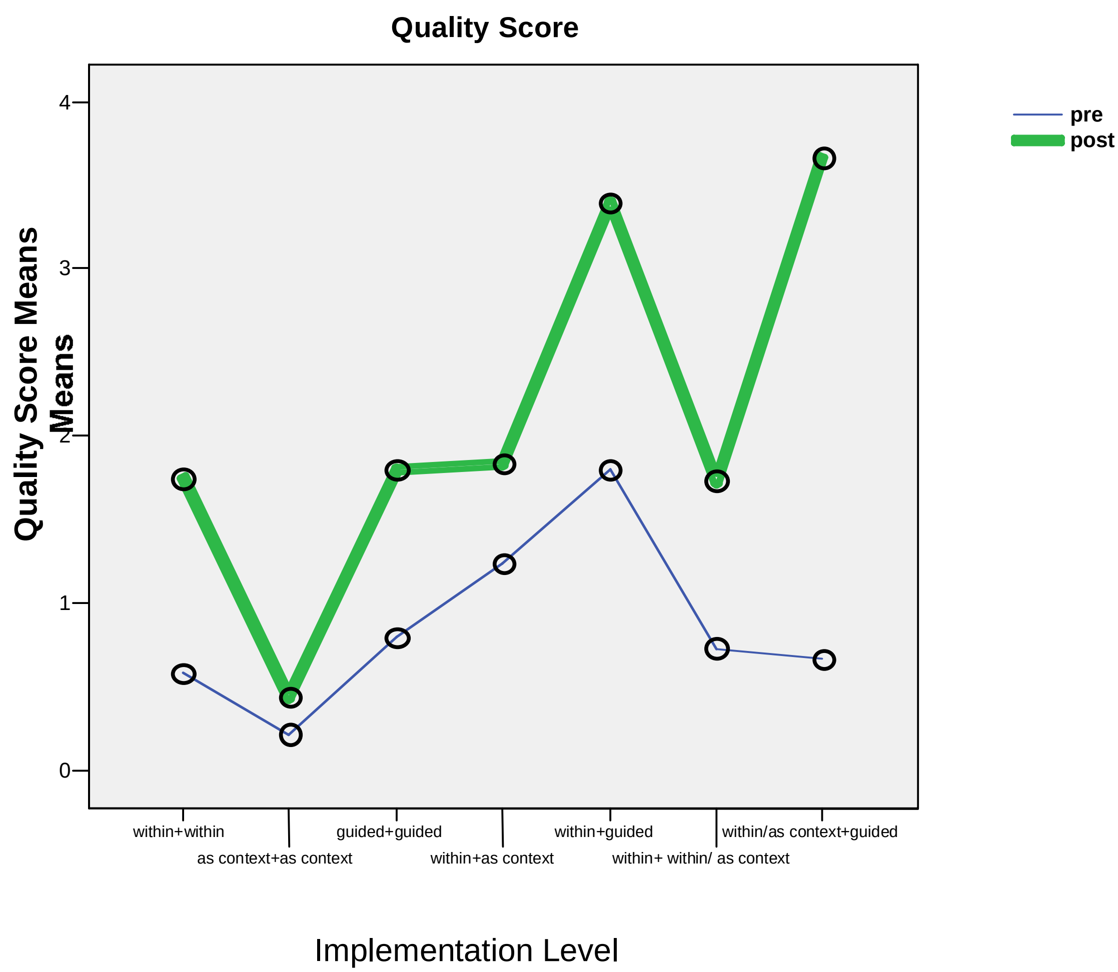

Figure 1. Concept Map Quality Scores across Implementation Levels

Interpretation

Learning Outcomes: All Learn from Cases

The findings from this study support the conclusion that, overall, interactive, case-based instruction *is* an effective instructional medium for all learners 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), content of courses (introductory/generic SPED/ specialized EBD courses), and prior experience as a teacher (none/novice/experienced). 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 instructional method across diverse learners in teacher education with one exception. Undergraduate general education learners did not demonstrate growth in breadth and interconnectedness of concepts, although their conceptual quality, as revealed on concept maps, significantly moved from a “none” to a “novice” level of knowledge (Table 4).

Instructional Implementation: Limited Case Usage is Less Effective than Embedded Activities and Guided Transfer

How multimedia cases are integrated into courses appears to make a difference in case-based learning outcomes. Overall, significant learning occurred for all groups except for learners who used the cases only to contextualize additional course learning activities and assignments (Level 2) (Table 6). In this limited usage format, there was no emphasis on learning the information and doing practice or problem-solving activities within the case prior to other instructional activities. Learners explored the case for embedded information and then used the information to contextualize other assignments outside of the case that were the focus of the course.

Limiting case usage to contexts for course learning was not as effective as other implementation methods that required in-depth casework, guided application of material mastered in casework, or a combination of these two approaches. Conversely the highest post node and post link scores occurred in all implementation levels that required completion of embedded activities within the case plus offered guided application of the knowledge and skills represented in the cases to simulated or real situations (Levels 3, 5, and 7). Partial use of these multimedia cases or similar case-based materials with embedded information and activities is not recommended.

Instructional Design: Embedding Learning Activities within Cases Enhances Conceptual Outcomes

These multimedia cases are uniquely different from other forms of cases in the fact that learning activities are embedded, scaffolded, retained, reviewed and revised within the case. Consistent with the above finding on limited vs. full use of cases, engaging learners within cases prior to transfer activities supports conceptual development because learners are gaining and using information in a scaffolded environment. Going back to the theoretical work by Barab and Duffy (2000) on the design of practice fields, well-designed environments do more than provide authentic content—they provide realistic activities or experiences for learners to be engaged in authentic problem solving and critical thinking in the domain. Instructional designers can enhance learning from cases by embedding learning activities into the case environments and providing appropriate scaffolds for learners to solve, review, and reflect on authentic problems.

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, and amount of prior teaching experience. Overall, learners 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 learners had conceptual change for quality of content although they did not increase in the amount (measured by nodes) or interconnectedness (measured by links) of their knowledge; these learners started with essentially no concept of the field and emerged at a novice level similar to those beginning their specialized training.

Finally when level of implementation was analyzed, those students using the cases "as context only" received the lowest post scores on all three concept map scores (nodes, links and quality scores) compared to all other combinations of instructional implementations. Those students in the "learning within the cases and learning within the cases as a context for assignments (Level 6), where one of the cases was used primarily to contextualize course learning activities and assignments, showed a decrease in to pre-to-post nodes and links concept map scores.

In summary, these robust multimedia cases were effectively integrated into appropriate instructional programs over a sufficiently long treatment period to stabilize outcomes. Significant learning resulted for all learners from casework and completion of embedded learning and problem-solving activities within the cases enhanced conceptual outcomes. However, case usage in and of itself did not ensure learning without effective implementation and opportunities for applying knowledge and skills with instructor guidance. These conclusions may be limited to multimedia case materials that are robust, based on design principles for practice fields with embedded authentic activities, and implemented with technology supports.

The results support the conclusion that technology-enhanced case usage in and of itself does not ensure learning without effective instructional methods of implementation. To support learning with complex authentic cases, instructors need to go beyond using the materials to contextualize learning activities and assignments. Better learning outcomes occur when students fully engage in cases and complete embedded problem-solving activities, thus mastering knowledge and skills prior to applying that content to simulated and real situations. Work on this multi-site research project is ongoing and will report later on case-based instructional methods that facilitate transfer of knowledge and skills to actual classroom implementation.

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