Kenneth W. Miller

# Teaching Science Methods Online: Myths about Inquiry-based Online Learning

*The author addresses six myths about inquiry-based online science delivery and offers some strategies to demonstrate effective online science teaching.*

## Introduction

With universities, teacher education institutions, and high schools gearing up heavily in online course delivery in every discipline, science educators specifically are asking themselves "How do we provide this access to our students and still maintain our pedagogical integrity in science instruction?" This question seems to be at the heart of a national discussion. The standards in science promote an inquiry-based approach at both the national and state levels, therefore, an arguable difficulty exists in adapting a reticent online inquiry approach that is more consistent with the excitement of an inquiry based face-to-face classroom approach. Today's students require coursework when they want it, where it is convenient for them, and how it fits their needs. Many students need online delivery because of distance from the university or their already demanding schedules. Delivering coursework using scientific inquiry techniques can be problematic. This paper discusses six myths about inquiry-based online science delivery. Examples of how to design and promote inquiry that is embedded in the delivery of an online course are provided.

Katherine started her degree from Montana State University-Billing by driving three times a week from her home and family over 50 miles away. The worst part was not the slippery roads during the winter or the two-hour-a-day commute. The worst was that she often ran behind schedule to pick up her two sons after school in her hometown miles away.

David lives over 90 miles away from a community college or university. He helps his wife with their tamale company business which turns out over 600 tamales a week in a hometown kitchen, and he also drives a school bus route and works with the school district's technology department.

**Given the plethora of online learning courses at most post secondary institutions, we as science methods instructors find ourselves discussing the issues of sound pedagogical delivery.**

David has a two-year associate degree from a community college, and he is also a substitute teacher.

Programs in teacher education for learning online have given both these students options to fulfill their dreams of becoming teachers that previously were not available to them. The benefits do not stop with the individual. Rural schools in the Northwest are in dire need of elementary and secondary teachers. The state of Montana is a perfect example. Montana is the fourth largest state geographically in the United States, with many of its 900,000 people living in remote areas, hundreds of miles from the nearest four-year institution. Many of those seek to finish their degrees in elementary and secondary education and teach in the schools where they live, but it is emotionally, physically, and geographically impossible to restructure their lives and families to do so. Providing methods of teaching courses online within their regions and offering opportunities to intern in the schools where they weave theory into practice helps these students to earn their bachelors or masters degrees and become certified teachers.

Almost every community college and university within the current milieu offers online course offerings, and science teacher educators often find themselves in a quandary. Coursework and scheduling for online delivery increases, and there exists a philosophical struggle between perceived appropriate teaching strategies that promote the national and state science standards and what many believe we are capable of doing in online delivery platforms. Given the plethora of online learning courses at most post secondary institutions, we as science methods instructors find ourselves discussing the issues of sound pedagogical delivery.

Mission statements of public universities have at their heart *outreach and accessibility,* yet many state funded institutions do not provide, or cannot provide, outreach opportunities to their constituency unless those opportunities are offered online. Distance to universities, in many rural states is a barrier to possible on-campus attendance and participation; however, providing access to state institutions is the duty, and many times, the mission of those institutions. Access to institutional grounds should mean more than being physically able to set foot on the university campus quad. Using metaphoric language like "e-learning" or "open-education" advocates have hailed online learning as the harbinger of a complete transformation in teaching and learning (Cox, 2005). A synthesis of the professional development principles found in the standards, Loucks-Horsley, Stiles, and Hewson (1996) suggest that there should be an emphasis on "inquiry-based learning, problem-solving, student investigation and discovery, and application of knowledge" (p. 1). They continue by stating that approaches should be used to help students to "construct new understandings, through experiences that extend and challenge what they already know" (p. 1). Loucks-Horsley et al., thoroughly relate these practices to teacher education. They state that "engaging teachers in learning experiences that enhance their understanding" (p. 2) of science concepts and appropriate pedagogy should be a definite priority. They suggest that teachers, like students, learn best by doing science in an inquiry approach, investigating and constructing their own understandings. Loucks-Horsley suggests that professional development must include the modeling of effective learning environments.

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These reasons make online learning attractive and challenging. Gill (2003) suggests that almost 20% of training in "world class organizations" is being delivered online with an even greater percentage foreseen for the near future. Change of any kind is difficult and hence, fraught with myths. This paper will discuss six myths of online learning in an inquiry-based science methods course and begin to construct a better understanding of the power of online science content and pedagogical learning. Some strategies will be provided to demonstrate effective online science teaching.

***Myth One:*** *Good on campus face to face instructors make good instructors online*.

Most faculty, though quite pedagogically sound for on campus delivery, also understand that teaching online requires a different mindset and delivery style. A small on-campus survey showed that 10 faculty members were questioned prior to experiencing, developing and teaching courses online. All responded that they were quite hesitant to teach online, and most reported they did not think it was possible to teach their courses and their content totally online, void of face to face interaction. However, after planning online delivery and actually experiencing teaching online, this same faculty reported a new understanding of delivery methods and discussed how much learning took place in their online courses (Miller & Knuth, 2004). Some faculty echo, "It can't be done! To prepare science teachers appropriately, you have to be able to monitor student learning, model teaching strategies for the student, and mentor students in their teaching careers." Generally, these words originate from faculty relatively inexperienced in online delivery and/or those that lack the technological expertise to format an inquiry-based online course. Faculty with no experiences with online teaching typically made comments such as these:

- I think it will compromise quality, and that we will eventually lose our share of the market to larger universities with more attractive transcripts.
- When I first heard about online instruction, I thought, 'I don't like it and I don't think I will ever do it.'

After having taught their course online, faculty became more aware of the variety that online delivery could

produce. They then made comments like these:

- After teaching an online class, I think I really like teaching online. I get to know my students individually. Each one becomes unique, and I learn about each one's strengths better than when I had them in class. I also have the opportunity to relate each unit with a field experience, which I am unable to do with face to face, since we have so many restrictions on placements in our college.
- It is great! It forces me to be more constructivist. I lay the groundwork. I set the stage. I become a facilitator. The students have to get involved and take responsibility for their own learning!

Instruction in an online format requires that faculty re-think the tried and true methods they use to teach on campus. Online delivery, sometimes call ePedagogy, does not provide instructors with instantaneous cues regarding their teaching and the students' learning. Online delivery must be well thought out in advance, as it is virtually impossible to 'shoot from the hip' and improvise online. Teaching online is different from teaching face-to- face, and instructors who teach online should receive training in online communications and course facilitation (Kleinman, 2005).

Being void of visual cues, online teaching forces instruction to be more reflective and planned. "It is true that face-to-face pedagogy can and should be used to inform online pedagogy. However, this in itself can not be the driving force to designing online courses; one must consider ePedagogy to create a successful and meaningful course" (Li & Akins, 2005). Consequently, a weak on campus teacher will quite likely make a weak online instructor. It can also be suggested that without appropriate e-pedagogical decisions, a good on-campus instructor will not necessarily make a good online instructor.

***Myth Two:*** *Online delivery is similar to correspondence coursework and limited to content learning*

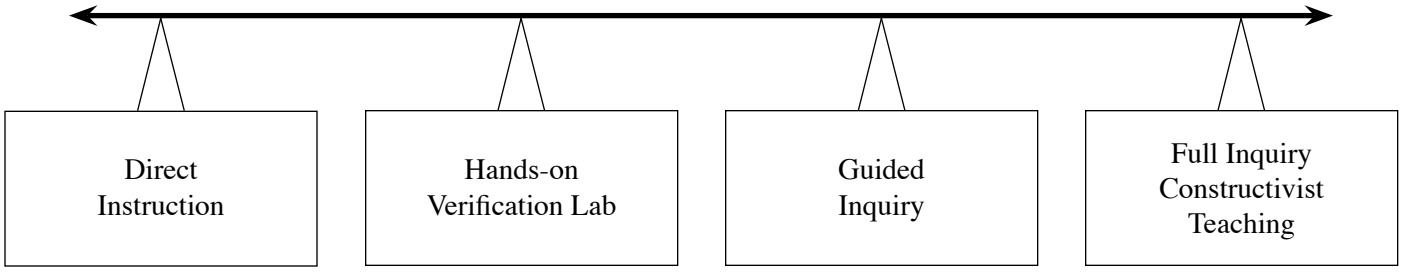
The definitions of inquiry and constructivist teaching come into play when we begin to think of training science teachers to teach. Certainly, the National Science Education Standards (NSES) call for inquiry as a way of life in the science classroom.

> The world is filled with the products of scientific inquiry, and scientific literacy has become a necessity for everyone. Everyone needs to use scientific information to make choices that arise every day. Everyone needs to be able to engage intelligently in public discourse and debate about important issues that involve science and technology, and everyone deserves to share in the excitement and personal fulfillment that can come from understanding and learning about the natural world. (National Research Council, 1996, para 1)

The NSES also suggest that the science teacher must use these inquiry-based techniques to develop appropriate content development in their students. However, an inquiry-based online science course is certainly not the same as the mail delivered correspondence course of yore. In sharp contrast to some initial perceptions, online courses can be designed to simulate constructivist teaching and inquiry approaches.

Figure 1 represents the continuum from which online courses can be designed. If the nature of the coursework is to develop a content knowledge base and provide student access to information, feedback loops from peers or the instructor do not need to be as prominent an embedded feature in the course. Hence, an instructor could possibly design a content driven course using a direct instruction model with little instructor or peer

**Figure 1. Continuum from which online courses can be designed.**



feedback. Given such a scenario, an online student could sign into a course, determine the unit's requirements, read, do activities, research, and comply with the requirements of that unit. The student would eventually be assessed on those requirements. The unit assessment, likely true/false or multiple choice, could quite possibly be the only feedback that the students might receive. Further, in some cases, that feedback can be totally computer generated. For example, at a nearby university, a beginning personal health course is offered each semester with almost one thousand students enrolled. The students read the material and respond to the content with exams to determine content understanding. Evaluation is multiple choice and true or false. The computer scores each student and records the grade in the online gradebook. This type of course is extremely efficient and generates a large number of FTE for the university. However, it is a course that is based upon content knowledge understanding; not pedagogical, attitudinal, and following the inquiry standards-based understandings as prescribed by the NSES.

Toward the middle of the continuum, a course can be developed that would enable more in-depth instructor feedback and can also include peer-to-peer discussions and feedback. Logistically, this type of feedback limits the total number of students in a course simply because of the time required by the instructor to interact with individuals and monitor their responses. Should there be a large number of students in the course, the instructor may establish discussion groups to facilitate content understanding. This plan allows for the instructor to interact and provide feedback to groups of 5-8 as they discuss with each other pre-determined questions, rather than to specific individuals. The instructor can direct or re-direct discussions of the group, thus providing the necessary feedback loops. Assessment can be more individualized and can provide the instructor with a deeper understanding of the students, as seen in more interactive, discussion-based, on-campus classrooms.

**It can also be suggested that without appropriate e-pedagogical decisions, a good on-campus instructor will not necessarily make a good online instructor.**

***Myth Three:*** *You cannot model constructivist inquiry teaching strategies online.*

Further along the continuum (see Figure 1), we can establish a guided inquiry course nearing full inquiry. How does an instructor design an online course that models appropriate standards based teaching pedagogy? Certainly, this is a daunting task. It requires that the instructor plan for inquiry-based activities that model appropriate constructivist techniques, yet with clearly defined e-pedagogical objectives. Let's see how this might be done.

Assume that you have introduced various teaching models, i.e. The Learning Cycle (Karplus, 1974; Lawson, Abrahamn, & Renner, 1989), The Conceptual Change Model (Hewson, 1992; Posner, Strike, Hewson, & Gertzog, 1982) The Instructional Theory Into Practice (ITIP) (Hunter, as described by Darling-Hammond, 1990); and the 5E teaching model (BSCS, 1989) in previous coursework. Now, you would like to have your students do an activity to experience one of these. You choose the Conceptual Change Model (CCM) because you are fairly sure from previous courses that your students need experiential opportunities with Bernoulli's Principle. You are fairly certain your students do not understand the CCM teaching model, and this becomes your primary objective for this unit. Bernoulli's principle, at a basic level, suggests that a fluid in motion has a lower pressure that surrounding fluid. Consequently, the surrounding fluid (or air) tends to move from a higher pressure to a lower pressure. You need to take into account that your students do not have access to equipment other than most household materials. Again, your major objective in this method of science teaching course is for the students is to understand the steps and stages of the CCM and how it is used in the classroom.

A series of digital video segments are constructed by the instructor to model this inquiry-based activity. These videos represent a modeling of the steps of the CCM and help to develop the activity sequentially, following the CCM format. Students are directed to watch a segment of a video and respond online in a discussion format. The following segments and directed student responses show how to model inquiry-based teaching through online delivery.

Video Segment One: Show a video where the instructor asks the students to predict what would happen, if anything, to a strip of paper when you blow across it. (the paper moves up and flutters). Have the students enter into the discussion area of the online

course, where they are directed to predict what will happen to the strip of paper and why they think this will happen. Students are encouraged to discuss these concepts within their small groups and try to come up with a collaborative answer. Once they all agree on an answer, direct the students to try the activity and discuss their results.

***Myth Four:*** *Interaction among peers is weak in online delivery formats.*

Video Segment Two: Students are directed to another video, where they are asked to view a folded piece of paper making a tent. Another video segment shows the instructor modeling the set up of the experiment. The students observe the instructor about to blow through a straw and through the paper tent. The instructor directs the students to go back into the threaded discussion area and predict what they think will happen, form a consensus with their group, and finally try the activity. An additional discussion area is set up for the students to discuss their results. They are then directed to additional video segments, using different materials that also demonstrate the same concept. Students continue to interact in similar discussions.

The instruction proceeds to the stage of the teaching model, where the concept is developed. Students are encouraged to discuss their understandings in additional discussions. From there, the instruction leads to another stage of the CCM into an extension or application of the concept. Students again are led to the discussion area where they discuss where they have seen this concept before.

Given the primary objective being an understanding of the CCM, the lesson continues with an assignment to complete and return digitally to the instructor for grading. This assignment instructs the students to replay the entire activity around the concept of Bernoulli's principle and write what was occurring in class for each step of the CCM model. This now creates student reflection necessary to provide closure, and more importantly, a deeper understanding of the CCM, which becomes an assessment tool for the instructor.

## The very nature of online is that of interaction within the medium.

The interaction between and among peers and the instructor is strong. Students in an online format are not allowed to simply sit back and let others discuss and lead discussions. The very nature of online is that of interaction within the medium. To encourage this sort of collaboration, it is important to value the discussions, and that should reflect in the course grade. My experience and other research (Nicaise & Crane, 1999) show that many of our students tend to do only that which is required. Valuing the amount of collegial interaction with peers and the instructor, as a representative part of the student's grade, can certainly enhance the discussions. It is in this manner that myth number four—suggesting a weak interaction amongst peers—is debunked.

***Myth Five:*** *Online delivery does not allow students to take theory into practice.*

The structure of many online courses might not allow students to take theory into practice. It is arguable though, that online might allow for a more significant experience for students if the requirements for the teacher education program are such that it necessitates an interaction in the schools. For example, if students are required to interact in field experience with assignments from a co-existing online course, theory into practice can easily occur, especially if the instructor allows online interaction regarding the field experiences. Miller & Knuth (2004) found that students involved in field experiences while taking an online course scored as well with no statistical differences on student teaching measures as students taking courses on campus. A comparison of an online course and a face-to-face science education course, Harlen & Altobello's (2003) results showed better learning outcomes online.

Certainly, field experiences can enhance the understandings presented in an online format, but the format can also expand the community of learners and decrease the physical isolation of online learning. Discussions can be incorporated easily that allow for peer to peer and instructor to student dialogue that truly dispel the theory into practice myth.

***Myth Six:*** *In order to succeed as a teacher, students studying to be teachers must be able to watch the instructor model an appropriate lesson.*

Faculty discussions related to the innovation of online instruction have certainly been diverse, if not in a direct dichotomy. Faculty argue that learning apart from the intensity of the classroom cannot occur outside of their ownership, direction, and personal interaction. Many claim the need for *appropriate modeling,* and suggest that their *materials and mode of presentation will not fit an online environment*. When faculty members discuss the topic of online instruction,

several suggest that their methods of teaching are not conducive to an online format. In essence, they have difficulty seeing how their materials and classroom instruction can transfer to an online environment. Some charge that learning cannot occur in absence of good instruction, with the understanding that good instruction occurs only from the pedagogical structure of face-to-face communication. These arguments are of value and need to be understood. Accommodations for these understandings are appropriate, keeping in mind that learning is experiential and most faculty have little or no online experiences of their own. Nor have they been tooled in online learning e-pedagogy. Still, theoretical constructs for learning are similar for both online and on-campus delivery. As discussed in previous myths, being "sage on the stage" is not a necessary component of constructivist "guide on the side" learning.

## Conclusion

Certainly as higher education, secondary education, and other uses of internet based learning continue to grow, those asked to design courses and teach those courses will have discussions as to the appropriateness of the delivery system. But, as Li and Akins (2005) suggest, the quality of that education is dependent on the clarity of the goals and good e-pedagogy designed to meet those goals. We will need committed learners and instructors and excellent supporting structures willing to learn to implement inquiry based methods into online teaching. The potential for e-learning is great and certainly in demand. It appears that the quality of the course content and design, and the nature of the interactions with the instructor, are more important determinants of learning than whether the course is taught face-to-face, online, or some blend of both (Koory 2003). As faculty members begin the arduous journey toward making their online teaching more inquiry-based, there will be other barriers with more myths to dispel.

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**Kenneth W. Miller** is professor of science education, Department of Educational Theroy and Practice, Montana State University-Billings, 1500 University Drive, Billings, Montana 59101. Correspondence concerning this article may be sent to <kmiller@msubillings.edu>.