Review Article

Analyzing activity theory with creative inquiry movements in an innovative technology classroom

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Fourman J. Analyzing activity theory with creative inquiry movements in an innovative technology classroom. Clin Pharmacol Toxicol Res. 2018;1(2):1-6.

This essay examines the literature for examples of educational environments with technology that have used Activity Theory (AT) as a qualitative guideline to determine educational outcomes. The essay contains a similar literature review for technology enriched classrooms that have used Creative Inquiry (CI) movements as a guideline for educational data collection. Since, AT and CI use strategies of asking pivotal questions and using cooperative systems, an anchoring of AT and CI with distributed cognition starts off the discussion. Case examples of the effective use of AT and CI in technology rich classrooms is provided with a conclusion that lists similarities and differences of the two approaches.

Key Words: Activity theory, Creative inquiry; Education; Technology

INTRODUCTION

Activity theorists have always addressed practical needs, putting their efforts towards education, design and evaluation. Contrary to its name, activity theory (AT) is a clarifying platform rather than a strongly predictive theory. AT helps us understand the connection of consciousness and activity. To do this, AT builds on intentionality, history, mediation and collaboration. Through these activities, consciousness is built around everyday activities. People do everyday activities in a social matrix made of social interactions and artifacts. Artifacts can be physical tools or sign systems such as language. “Understanding the interpenetration of the individual, other people, and artifacts in everyday activity is the challenge activity theory has set for itself” [1]. The first part of this essay is a literature review of technology use in interactive classrooms. Researchers studying these classrooms have used AT to qualitatively determine educational outcomes. The essay’s second part will be a similar literature review of technology enriched classrooms that have used Creative Inquiry (CI) movements as a lens for data collection. CI uses techniques of asking and answering pivotal question about the goals of a desired result to obtain a specific outcome. It employs looking at structure, materials and forms of inquiry but also at reflection and action. This will lead to a discussion of educator distributed cognition regarding technology use. Technology use is defined in this essay as the broad variety of artifacts used in a classroom and/or used by students, either as tangible objects or internet connectivity. This could encompass any computers, projectors, mobile devices, blogs, chat platforms, shared electronic documents, websites, or other student-technology interactions. Lastly, similarities and differences of the two approaches, AT and CI, will be discussed.

CONSTRUCTION THEORY

To give background information, a discussion follows on constructionist theory regarding people using computers to enrich information delivery and storage. The use of any computer program to collect, store and distribute information in a classroom can be disruptive [2]. With the disruption, user resistance is often apparent. This is clear in a classroom where the educator has traditionally maintained control, especially in a university setting. When a computer system is implemented, an educator is expected to display behavior such as “flexibility, creativity, collaboration and continuous learning” [2]. The computer system is to encourage the educator to be motivated and more efficient. If this viewpoint is overlapped with constructionist theory, which examines how people come to share an assumption about reality, then we see educators expected to embrace computer programs.

At times, the institution’s management will initiate the computer programs. Management has their goals. However, the management’s goals may not be the same as the educators. Yet, both management and the educators make up the learning institution. If the learning institution is deploying the software, then it is expected that the computer with its software becomes part of the constructed reality [2]. Therefore, how an institution integrates the new technology will result in it being well rated and used by both educator and student. Thus, while “creating new learning environments or learning communities, it is not just a matter of implementing and putting into use new technology but in many cases, also applying simultaneously new practices of learning and instruction” [3].

Per Sfard [4], the way educators perceive the learning task can be described in two metaphors – acquisition and participation. In the acquisition metaphor, educators package the information and transmit it to the students. In the participation metaphor, the learning process is collaborative. Yet, the participation metaphor seems to skip the step that learning is acquired. Koschmann [5] says these two metaphors are too segmented. Instead, Koshmann [5] proposes a “transaction metaphor” that incorporates both participation and acquisition. Correspondingly, Gifford and Enyedy [6], argue that learning should not be perceived as a social or individual activity. Instead, these researchers suggest the term “Activity Centered Design” whose platform is based on Vygotsky’s AT [7]. “Activity is mediated by cultural artifacts, that activity must be analyzed at various levels and that internal activity (thinking) first occurs in the social plane (contextual activity)” [6].

Thus, it can be said that many scholars propose that learning begins with social context. Vygotsky [8] purposes that participatory learning fosters concepts, constructs, attitudes and skills. AT is a model that can depict Vygotsky’s learning claims. AT offers concepts on both human activity and describing the task. Nardi [9] affirms that AT is a tool that classrooms with new technology and/or existing technology can use when struggling to understand context, practice and the situation’s constructionist realities. If the use of technology is to enhance learning, then it needs to be more than input-output. This is where models like AT can help. AT provides concepts on orientation and perspective. It is also versatile to be adapted to different learning situations. Per Engestrom, as cited by Foot [10], AT’s conceptual elements should be adapted per the “specific nature” of the learning’s context under scrutiny. Therefore, since technology models have a

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***Received:** October 08, 2018, **Accepted:** November 19, 2018, **Published:** November 26, 2018*

potential impact on how available technologies are used in the educational setting, this essay will continue by examining the use of AT.

ACTIVITY THEORY

Educational innovation in technology education using AT started in the early 2000s. Before this, innovations in the classroom were dependent on isolated events. There was no consideration that one innovation could be contingent on another innovation. Further, previous efforts in educational innovation had not considered that new efforts were a process. This changed when Russell and Schneiderheinze [11] used AT in their research conducted with educators using new technology to foster innovation.

To give a foundational background to their study employing AT methodology, Russell and Schneiderheinze [11] discuss contemporary constructivist based learning. Per Jonassen, Peck and Wilson [12], modern constructivist learning involves information that is embedded in activity, and anchored in activity context. Information construction can be very impactful to how students interact and respond. When technology is used, it is meant to positively influence learning outcomes. However, there can be a tension between the educator and the mandated use of new technology. The ways the educators respond to these tensions affects the technology's implementation.

To study educator responses to technology, Russell and Schneiderheinze [11] studied four educators who together designed and implemented a constructivist-based learning environment (CBLE). The educators designed two innovations–an online technology and a format for a design process unit using constructivist philosophy. Russell and Schneiderheinze [11] wanted to investigate the implementation effectiveness of launching two innovations at the same time. They also wanted to see how the educators responded to the tension of implementing two innovations simultaneously.

The researchers also used AT as a qualitative template for data analysis structuring. AT was used because the tool has built-in layers of artifacts, divisions of labor, sign symbols and activities. These layers have similar characteristics that allow researchers to look for patterns in the AT schematic. For example, the innovations the educators engaged in had a common goal with certain activities. The educators stayed in contact with each other via on-line chat rooms and discussion boards. In addition, regarding technology, each educator had the same equipment–computers, lap tops, projectors, printers and cameras. The educators gave students problems in the form of case studies. Each case study was grouped with like cases in an innovation cluster. Class progress was tracked through interviews, conferences and messages on discussion boards.

Educator one used the mediating tools to teach the innovation cluster but then decided that the activities were not following preset standards. She then decided to follow more of the standard teaching method without the technology. Educator two had trouble staying connected to the technology's server and breaking through the institution's firewall. All of this caused her to lose teaching time. Due to the time factor, the educator ended the innovation unit early. The educator realized that connection problems are a risk when using technology. However, she remained positive about the novel teaching approach.

Educator three had a departmentalized schedule which disrupted her activities. This was an activity rule she could mitigate by requesting a departmentalized pass during the innovation cluster. Her students were successful interacting with the unit activities, even reaching out to the community for support. Educator four completed all units in the clusters. She felt that unit one was pertinent to teaching present standards. However, she described units two and three as "useless" [11].

Russell and Schneiderheinze [11] concluded with the suggestion that student engagement is important. Yet, imperative to successful implementation of innovation is the instructor's agreement to employ novel, technical work activities. The researchers emphasized that the structure of AT was a successful qualitative measurement paradigm for the study.

Another study to use AT as a framework happened in 2009. This study focused on learning teamwork skills in university computer programming courses [13]. NUCLEO, an e-learning framework for blended solutions was the learning platform. NUCLEO uses Problem Based Learning (PB) as the pedagogical standard. AT was used to analyze team dynamics and conflicts that arose between team members. The student interface was a multi-user virtual world and role-playing game

The following were the elements of AT in the Sancho-Thomas et al. [13] study:

- Activity – This is the students' learning of technical and teamwork skills.
- Subjects – The students are the subjects in this activity.
- Objects – The object affected in this activity are problem-solving skills. Also impacted are the students' final grades.
- Communities – The communities are the groups involved in the activity. One community group is the student teams. There are communities at other levels too. In this instance, the university is a group. Another community group is the students' society and culture.
- Rules – The rules for this activity are the ones applied to working collaboratively in teams [14].
- Division of Labor – The teams needed to both work independently and collaboratively.
- Tools – The tools used for the activities were face-to-face meetings and the virtual environment.

This research has generated data to make pertinent conclusions. Students' questionnaires pointed out positive experience learning team skills such as collaboration. 90.91% of the students confirmed that the activities improved their teamwork skills. 65.91% of the students positively commented that the teamwork model was constructive [13].

Correspondingly, Anthony [15] conducted a research study using AT as a platform to investigate classroom system interactions and impact on technology integration. The conceptual framework of Anthony's [15] study follows:

- Activity – The integration of technology system planning by administration and its implementation by educators in the classroom. This was an implementation of an individual student laptop program.
- Subjects – The subjects for the study are the impacted schools, educators and students.
- Objects – The object is the vision that technology integration is to address.
- Communities – The communities impacted are the educators when they meet to plan the technology implementation.
- Rules – The rules are the school's acceptable technology standards.
- Division of Labor – The division of labor is the technology support team that is to address any connection or interface problems.
- Tools – The tools are the computers' hardware and software.

The researcher asks the following questions [15]:

1. Did administration support of technology systems impact educator's implementation experiences?
2. How did the impacted community interface with the laptop program?

Anthony's [15] study was longitudinal over a three-year period. Data was collected from classroom educators, a principal, a superintendent, and a technology integration specialist. Interviews were used to collect the data. Anthony [15] examined the frequency that educators used the technology and how central it was to the classroom routines. The centrality of the technology was coded as either seamlessly integral or peripheral to routine. The study found that there is interest in technology when it is new. However, as time moves along, there is a need to re-evaluate the technology program to keep it current. It was also found that the administration of a program needs to prepare the implementing educators before they acquire the new technology in their classrooms.

The next technology research study employing AT was by Gomez and Duart [16]. In this research, AT was used to analysis subject data. The study was based on a hybrid learning approach of both face-to-face instruction and e-learning. These researchers found that face-to-face sessions are usually oriented to lecture. During e-learning, there was usually a diversity of activities between discussion and independent learning. The students also felt like they had more clarity of information when the e-learning took place since the instructor was more likely to explain how all the technology integrated. Regarding student-student interaction, those interviewed recognized the value of group work. The students said they learned more in a group than individually. Time-management was the hardest thing for students to accomplish while doing group work. Others said they appreciated the pressure with meeting specific deadlines. All students were happy with the diversity of hybrid learning activities.

Anthony [15] used the Pearson Correlation Coefficient of 0.96 to conclude that student viewpoint regarding learning was strongly related to relevance and contribution to the learning activities. The hybrid program received a high score for having activities that integrated "face-to-face, e-learning and independent learning spaces and time".

Park's [17] research compliments Anthony's [15] study as he tested using synchronous computer-mediated classroom discussion (SCMD). AT was used as the theoretical framework through which the data was analyzed. In this study, the university students had half of their class in a face-to-face lecture with the instructor. The other half of the class continued the discussion by using an on-line chat board via each student's computer. Students met for 14 class sessions using this format. An outline of the AT for SCMD follows [17]:

- Activity – The activity was using half a class session with traditional face-to-face student/educator discussion. The other half of the class continued the discussion using an on-line chat board.
- Subjects – The students and instructor that participated in the discussions were the subjects in this study.
- Objects – The objects observed in this study were the utterances from the instructor and student regarding the course topics.
- Tools – The research used both written and electronic tools. The SCMC computer software and hardware were the electronic tools. The students' written assignments were evaluated and used as semiotic tools.
- Community – The community were all those that shared in the classroom discussions.
- Rules – The rules for this study included the rules for tool uses, the university rules and regulations, and the patterns surrounding the topics discussed.
- Division of Labor – The division of labor was dispersed to the instructor and students. Also involved was the university technology support staff who helped with interface issues.

Findings from this study suggested that both the educator and students benefited from the diversity of discussion format.

It is suggested that the research examined in the first part of this essay affirms that students learn from active learning classrooms that employ technology in novel ways. However, a large part of the success of the technology implementation was giving the instructors ample administrative support. This conclusion resonates with Horne and Murniati [18]. Their research concluded that institutional administration needs to understand the rigor classroom educators experience when using technology infused curricula. Educators felt that since they were expected to implement the technology approach, the content of the information needed to be pertinent and coincide with preset standards. If the administration's goal is a classroom based on technology integration, then the institution needs to address educator technology training, implementation and feedback. The administration needs to also be flexible to adjust their teaching goals and ultimate outputs per educator implementation strategies [18].

CREATIVE INQUIRY MOVEMENTS

As we have seen with AT analysis in the previous part of this essay, the use of technology in the classroom setting can provoke an organizational culture shift [19]. Both using and designing technology for instruction is enhanced by what Buchanan terms "design thinking." We have also seen that both administrator and instructor need to collaborate for technology implementation to be successful. This puts both parties in leadership roles. Senge [20] writes: "The essence of the new role (of leaders), I believe, will be what we might call manager as researcher and designer. What does she or he research? Understanding the organization as a system and understanding the internal and external forces driving change. What does he or she design? The learning process whereby managers throughout the organization come to understand these trends and forces."

Design thinking is the bridge spanning community involvement and classroom technology implementation. Per Simon [21], this type of thinking is the CI process. CI has concern for the limits of cognitive load of information that is held by an individual. It is also concerned with the movement in communication among those involved in the new technology [19]. Thus, CI is the discipline and practice of asking and answering question about "the purpose, form, materials and efficient production of a desired result to reach a specified outcome" [19].

Nelson [22] outlines the design CI movements below:

- Invention – This step is the creation of new ideas in design.
- Judgment – This step determines the probability of design project success.
- Connection and Development – This step connects the design with human satisfaction.
- Integration and Evaluation – This step evaluates the design for its worth.

Correspondingly, this section will examine research employing CI movements as data gathering paradigms.

Kimbler and Melloy [23] have used CI in industrial engineering at Clemson. The researchers have developed a CI rubric with the following objectives [23]:

- Provide CI experience to all undergraduates at all academic levels.
- Improve the value of senior year experiences by integration with CI in earlier years.
- Inspire students to consider advanced degrees earlier.
- Provide a model for CI in engineering B. S. degrees.

Table 1: Clemson Rubric Matched to Creative Inquiry Movements

Clemson Rubric	Creative Inquiry Movements
Provide CI experience to all undergraduates' at all academic levels.	Invention
Improve the value of senior year experiences by integration with CI in earlier years.	Judgment
Inspire students to consider advanced degrees earlier.	Connection and Development
Provide a model for CI in engineering B. S. degrees.	Integration and Evaluation

From these objectives, the Clemson engineering students will have the following competencies [23]:

- Ability to engage in critical thinking for engineering research or design.
- Constructively integrate and evaluate engineering discovery processes.
- Communicate the CI outcomes.

Kimbler and Melloy [23] have integrated CI into the engineering curriculum. This integration is an on-going data collection project since the CI program is voluntary. Research results on the effectiveness of the program are anecdotal. However, it is suggested that the researchers' perception is that student research is growing because of the CI curriculum. Final evaluation of the program has yet to be conclusive.

Mulvihill and Swaminathan [24] employed technology to enhance a qualitative research class. The researchers wanted to engage students into using educational technology for research data designs, collection, analysis, and display. One technology that the researchers used was blogs. Mulvihill and Swaminathan [24] posted assignments on the blog. However, they found that the digital discussion became data itself. Thus, they could conduct a "metro-analysis to examine not only the content of the blog, but also the multi-vocal content within which the blog content is being constructed" [24]. In addition, social media tools were used such as Facebook, Twitter and Surveymonkey. From these tools, qualitative transcripts were generated.

These methods can be put into the CI framework:

- Invention – Technology used to enhance qualitative research class.
- Judgement – Determining how data can be collected from the technology.
- Communication and Development – Students were more likely to use social media since their peers use these tools.
- Integration and Evaluation – Meta-analysis from the blogs was an option.

The researchers felt that there is positive ways technology can help with qualitative data collection. Mulvihill and Swaminathan [24] are continuing to research the intersection of electronic technologies and CI in this field.

Costantino [25] used CI in the form of an in-process critique to enhance creative problem solving in a design studio classroom. This researcher was focused on analyzing ill-structured problems. Per Costantino, artists and designers are interested in problem finding and framing. The researcher used problem-based learning (PBL) techniques to identify open-ended, ill-structured problems. PBL consists of the following six steps [25].

1. Overview in which the facilitator describes the focus of the session.
2. Presentation of the artifact, observation, or issue by the presenter (who is different from the facilitator) in which the presenter explains what is to be "tuned" to the question or concerns that should focus the feedback.
3. Opportunity for participation to ask the presenter clarifying questions.
4. Discussion of the artifact or issue during which the presenter remains silent, listening and taking notes.
5. Presenter reflects on the feedback.
6. Facilitator debriefs the session.

Critiques can be carried on between educator and student or, student and group. Often critiques serve as a part of a project's final assessment. Different ways to conduct the critique can be used. For example, the educator can ask the student questions or classroom peers can do so. Regardless, the critique is an important part of the design studio pedagogy [26].

Table 2 aligns the PBL steps to the CI framework.

Table 2: Problem-Based Learning Matched to Creative Inquiry Movements

Problem-Based Learning	Creative Inquiry Movements
Overview in which the facilitator describes the focus of the session. Presentation of the artifact, observation, or issue by the presenter (who is different from the facilitator) in which the presenter explains what is to be "tuned" to the question or concerns that should focus the feedback.	Invention
Opportunity for participation to ask the presenter clarifying questions.	Judgement
Discussion of the artifact or issue during which the presenter remains silent, listening and taking notes.	
Presenter reflects on the feedback.	Connection and Development
Facilitator debriefs the session.	Integration and Evaluation

Costantino [25] says more research is needed to determine the potential for in-process critique as a tool of student learning.

COMPARISON AND CONTRAST

Per this review, both AT and CI are useful paradigms to measure research outcomes. AT can be used to translate the context of the research terms into measurable concepts. For example, the AT concept of community in Russell and Schneiderheinze's [11] research, the community was at several levels – student teams, the university, and the student's culture. To compare, the CI concept of connection and development can correspond to community. Per Nelson [22], connection and development connects to human satisfaction. The word "human" can easily be replaced by the word "community."

Another AT concept to examine is rules. The rules in an activity give it structure and boundaries. This was apparent in Anthony's [15] research in which the rules applied to what students could and could not digitally access. Similarly, the rules in CI movements are the judgements assigned to the activity. This was apparent in Mulvihill and Swaminathan's [24] study in which the judgement was how the data could be collected from the technology. Yet, another AT term to discern is division of labor. This is the division of activities among the study's participants. In the Park's [17] study, the division of labor was dispersed among the instructor and students. Also involved was the universities technical support team. Similarly, is the CI term of integration? In the Kimbler and Melloy [23] study, the activity of providing CI to the students was the responsibility of the Clemson faculty. The output of this curriculum responsibility is still being evaluated.

Both AT and CI are effective ways to evaluate research, especially qualitative. However, in contrast, AT has more ways to categorize qualitative research as depicted in the above table. Another difference is that AT has a tangible framework often illustrated as overlapping triangles with arrows going back and forth from points on the diagram [27]. The main triangle has the categories of tools, rules and division of labor at each vertex. The inverted triangle within the main triangle has the categories of subjects, community and objects. Regardless, the main objective of both triangles together is a positive activity outcome [27]. Table 3 is a comparison of AT and CI terms.

Table 3: Comparison of Terms: Activity Theory and Creative Inquiry Movements

Activity Theory Terms	Creative Inquiry Movement Terms
Activity	Invention
Subjects	Connection and Development
Objects	Invention
Communities	Connection and Development
Rules	Judgement
Division of Labor	Integration and Evaluation
Tools	Integration

In addition, the action can move along the AT diagram of triangles depending on the researcher. An example of this is depicted in the Russell and Schneiderheinze [11] study of educator two who effectively involved the community and divided labor to achieve the pedagogical goals. Educator two's AT strategy was to involve the community in the pedagogical objective. To reach that goal, the educator involved the principal, the technology designers, and other participating instructors in the collaboration. Thus, educator two could divide the labor to maintain the institution's web server. She was also able to provide community professional feedback to the students. The positive outcome was the development of problem solving skills organized via multiple perspectives.

In contrast, the CI movements are not depicted with a diagram. However, they can be externally represented in a table as seen in this essay. Another observed difference from the studies reviewed is that the AT research resulted in numerical data. The CI studies concluded with the researchers' opinions that the technology used was effective in their classrooms. Several of the researchers agreed that further studies using CI are needed.

DISCUSSION

The learning theory of distributed cognition brings AI and CI together. This discussion will clarify why this is true. The educators' perception of the new technology was an important aspect of the implementation. There was concern that using the technology and the associated curriculum would not accomplish preset required standards. This was apparent when educator four called some of the innovation "useless" [11]. Creativity can be viewed in the teaching profession as risky. Especially teaching with technologies not previously tested for effectiveness. Educators can be pressured to conform to the status of "proper educator" who may or may not use blogs or social media in the classroom [28]. Per Edwards and Blake [28], "there are too many competing conceptions of improvement in education to allow smooth progress towards untroubled clarity in the face of indeterminate situation".

However, when the educator has a support team for new technology use in the classroom, team organizational change can happen [29]. This is also an example of distributed cognition.

Thus, distributed cognition is the learning theory that pulls AI and CI together. Per Turner [30], a classroom using technology is no longer individual cognition but an expanded cognition across many individuals. Such is the case with the educators in our research using technology with the support of other educators, administrators and technical staff. Such support encourages a cognitive system. A busy classroom using new technology is a system of intelligent computer users "interacting with each other by way of a range of artifacts, technology and representations to achieve their goals" [30]. True, the instructors in this literature review had responsibilities for their individual classrooms. However, there were impacted communities. For example, in Russell and Schneiderheinze's [11] research, the community encompassed not only the students but their society and culture as well. The communities engage in activities mediated by the instructor and other small groups involved in the research. This resonates with Stahl [31] who says, "much of the coordination, decision making, articulation, brainstorming, discovery and knowledge building is accomplished by small groups".

While this was apparent with the research using AT, it was also apparent with CI movements. For example, the CI research at Clemson involved both the faculty and the university curriculum committee. Further, this corresponds with whether educators in this essay had technology support. Per Stahl [31], Engestrom's [27] work with AT "paraphrases how the group deals politically with organizational management issues".

In conclusion, this essay has looked at research using both AT and CI movements as a framework to both analyze and synthesize research. The studies picked for this review were classrooms or institutions that use technology for innovative strategies. A common theme in studies that have used AT is that support for the technologies, both with the instructional staff and the administration, is important for implementation success. A common theme with studies that use CI is that the perception about using the technology is positive. Lastly, this essay clarifies that distributed cognition is the common theory of learning that unites AI and CI. It is suggested that more research in global classrooms be conducted to see if the location of classroom impacts using the CI schematic. An additional focus on the use CI in global instructional situations could create more numerical data, as this seems to be lacking in CI research, as compared to learning environments using AT.

ACKNOWLEDGEMENTS

I am grateful to Purdue University professors Kari Clase, Steve Byrn, Geanie Umberger and James Mohler. Thank you for all your research guidance. I also want to thank Purdue Polytechnic for the opportunity to participate and study with the Biotechnology Innovation and Regulatory Science (BIRS) Center.

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