Teacher Research: The Key to Understanding the Effects of Classroom Technology on Learning

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As teacher educators we're particularly interested in what research on technology reveals about its value in promoting learning. The early reviews of technology studies by Clark (1983) and Kozma (1991) revealed that most research on technology and learning does nothing more than compare media in which the central questions are which is faster, lasts longer, or holds more data. They cautioned that this kind of research does not tell us anything about the influence of technology on learning. Not surprisingly, our review of studies conducted over the last decade indicates that research on the use of technology in education continues to be misguided. Our analysis did not provide any support for the positive value of technology alone as the medium that enhances student learning. In this regard, educators are largely operating on perceptions of what technology will do for learners and learning rather than evidence.

Does this mean that spending money to put computers into classrooms is akin to tossing coins into a bottomless well? Are technology advocates simply engaging in wishful thinking? On one level, it would be fair to answer yes to both questions because the connections between technology and improved learning are not well supported. Yet, our feeling is that such a response is misleading. Researchers have failed to show new ways technology can promote learning because they continue to ask the same questions in the same way. Studies in which we examine which medium is better for which learners and for what purpose may well provide different results and, in fact, this proved to be the case in Kozma's (1991) review. Micro studies that include the characteristics of learners and the learning environment and that address multimedia have a greater opportunity to provide valuable information about technology and learning.

Teachers as Researchers

We entered our study with the belief that the teacher plays a critical role in promoting learning with technology. This belief is supported by our understanding that computers provide information—not knowledge. Significant differences between the two exist. Information is discrete; knowledge is arranged in meaningful webs. Information can be transmitted; knowledge needs to be constructed. Information is demonstrated by reproduction; knowledge is demonstrated by novel application. Transforming information to knowledge requires tutelage and a community of learners (Salomon, 2000). If knowledge is the goal of education, the teacher as tutor, facilitator, and manager of the transformative process is essential. This view was confirmed in the *Research Report on the Effectiveness of Technology in Schools* (Sivin-Kachala & Bialo, 2000): "A growing body of research shows...that the effectiveness of educational technology depends on a match between goals of instruction, characteristics of learners, the design of the software and technology implementation decisions made by educators" (p. 15). We urge further research on the role of the teacher in developing media and methods to promote learning. Technology use in education settings must be based on its ability to support rather than determine desired outcomes. The aim ought be uncovering *what technology should be doing and how we should be using it* in order to prepare learners who are independent and mindful thinkers able to solve complex problems. Who better to do this research than teachers?

To some extent, teachers engage in research whenever they're in their classrooms working with students. As a function of preparing, delivering, and assessing lessons, teachers gather data, through formal and informal means, from their students, colleagues, and others in order to make sound instructional and managerial decisions. For example, did students' responses to questions demonstrate their understanding of new material? Will my colleague's approach to motivating students work as effectively with my students as it does with hers?

The point is that the process of asking questions followed by gathering and examining data in order to make informed decisions is a natural function of teaching. We argue the need for teachers to formalize this process by applying the tenets of action research in order to better understand the role of technology in the classroom and its potential impact on student learning.

Action Research

Action research, by its nature locally appropriate, cyclical in process, and cooperative in execution, is the most important type of research for the questions of technology and learning. Kurt Lewin, credited with suggesting this type of research in the 1940s, believed that knowledge should be created from problem solving in real-life situations (Anderson, Herr, & Nihlen, 1994).

Several features of action research make it particularly appropriate for teachers. All actors in the research are equal participants. The students who respond to the survey are as involved as the teacher asking the questions. The research is typically done in a unique context—one classroom, rather than many classrooms or many schools.

Action research is cyclical in nature, with four phases: plan, act, observe, and reflect. (The last phase may lead to planning for further action.) Because the research relies a great deal on observation, it is important to triangulate data sources—where interviews are balanced against surveys and observations against documents. There is less reliance on the trappings of traditional research such as validity, reliability, and generalizability. In the case of a teacher researcher, the results of an action research study can provide enough contextualization to guide another teacher in his or her own study. Working within one department or one school, teachers can process the outcomes of their research to benefit their local areas. "There is an expectation with action research that it will result in some practical outcome related to the lives or work of the participants" (Stringer, 1996, p. xvi).

Research Model for Teachers

The model we propose for teacher action research follows the cyclical structure outlined by Kemmis and McTaggart (1988). The four "moments" of action research defined by Kemmis and McTaggart guide our model: (a) develop a plan of action to improve what is already happening, (b) implement the plan, (c) observe the effect of the implementation in the context of your classroom, and (d) reflect on the effects as a basis for further planning or other action.

Our focus is computer technology and its impact on learning, though action research need not be confined solely to this arena. The model we propose is designed specifically for teachers who are experienced using computers and who want to know if using that technology in certain ways enhances the learning of students. While this model consists of six parts, they fall within the four "moments" described by Kemmis and McTaggart.

- Developing an action plan involves:
  1. Assessing current use of technology.
  2. Formulating research question(s).
  3. Establishing a research framework.
- Implementing the plan requires:
  4. Gathering data in a variety of ways.
- Observing the effect of the implementation relies on:
  5. Thorough data analysis.
- Reflecting on the effects as a basis for further action enhances:
  6. Informed decision making.

Developing an Action Plan

Teachers and students utilize computer-based technology in numerous ways for instructional and managerial purposes. Our interest is with instructional use that may include basic-level applications such as integrating curriculum-related software and using Web-based resources or more advanced applications such as generating computer-assisted presentations and creating and maintaining Web sites to support classroom instruction.

Assessing Current Use of Technology

In order for teachers and students to begin an assessment, they should address the following questions:

- *What* technology do you currently use in your classrooms to promote learning?
- *How* do you use that technology?
- *Why* do you use it in that way?
- *How do you know* that using technology in this way leads to desired outcomes?

By way of example, suppose a teacher in a high school physics of technology class has recently learned about WebQuests[1]. A WebQuest is an inquiry-oriented activity in which students conduct a focused search of the Internet to find specific information. The WebQuest provides a clearly defined task, the

[1] Developed by Bernie Dodge with Tom March. See San Diego State University Web site *(http://webquest.sdsu.edu/webquest.html)* for information.

process students will use, and predetermined resources needed to complete the task. Over the course of a year, our high school teacher engages his students in 30 experiments designed to help them understand how physics is applied to modern problems. He often introduces new experiments by requiring students to design and create a product that will be used to conduct the experiment. He challenges them by providing little or no guidance about the process or about the technology needed to complete the task. His expectation is that students will use the Internet and/or library resources *(what)* to figure it out. This method has worked fairly well in the several years he has been teaching this course, but he is intrigued by the WebQuest approach *(why)* and would like to try it with the next experiment. The teacher decides that he will design a WebQuest *(how)* on constructing pinhole cameras to measure distance to the sun as part of the unit on light and optical systems. After implementing this new approach, he wonders if the time he spent creating the WebQuest will make a difference in students' ability to grasp the content and produce the product *(how he knows)*.

Formulating Research Questions

Uncertainty about a new approach can lead to questions about its value, encouraging a teacher to develop some measure of its impact. In our example, the *primary question* is, Will the use of a WebQuest that identifies the resources that students need to complete the task versus leaving the process open to the students' discretion make a difference in the students' ability to create the pinhole camera? Additional evidence of the value of the WebQuest will be available when students use the cameras they've created because the accuracy of the instrument impacts the outcome of the experiment. In developing a framework to research this, additional *(secondary)* questions arise: How will the teacher measure change in students' knowledge about the topic? Will this question best be answered by a survey; observations; student products? What role will students play in answering these questions?

Establishing a Research Framework.

The structure of the research will influence the value of the findings. Therefore, it is important to consider multiple measures, as well as who needs to be informed and what conditions need to be met prior to implementation. Questions to be answered are:

- *What measures* are best suited to this study?
- *What population* do you intend to study?
- What is the *timeframe* for this study?
- Are there any *conditions* that need to be met prior to implementation (e.g., parental permission, administrative support)?

Initially, our teacher decides that administering a simple survey to his students will provide him with the information he needs. After sharing his research plan with his department chair, he recognizes that relying on a single source of data may not be sufficient to establish confidence in the results. He modifies his framework to include pre and posttests and observation.

Since this is our physics teacher's first attempt at action research, he decides to focus his study on a single experiment for one of his physics of technology classes *(population)*. He chose this as a first step in determining the value of a WebQuest before using it as regular practice for all experiments. He would like to explore the possibility that this method will improve students' learning about the topic and their ability to produce the required product. Since these students have completed several experiments this year already, the teacher has some basis for comparing the effectiveness of this new approach (structured inquiry) to what he's done with previous experiments (independent inquiry).

Decisions about when he will implement the study *(timeframe)* are influenced by when the material is addressed within the unit of study. In this case, he plans to spend one 90-minute class session with the WebQuest, allowing two additional class periods for construction of the pinhole camera and another for conducting the experiment. Our teacher enlists the support of an assistant principal in conducting the observation. He informs students that they will be involved in a research project at some point during the semester and he will be asking them for their input. As a final step, he confers with administrators about the need for student permission to participate in the research project before proceeding *(conditions)*.

Implementing the Plan

Gathering the Data

Once the research framework is established and the measures identified and/or constructed, a teacher is ready to move to data collection. In our sample case, the teacher administers a pretest measure of students' content knowledge about pinhole cameras and their use in measuring great distances and their attitudes about that subject. Content questions capture the major themes and concepts of the experiment. Questions about content ask for open-ended responses to measure what students already know about the topic and where they learned it. Students use a Likert scale to respond to questions about their attitudes toward the subject of light and optical systems as a topic of study. The teacher does not look at the pretest data prior to presenting the WebQuest to assure the validity of his research.

Our teacher presents the lesson, explaining the parameters of the WebQuest process and providing students with guided instruction. Students complete the WebQuest, then conduct the experiment using their cameras. Following this, the teacher administers a posttest that includes both content knowledge and attitude toward the subject measures. He also examines the students' products (pinhole cameras) for accuracy. To gauge the degree to which students found the process effective, he constructs and administers a brief survey asking questions specific to the WebQuest. He also has data from the observation conducted by his assistant principal who agreed to sit in on the WebQuest and experiment class sessions and take notes about students' level of engagement as indicated by attention to instruction, active questioning, active participation, and on-task behavior *(process)*.

Observing the Effect of the Implementation

Data Analysis

In this phase, the researcher reviews and analyzes the test and observation data in order to draw conclusions. For our teacher, the focus is on whether the use of a WebQuest helped students develop an accurate instrument through structured inquiry *(content)*.

In part, this can be determined by the accuracy of students' measurements using the pinhole cameras. Additionally, our teacher wants to know whether the students acquired content knowledge and how they felt about the new approach. The pre and posttests give the teacher information on knowledge gained about the concepts and themes presented in the experiment and product developed. In his analysis of the tests, the teacher looks for changes in the amount of information students included in their responses and the degree to which those responses reflect an understanding of the scientific principles embedded in the experiment. In analyzing student attitudes about the topic, the teacher develops a frequency distribution of pre and posttest Likert scales in order to make comparisons. The student responses on the survey to the method of presentation are compared with the observations of the assistant principal.

Formulate Conclusions

Before formulating any conclusions, researchers need to assess the strength of the evidence. Multiple measures, as in our example, increase the trustworthiness of the findings. Complementary results allow the researcher to have confidence in the conclusions, whereas conflicting results suggest a need for further study.

Our physics of technology teacher has multiple measures, both quantitative and qualitative. He believes the evidence is strong enough that he can draw some preliminary conclusions. He determines there is an increase in student knowledge. The observation of the students supports their on-task behavior. However, he is not certain that this change is a result of the WebQuest method because the additional information about student attitudes toward the process is mixed. Table 1 is a summary of our framework for action research.

Reflecting on the Effects as a Basis for Planning

Informed Decision Making

At this point, the teacher researcher reflects on the conclusions of the analysis to determine future actions. What are the implications for one's own practice and continued study? The purpose of reflecting on the analysis is to better inform instructional decisions. While this type of research is limited regarding its generalizability to large populations, it can be effectively applied to make informed decisions at the classroom level, share at the team or department level, and expand to a system level through replication.

Table 1. Framework for Teacher Action Research on Classroom Technologies and Learning

Steps of the Plan	Example
■ **Develop a Plan of Action:**	■ **Develop a Plan of Action:**
✧ 1. Assess Current Technology Use	1. The teacher answers questions about what type of technology he uses at present; why he thinks this works; & *how he knows.* Leads to other questions.
✧ 2. Formulate Research Question(s)	2. The teacher's new knowledge about WebQuests raises questions about how or if this newer method might be better. In particular, will the use of a WebQuest make a difference in students' ability to learn the content or develop the product? *(research question)*
✧ 3. Establish Research Framework	3. The teacher now decides: which classes to study *(population)*; what time it will take to conduct the study *(timeframe)*; how to gather data (*measures*—surveys, observation); what permissions or support are needed *(other conditions that need to be met)*.
■ **Implement the Plan** ✧ 4. Gather Data	■ **Implement the Plan** 4. The teacher *applies the pretest* to learn about prior knowledge and attitudes; The teacher *uses the Webquest* to support instruction on the topic under study; The teacher and administrator *observe* during lesson; The teacher *administers posttest* of content and attitude; The teacher *administers survey* of attitude toward process.
■ **Observe Effect of Implementation** ✧ 5. Data Analysis	■ **Observe Effect of Implementation** 5. The teacher *compares* pre and posttest data about students' attitudes and content; Observations and surveys are *analyzed* to confirm or challenge students' responses; Multiple measures make teacher more confident of results and teacher *draws conclusions* about the value of this method.
■ **Reflect on Effects as Basis for Planning** ✧ 6. Informed Decision Making	■ **Reflect on Effects as Basis for Planning** 6. The teacher *finds* results are not definitive. This encourages the teacher to study the method further and share information with colleagues and administrators as the basis for planning about technology use in their school.

Note. Model follows the structure outlined by Kemmis and McTaggart (1988).

In light of his analysis and conclusions, our teacher acts in several ways. Since the data are not definitive, he is encouraged to do further research with other classes and other experiments. He explains the results of the study to his colleagues and encourages them to do similar studies so they may compare the results. He also shares the results with the administrator observer and with the student participants.

The administrator, recognizing that she has a teacher interested in doing research on technology and its impact on instruction, can now facilitate a number of related opportunities for the teacher. The students as participants in this action research benefit by having a new knowledge of the way the teacher thinks about instruction and the importance of their role in his decision making.

Conclusions

Because comparison studies have yielded little substantive data on the impact of computer technology on student learning and earlier reviews by Clark (1983) and Kozma (1991) led them to urge researchers to focus on the teacher as the mediator of instruction, we devised a scheme that involves the teacher.

The action research model we outline here involves the teacher and his or her students in the analysis of technology use for classroom learning. In this case, the importance of the role of teachers as researchers and students as participants cannot be overstated. Anyone familiar with teaching recognizes that teachers are making decisions in their classrooms daily as they plan, deliver, and assess instruction. Typically those decisions have relied on anecdotal data, as has much of the research on technology and learning. We recognize that the questions about instructional technology are going to continue to be important in discussions of education practice. It is incumbent upon teachers to get involved in those discussions. The action research model establishes a framework for more deliberate consideration of the role of technology in the learning process; teachers work with their students to develop their own answers to the questions about technology use for instruction. Learners, not technology, are the focus of the study, an approach Clark (1983) and Kozma (1991) endorsed. We believe this type of research will provide more consistent and reliable data on the impact of teacher-mediated technology on student learning.

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