

Implementing Online Collaborative Professional Development for Innovative Educators

Donna Russell, Ph.D.

Assistant Professor
University of Missouri-Kansas
City
5100 Oak St.
Kansas City, Missouri, U.S.A.
russelldl@umkc.edu

Art Schneiderheinze, Ph.D.

Professional Development/Project
Supervision
Project Construct National Center
Columbia, Missouri, U.S.A.

Abstract. The purpose of this study was to describe how four teachers in different cities in Missouri implemented an innovation cluster that paired an online technology with a problem-based unit design framework. The motivating principle for the study originated from prior research on teacher adoption of technology innovations and principles of professional development for educators. Using a multiple case study research method, the researchers collected and analyzed data to (1) understand how effectively the teachers implemented the unit while participating in online collaborative professional development and (2) identify cross-case issues that arose as the teachers collaboratively implemented the problem-based unit.

Keywords: Guidelines, formatting instructions, author's kit, conference publications

OBJECTIVES AND PURPOSES

The purpose of this study was to understand how teachers participate in collaborative online professional development in order to implement an innovation cluster that included emerging online technologies and a framework for a constructivist-based learning environment. The researchers focused on three progressive issues that emerged during in vivo data structuring: (1) what factors in a teacher's school environments influence the implementation of an innovation cluster? (2) how does a teacher's participation in collaborative professional development influence the implementation of an innovation cluster? (3) how does a teacher's belief about learning and technology influence the implementation of an innovation cluster?

We used Activity Theory's concept of development of object in order to identify the work activity model of each teacher's classroom practice. We designed and categorized each teacher's AT model based on initial pre-unit interviews. We then identified the teacher's responses to contradictions, pressures within their work activity settings that arose during the implementation of the unit. We further defined the response of the teachers to these contradictions as turning points, changes in activity in their classroom. We then evaluated these turning point responses as resulting in 1) a resolution of the contradiction thereby widening of the teacher's object or 2) a response which did not resolve the contradiction resulting in narrowing of their object. Next we identified the cross-case issues that developed over time among the teachers in order to evaluate the effectiveness of the online collaboration that was the only collaborative professional development available to the teachers as they simultaneously implemented an online problem-based unit in their classrooms. As a result of this systemic and contextual identification of contradictions and the focus on three progressive issues in order to clarify the inter-relationships of these responses to the development of the object, we were able to identify the important influences that affected the effectiveness of the online professional development program in responding to contradictions in their work activity.

Theoretical framework

The theoretical grounding for this study was sociocultural theory of human interaction, and development (Vygotsky, 1978; Bruner, 1990) with an emphasis on understanding the processes of mediated activity (Wertsch, 1998). The researchers used Activity Theory, (Engeström, Miettinen & Punamaki, 1999; Il'enkov, 1977) in order to design a systems framework for understanding the implementation processes in context and over time. Activity Theory defines the elements of human interactions in a work activity setting and was used by the researchers to design analytical procedures that developed systemic and contextual relationships among the dataset (Engeström, 1987; Barab, Hay & Yamagata-Lynch, 2001; Schoenfeld, 1999). Using this systems-based methodology, the researchers studied the interactions of the constituents of the system that produce behavior (Aronson, 2003) and developed explanations that link the components as a "consilience of inductions" (Wilson,

1998, pg. 98). The compelling purpose of complex systems analysis is to recognize the organizing relationships between entities in the system from which emerge the unique properties of the systems (Banathy, 1991). This form of analysis provides contextually valid responses to complex social systems by making the interactions in the system explicit so practical and theoretical implications can be developed. The overarching premise for this form of analysis was that the nature of human development is socially embedded and fundamentally activity oriented resulting in an anticipated outcome (Cole & Engeström, 1993).

This research studies the online professional development of four k-12 teachers that implemented a collaborative online problem-based unit. The unit involved an introduction of two new tools, an online technology and a problem-based unit of study design template, into the classrooms. We defined the insertion of these two co-dependent tools as an innovation cluster. The insertion of new tools mediates the action of the agent (Wertsch, 1998). In this case study analysis the agents are the teachers. New tools contain both affordances and constraints that insert a source of tension into a work activity system identified as contradictions. We used previous research to define the relationship among the AT aspects of the implementation of this unit including studies of innovation (Rogers, 1995; Hall, Wallace, & Dossett, 1973; Wilson, Sherry, Dobrovolny, Batty, & Ryder, 2001) and collaborative design and implementation of a constructivist-based learning environment (Jonassen, 2000; Savery & Duffy, 1996; Lave & Wenger, 1991; Schank, 1994; Salomon, 1993) and identify the resulting contradictions in the work activity of these innovative teachers.

The object of an activity system is something given and something anticipated. In this study, the initial goal for the educators involved collaboratively implementing the problem-based unit and incorporating the online workspace so their students can work together online to problem-solve. Using Activity Theory (AT) to define the constituent components, nodes, of the work activity of the teachers, the researchers used N*UDIST software to structure the nodes of the AT model (e.g., motive, goal, subject, mediation, object, community, rules, division of labor, outcome) and integrated the theoretical constructs from related fields (e.g., professional development, innovation, collaboration) into operational categories of interactions in the work activity of the teachers. The researchers identified the contradictions in each teacher's work activity, structured around the three progressive issues. We then focused on defining the turning points resulting from these contradictions as teacher behaviors during the implementation of the unit in their classrooms and finally we evaluated these resulting turning point behaviors as resulting in a type of reformulation of the teachers' objects, such as widening, narrowing or disintegrating their object. Finally, the researchers also identified cross-case patterns of responses among all four teachers using the progressive issues that arose in vivo to clarify the relationships and develop conclusions concerning the four teachers' professional development responses. As a result, the researchers were able to describe the online collaborative professional development processes of the teachers and how they impacted their implementation of the advanced problem-based unit of study using online technology.

METHODS

Setting

The researchers studied four elementary teachers who work with students in 4th and 5th grades in four different cities throughout Missouri who were implementing a collaborative online problem-based unit during the final quarter of the 2001-2002 school year. The students represented inner city, small city, suburban and rural students. All the teachers had computer labs in their classrooms as a result of their participation in eMINTS (enhancing Missouri's Instructional Networked Teaching Strategies). eMINTS is a technology integration program developed by Missouri's Department of Elementary and Secondary Education (DESE). It establishes classroom computer labs in order to illustrate the use of technology in classroom instruction and trains teachers in constructivist-based instruction. Because of their involvement in the eMINTs program, the teachers that participated in this study had the same prior amount of technology and inquiry-based learning training, 3 years, and the same amount of hardware and software in their classrooms. The classroom settings are depicted in Table 1 below.

These four eMINTS teachers were invited to participate in an online pilot project with MOREnet (Missouri Research and Education Network) called the Pioneers Program. The teachers volunteered to implement a new Linux-based middleware, Shadow netWorkspace™ (SNS), and collaboratively develop and implement a problem-based unit that incorporates constructivist-based learning methods and takes advantage of the many affordances of SNS. SNS was provided free to their classrooms through the University of Missouri at Columbia's College of Education as part of the School of Information Sciences and Learning Technologies. SNS provided the teachers and the students with online workspaces where they could dialog in synchronous and asynchronous forums and work on creating and disseminating artifacts. The researchers designed professional development interactions among the teachers including an initial phone conference, multiple weekly chats, and

an online reflection journal. Throughout the implementation of the new unit, teachers' only collaborative professional dialogs were in the seven weekly online chat rooms.

The unit that the teachers volunteered to implement was an authentic design-based problem solving unit titled "Improving I-70". The researchers created a unit design template which was used by the teachers to develop their individual and collaborative problem-based unit. The problem addressed by the students was the repair of Interstate 70 which runs across the state of Missouri. Each classroom worked collaboratively online with students in the other classrooms to design a response to the state-wide problem from the multiple perspectives of students in a rural, urban, suburban and small city setting. The unit was designed to be implemented in three phases. In Phase 1 the students worked in their local classrooms developing the problem background. In Phase 2 the students worked in online SNS workgroups to understand different areas of expertise involved in solving the problem. In Phase 3 the students worked back in their local classrooms to develop strategies to solve the problem. The purpose of the collaborative online problem-based unit was for the students to develop problem-solving abilities with multiple perspectives.

Table 1: Classroom Descriptors

	Grade	Community	Students	Technology Access
Linda	4 th	suburban	12 boys and 10 girls, all Caucasian	As a part of their participation in the eMINTS program, each teacher has 12-14 Pentium3 LCD computers, a teacher workstation, laptop, a Smartboard and projector, a scanner, a color printer, and a digital camera.
Helen	4 th	rural	12 boys and 12 girls, all Caucasian	
Janice	5 th	urban	7 boys and 10 girls, all Black or African-American	
Carol	4 th	mid-size city	9 boys, 10 girls; 11 Caucasian, 8 Black or African-American	

Findings

The data collection process used interpretive research practices (Fraenkel & Wallen, 1996) to capture the dynamics and complexity of the teachers' online professional development throughout implementation of the unit (before, during, and after implementing the unit). The goal of data collection was to capture aspects of the implementation and identify the influence of the online professional development in a way that enables the researchers to fully realize its complexity and make it available for contextual analysis and evaluation. The data collected from the teachers included initial and follow-up interviews, transcripts from a phone conference and seven chatroom conferences, messages posted on discussion boards, reflective questionnaires related to their design of the unit and the principles of constructivist learning, an online journal, and documents the teachers produced related to the unit and technology.

Each teacher's transformative processes were analyzed through the identification of contradictions using activity theory. Secondary contradictions were identified in each individual teacher's activity setting. These contextual contradictions defined the progressive issue, what factors in individual teacher's school environments influenced the implementation of an innovation cluster? The researchers designed an AT teacher model for each teacher to illustrate secondary contradictions. An example of a teacher's post-unit AT model is shown as Figure 1 below. Contradictions unresolved are shown as solid broken lines in AT Model. Resolved contradictions are shown as dashed broken lines. The top of the triangle depicts the new tools inserted into the activity system of each teacher which included the new problem-based unit, Improving I-70 and SNS. The middle of the triangle shows the subject, the names are pseudonyms, and the object, the implementation of the problem-based unit using SNS with the teacher's initial anticipated outcome for the activity, the potential to develop advanced problem-solving skills including multiple perspectives in their students. The bottom of the triangle depicts the contextual issues such as rules in the context, school or district, community, and division of labor, those necessary to the implementation. The factors listed in each category were assigned after initial interviews with the teachers.

A tertiary contradiction occurs between interacting activity systems. This type of contradiction was a response to the second progressive issue, how does a teacher's participation in collaborative professional development influence the implementation of an innovation cluster? This type of contradiction occurred when the teachers collaborated to define a common object during their weekly online chats. The researchers coded the teachers' online dialogs to define the dialogic turning points as text instances when the teachers redefined their object and changed an aspect of their implementation in their classrooms (Kärkkäinen, 1999). A dialogic turning point is an event when a teacher or the teachers began to outline their object in a different way. The signifiers of

turning points can be a questioning of an established practice or concept, an aspect of a multi-voicedness of the collaborative processes and a change in emphasis in the sequencing of the dialog. These aspects of the identification of turning points in the reformulation of object are described by Virkkunen (cited in Käkkinen, 1999) and are based on Leont'ev's concept of object, Halliday's theory of register (Wells, 1999) and Bakhtin's concept of voice (Bakhtin, 1982).

We operationalized the concept of dialogic turning points using three indicators of transformation: disturbance clusters, questioning, and interaction of different voices. The first indicator of change was the appearance of disturbance clusters, namely clusters of dilemmas, disturbances, and innovation attempts of team discourse. Halliday's concept of register focuses on the identification of patterns in social dialog. Dialogic turning points were identified as breaks from this pattern of exchange. The second indicator was questioning. A part of the transformational process was questioning of the ideas and accepted practice. The researchers located points of change by identifying questioning episodes in the dialog of the teachers indicating a change in the formulation of the object. The last indicator of dialogic turning points used in the study was the concept of multi-voicedness. This concept is based on Bakhtin's theory of genre in social language. The multiple voices of the teachers during their dialogs throughout the design and implementation of the unit introduced variations in their concepts of the pedagogy of reform and perceived attributes of the innovation cluster.

A primary contradiction defines the relationship between motive and outcome. A primary contradiction is as negative tension between the concepts underlying the implementation of the object. This type of contradiction defined the progressive issue, how do individual teacher's beliefs about learning and technology influence the implementation of an innovation cluster? In this study the teacher's pre-unit motive for implementing the innovation cluster was defined as the potential to develop advanced problem-solving abilities in the students with awareness of multiple perspectives in problem-solving. The researchers identified changes in motive and outcome relationships by the teachers in response to work-related pressures. The researchers coded the teachers' concept of the learning processes potentially available as a result of developing their object, the implementation of the unit, as hierarchical levels of the teacher's philosophy of learning using Bereiter's Scheme of Knowledge (Bereiter, 2002).

Case Study Conclusions

Linda's final Activity Theory model is shown below as Figure 1. Linda is a suburban teacher that has developed innovative units previously and was very supportive of the goals for the I-70 unit. In her pre-unit interview she stated her goals for her students for implementing this unit as the development of problem-solving skills with multiple perspectives. Linda experienced three contradictions during implementation of the unit. She resolved one and two were unresolved. She overall narrowed her object in-depth because, although she completed the entire unit, she did not implement Phase 2 online with the other classes which prevented her students from studying the problem with the perspective of the other classes. Pre-unit she described her local work environment as very collaborative and supportive of reform efforts. Prior to beginning the unit, she resolved a contradiction in her local work environment between rules and subject when she changed her schedule so she would not be departmentalized during the unit.

Both of her unresolved contradictions were related to the mediational tools that she added to her classroom practice, the I-70 Unit and SNS. The tool to subject contradiction shown below was between the learning potential of the problem-based unit and her beliefs about student learning. It was identified during the post-unit interview when she said that she would not again implement an authentic problem-based unit such as Improving I-70 because it did not deliver enough content for standardized testing. Her original stated motive for implementing the unit, to develop problem-solving abilities with awareness of multiple-perspectives, was coded as a Level 5 learning response using Bereiter's Scheme of Knowledge. However, her post-unit subject concept of delivering content in order to prepare students to take a standardized test was coded as a Level 2 knowledge response. The unresolved tool to object contradiction was identified in her online dialogs. During Phase 2 when all the students worked online in groups, Linda expressed discomfort with the student online chats describing them as "chaotic." When she decided to take her students off the internet so she could finish the unit in her classroom where she was more comfortable with the learning activities, she prevented them from studying a problem from multiple perspectives. This contradiction between her beliefs about learning and the problem-based unit was not resolved as a result of her online professional development processes.

She did not resolve either contradiction as a result of the online professional development. She did not contact either researcher for help during the unit. She had experienced inquiry-based learning units prior to the development of this problem-based unit. However, she had not previously worked in open-ended problem-solving problems with her students. Her inert contradictory concepts of how this unit would progress in her classroom and how her students would respond in the unit's online activities were not identified and addressed in the online professional development process.

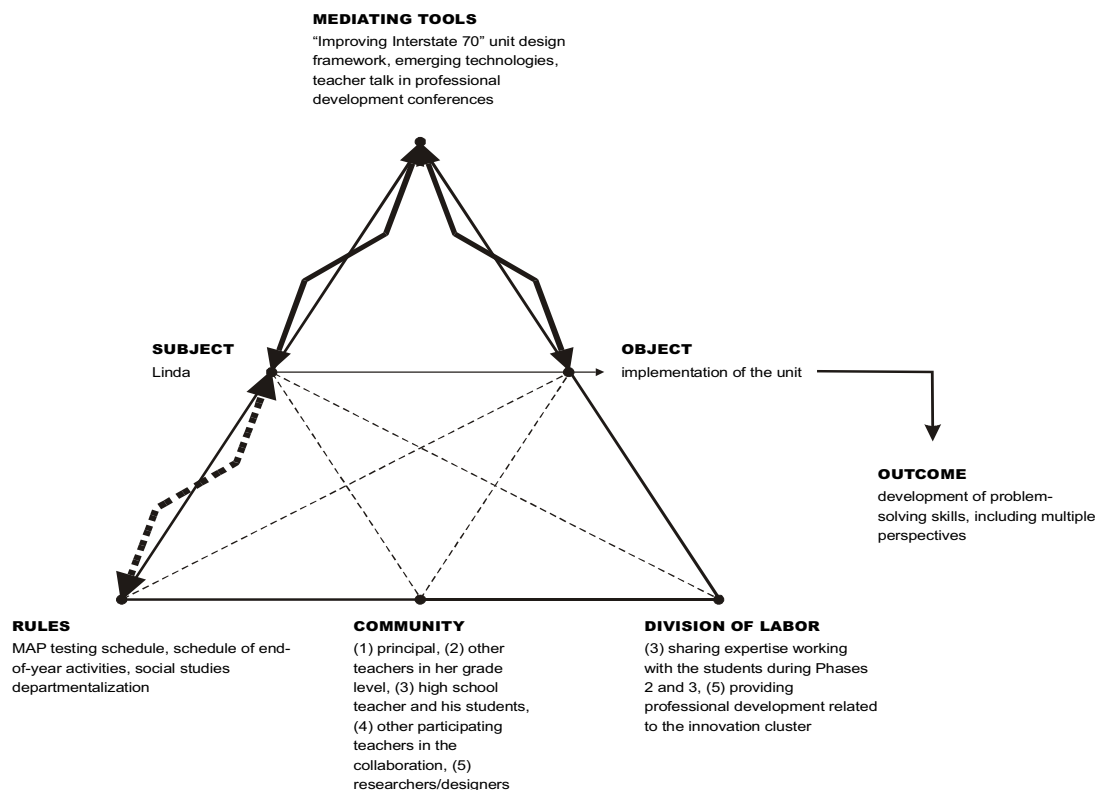


Figure 1: Linda's Final Activity Theory Model

Helen, the rural teacher, experienced two contradictions, both unresolved, and overall disintegrated her object by ending her unit early. In her pre-unit interview she was very supportive of the new online tool and the unit goals. Pre-unit she described her local context as collaborative and supportive. However, she did not describe her technology support person as supportive. Her contradictions both occurred as context-related problems. Helen had an unresolved contradiction between object and division of labor. Her technology support person added a filter to her local server during the unit and she was off-line for over a week during the unit. She did not talk to him about her sudden loss of the internet and, as a result, her students lost valuable online collaboration time during the unit. The second unresolved contradiction was between community and object. Prior to the unit in an online chat with the other teachers, she agreed to a shortened schedule for her unit even though her rural school ended the school year earlier than the others. Eventually she ran out of time to implement the unit and disintegrated her object. As a result of her online professional development, Helen lessened her ability to implement her unit goals. Helen did not effectively communicate about her unit goals and technology needs. This limited her potential to resolve contradictions.

Janice, the urban teacher, experienced four contradictions, two resolved and two unresolved, and overall widened her object in depth by adding new learning experiences to her unit. Prior to the unit, Janice did not expect her students to successfully communicate online with the other students. She felt they would not be able to type a coherent sentence. In her urban district she was under a lot of pressure to raise student test scores. She only volunteered for this collaborative unit because she felt pressure from the district to use her eMINTS technology in innovative ways. She described her local context as non-collaborative and not supportive of innovation. The two unresolved contradictions were both related to local context issues including the continuing of departmentalization in her school throughout the unit, rules, and problems with her local server, division of labor. She did not dialog within her school with either the other teachers or her principal to end departmentalization or with her technology support person. This limited her ability to resolve contradictions related to context.

However, during the course of the unit she was open to all professional development processes outside the school available to her. She worked very collaboratively online resolving two contradictions related to her object by adding new activities as a result of dialoging online with the other teachers. She developed her urban community resources by asking an engineer to come in each week and work with her students. She also asked the local researcher to come into her classroom and work with her. As the unit progressed she found her urban

students to be very successful at problem-solving and interacting online with the other students. As a result of her students' success in the unit, she radically changed how she thought about the learning potential of her urban students and resolved the primary subject contradiction between her beliefs about the learning and the development of her object. In her post-unit interview she said she was planning more problem-based units for her students in the future. She stated that she "would never teach long-division for six weeks again." Her openness to professional development helped her overcome contradictions between her beliefs about the learning of her students and the implementation of a problem-based unit despite the pressure to prepare her urban students to take a standardized test and her perception of her school and district as not being supportive of innovation.

Carol, the small city teacher, experienced four contradictions; two resolved and unresolved, and overall widened her object temporally by increasing the length of the unit and adding more activities. In her pre-unit interview, Carol stated that she did not want to do the entire unit. She only wanted to do Phase 1 and use SNS in her own classroom. She stated that Phase 2 and Phase 3, which included the online collaborations and the more advanced problem-solving processes, were "useless" and too difficult for her students. She stated that she did not work collaboratively with other teachers in her local context calling the process "lock-step" teaching. She volunteered for the unit in order to get SNS into her classroom. Nevertheless, she eventually completed Phase 2 and 3 so she could work with the other teachers. In her post-unit interview she said she did not want to stop the unit because it would she did not want to "let down" the other teachers. She also benefited from the online professional development by adding new activities as a result of the dialogs. However, unlike Janice, in her post unit interview she again stated that she did not believe that the collaboration phase or the problem-solving phase of the unit were beneficial to her students. The online professional development did not help her resolve this contradiction between her learning beliefs and the object of her work activity.

Cross-Case Conclusions

In order to look for patterns among all four teachers, the researchers designed a Transformation Model, figure 2 below, that shows the AT models for each teacher, the turning points and when these turning points occurred during the unit. The Transformation Model shows the AT Models of the teachers pre-unit and during each of the three phases of the unit. A TP in the transformation model represents the teacher's response to a contradiction in relation to the phase of the unit. The turning points are shown on the line going through the AT triangles. The line widens or narrows dependent upon whether the TP resulted in a widening or a narrowing of the object. The final AT model for each teacher is show inside the circle. This Transformation Model graphically depicts the contradictions that arose during the implementation of the unit and how the teachers' responded to the problems. This model aided the researchers in the identification of patterns of responses among all the teachers over the course of the unit. It also allowed the researchers to identify the types of online professional development that were effective or ineffective in aiding the teachers in meeting their goals.

Using the transformation model, the researchers found that all the teachers narrowed their object during Phase 2 when all their students were online in synchronous chat rooms. In all cases, the teachers' responses to the contradictions that occurred during this critical phase of the unit were to use SNS less or not at all. Without SNS the students could not interact with other students throughout the state and understand the problem from multiple perspectives. The collaborative professional development process available to the teachers, a weekly online chat, was insufficient to help these teachers in resolving contradictions, especially critical technology-based contradictions, during this phase.

Two teachers, Janice and Carol, benefited from the online collaboration. Both of these teachers decided as a result of the online professional development to develop new lessons or extend the unit. In their initial interviews both had described their local context as not collaborative. Both Linda and Helen described their context as collaborative prior to the initiation of the unit. During the unit, Linda did not make any decisions that developed her unit or solved any contradictions. Helen made a decision online to delay the initiation of her unit that lessened her ability to implement the unit as she planned. This decision led to her ultimately having to stop the unit during Phase 2. The online professional development was beneficial only to the two teachers who stated pre-unit that they did not work collaboratively in their local context.

There were three belief turning points among the four teachers. Two resulted in a narrowing of the object. One teacher, the urban teacher, changed her beliefs about the potential of her students as a result of working collaboratively with the other teachers and the researchers. Janice identified and resolved the primary contradiction between what she believed her urban students could potentially do and how the unit could develop their potential. Janice developed all professional development processes available to her including, but not limited to, the online professional development. The other two teachers, Linda and Carol, did not identify or resolve their primary belief contradictions as a result of the online professional development. Carol did implement the entire unit despite her belief that the unit was too difficult and useless to her students because she

wanted to continue to work with the other teachers. Linda cut short her students' online interactions because she could not reconcile their online problem-solving activities with her concepts of learning activities.

In response to the first progressive issue, what factors in a teacher's school environments influence the implementation of an innovation cluster, teachers who are implementing innovation need problem-solving professional development programs that allow them to resolve the potential contradictions that will occur in their local activity setting as a result of implementing change. Anticipatory problem-solving and the definition of productive communication structures are beneficial constructs for online professional development models of teachers implementing innovation. These teachers used the online professional development program to share information and schedule events but they also needed the online forum to aid them in developing supportive structures in anticipation of problems, especially technology-based problems, which arise when implementing technology-based learning environments.

In response to the second issue, how does a teacher's participation in collaborative professional development influence the implementation of an innovation cluster, the researchers found that the two teachers who described their local contexts as not collaborative benefited, they resolved contradictions, as a result of their chat room dialogs. However, the two teachers who said they were already working at a high level of collaboration locally did not benefit and one even reduced the effectiveness of their reform efforts as a result of decisions made during the collaborative chat room dialogs. Collaborative online processes should be modified to fit the level of previous collaboration and innovation of the participating teachers. Teachers that are isolated in their local context can be more effective implementing innovative as a result of sharing information online with other innovators. However, teachers who are already innovative and working collaboratively need an online professional development program that will develop their reform capabilities more fully by integrating dialogs with experts, mentors or other innovative educators that are working at the same or a higher level of innovation.

In response to the third issue, how does a teacher's belief about learning and technology influence the implementation of an innovation cluster, teachers implementing reform-based units designed to develop advanced learning processes in their students can have primary contradictions between their beliefs about learning and the instructional processes required for practical implementation of the innovative tools that they bring into their classroom. When confronted with a contradiction between their motive and the practice none of the teachers overcame primary-based contradiction with only a weekly chat as their professional development program. Previous studies have identified effective reform-based processes in professional development in education (Korthagen, 1993; Shulman, 1986; Schön, 1983; Lieberman, 1997). These studies have identified the importance of collaborative professional development for teachers implementing reform that involve both advancement of the teachers' understanding of inert (gestalt) cognitive theories (episteme) as well as the development of the practical (phronesis) instructional design aspects necessary to implement units based on these theories (Korthagen, 1993). Online professional development programs for innovators should include multiple forums allowing teachers to dialog in private and public concerning their beliefs about the types of constructivist-based learning processes and activities that they are developing in their classrooms. These processes should occur prior to the implementation of reform and during the implementation process. For example, field-based case study analysis where teachers view and then dialog with other teachers implementing similar levels of constructivist-based learning environments can help highly innovative teachers understand and make overt their underlying beliefs in order to identify and resolve primary contradictions. Innovators in education require a different quality and form of professional development programs to be successful. The design of professional development programs should include processes that help innovators in education problem-solve, proactively communicate their goals and needs and develop coherent mental models of the classrooms that they are developing.

Innovation in education can be a sporadic process as teachers respond to pressures to use new technologies and correspondingly attempt to incorporate new understandings about learning emerging from research in cognitive science. However as teachers attempt to reconcile these new understandings about human learning processes and the addition of these new technologies into educational processes there are no assurances that the two will be compatibly linked and utilized for the development of knowledge needed by students participating in a post-industrialist, knowledge-based, technology infused modern society (Bereiter, 2002). When teachers attempt to implement a technology innovation, they naturally face the complex challenge of fitting together new ideas with deep-rooted beliefs and practices. As a result, teachers often introduce an innovation in ways that reflect a negotiation between old and new ways of doing things (Bruce, Peyton, & Batson, 1993; Bruce & Peyton, 1990) and they may not have adequate professional development to reconcile these tensions with their goals for implementing innovation into their classrooms. As a result, there is an imperative to develop new understandings concerning effective professional development programs for innovative teachers implementing cognitive-based reforms that are anchored in the concept of developing knowledge workers for a technologically-advanced society.

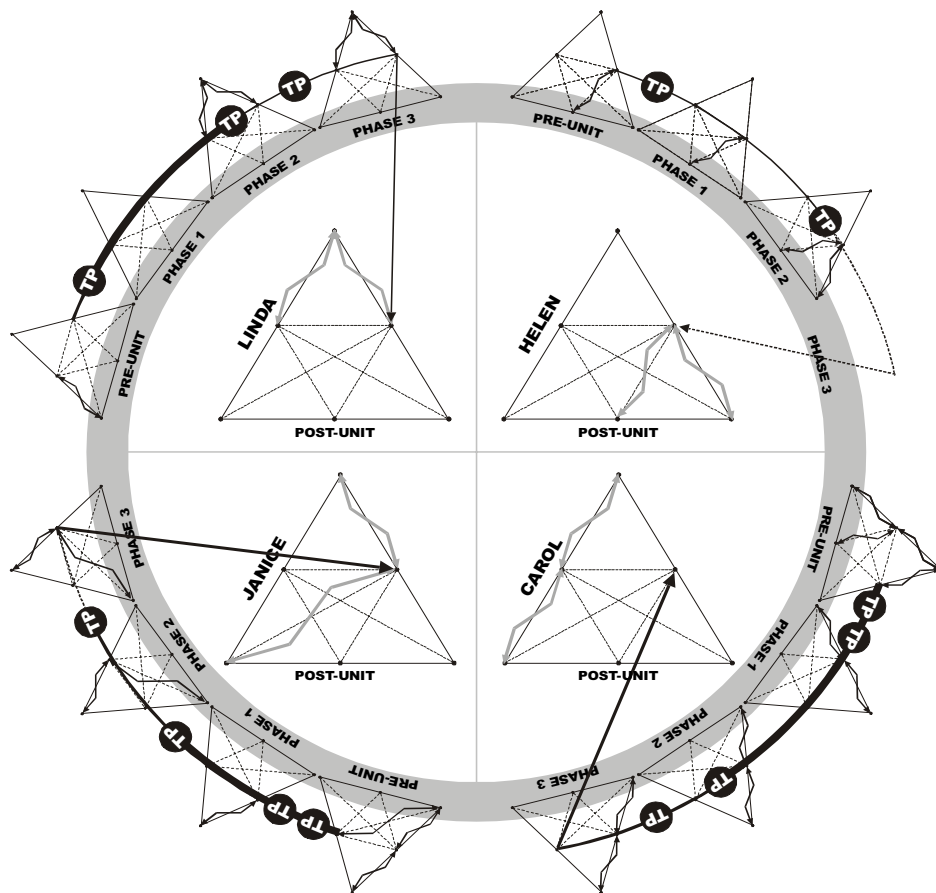


Figure 2. Transformation Model

REFERENCES

- Aronson, Daniel. (2003). *Targeted Innovation: Using systems thinking to increase the benefits of innovation efforts*. R & D Innovator. (6.2).
- Bakhtin, M. M. (1982). *The dialogic imagination: Four essays*. Austin: University of Texas Press.
- Banathy, B. (1991). *Systems design of education: A journey to create the future*. Englewood Cliffs, N.J: Educational Technology Publications.
- Barab, S. A., Hay, K. E., Yamagata-Lynch, L. C. (2001). Constructing networks of activity: An in-situ research methodology. *The Journal of the Learning Sciences*, 10(1&2), 63-112.
- Bereiter, C. (2002). *Education and mind in the knowledge age*. New Jersey: Lawrence Erlbaum Associates.
- Bruce, B.C., & Peyton, J.K. (1990). A new writing environment and an old culture: A situated evaluation of computer networking to teach writing. *Interactive Learning Environments*, 1, 171-191.
- Bruce, B.C., Peyton, J.K., & Batson, T.W. (1993). *Network-based classrooms: Promises and realities*. New York: Cambridge University Press.
- Bruner, J. (1990). *Acts of meaning*. Cambridge, MA: Harvard University Press.
- Cole, M., & Engeström, Y. (1993). A cultural-historical approach to distributed cognition. In G. Salomon (Ed.), *Distributed cognition: Psychological and educational considerations*. Cambridge, MA: Cambridge University Press.
- Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki: Orienta-Konsultit.
- Engeström, Y., Miettinen, R., & Punamaki, R. (Eds.). (1999). *Perspectives on activity theory*. Cambridge, U.K.: Cambridge University Press.

- Fraenkel, J.R., & Wallen, N.E. (1996). *How to design and evaluate research in education*. NY: McGraw-Hill, Inc.
- Hall, G.E., Wallace, R.C., & Dossett, W.A. (1973). *A developmental conceptualization of the adoption process within educational institutions*, Austin, TX: Research and Development Center for Teacher Education, The University of Texas.
- Il'enkov, E. V. (1977). *Dialectical logic: Essays in its history and theory*. Moscow: Progress.
- Jonassen, D. H. (2000). *Toward a design theory of problem solving*. Educational Technology Research and Development, 48(4), 63-85.
- Kärkkäinen, M. (1999). *A longitudinal study of planning and implementing curriculum units in elementary school teacher teams*. Retrieved March 3, 2002, from University of Helsinki, eThesis: Electronic Publications at University of Helsinki: <http://ethesis.helsinki.fi/english.html>.
- Korthagen, F. (1993). Two modes of reflection. *Teacher and Teacher Education*, 9(3), 317-326.
- Lave, J., Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
- Lieberman, A., & Grolnick, M. (1997). Networks, reform and the professional development of teachers. In A. Hargreaves (Ed.), *1997 ASCD Yearbook: Rethinking Educational Change with Heart and Mind* (pp. 192–215). Alexandria, VA: Association for Supervision and Curriculum Development.
- Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). NY: The Free Press.
- Salomon, G. (1993). No distribution without individuals' cognition: A dynamic interactional view. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations*. NY: Cambridge University Press.
- Savery, J. R., & Duffy, T. M. (1996). Problem based learning: An instructional model and its constructivist framework. *Educational Technology*, 35(5), 31-38.
- Schank, R. C. (1994). Goal-based scenarios. In R. C. S. a. E. Langer (Ed.), *Beliefs, reasoning, and decision making: Psycho-logic in honor of Bob Abelson*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Schoenfeld, A. (1999). Looking towards the 21st Century: Challenges of educational theory and practice. *Educational Researcher*, 28(7), 4-14.
- Schön, D. A. (1987). *Educating the reflective practitioner*. San Francisco: Jossey-Bass.
- Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.
- Vygotsky, L.S. (1978). *Mind in Society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Wells, G. (1999). The complementary contributions of Halliday and Vygotsky to a "language-based theory of learning". In G. Wells (Ed.), *Dialogic Inquiry: Toward a practice and theory of education*. (pp 3-50). Cambridge: Harvard University Press.
- Wertsch, J. (1998). *Mind as action*. NY: Oxford University Press.
- Wilson, B., Sherry, L., Dobrovolny, J., Batty, M., & Ryder, M. (2001). Adoption of learning technologies in schools and universities. In H.H. Adelsberger, B. Collis, & J.M. Pawlowski (Eds.), *Handbook of Information Technologies for Education & Training*. New York: Springer-Verlag.
- Wilson, Edward O. (1998). *Consilience: The unity of knowledge*. New York. Alfred A. Knopf.