Learning Science Online:

A Descriptive Study of Online Science Courses for Teachers

Conference Report

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Online education is a rapidly growing phenomenon for science teachers that is not only well suited to many teachers' lifestyles, but also offers interesting new opportunities for teaching and learning science. The role of online learning environments as tools for science teacher professional development has expanded at such a rate that the dearth of even the most descriptive knowledge about these online environments is startling. To begin addressing the gaps in research, the Learning Science Online (LSO) project, funded by the National Science Foundation, undertook a study of 40 graduate-level online science courses for K-12 teachers, asking:

- Who are the students in online science courses for teachers?
- Who are the instructors in online science courses for teachers?
- What does science teaching and learning look like in these courses?

The emphasis in this study is a description of patterns across all courses, rather than the evaluation of individual courses. This report, a supplement to the full technical report (Asbell-Clarke & Rowe, 2007), summarizes for online course developers the practical implications of these findings that emerged as part of a two-day conference attended by a panel of online course providers and educational researchers.

Conference

In November 2006, LSO hosted a two-day conference to share preliminary findings with LSO program representatives as well as advisors to LSO study[i] Program coordinators from the six programs that hosted the online courses in this study were invited to attend. Three program coordinators, representing 31 of the 40 courses in the study (78 percent), attended. They, in turn, invited other interested parties from their programs, including instructors of individual courses, faculty developing a new online program, and professional development colleagues. Also in attendance were five members of the LSO advisory board representing the perspectives of science educators, online education researchers, gender studies researchers, and quantitative research methodologists. A total of 16 people attended the conference—3 LSO staff and 13 invited guests.

An initial draft of the full LSO report was distributed to the panel in advance. The findings are organized around the following topics:

- LSO Study Background & Participants
- Students
- Instructors
- Teaching and Learning.

This structure served to guide the discussions, and panelists were asked to discuss implications of the study—what could explain the findings as well as how the findings will shape their future practices.

LSO Study Background & Participants

LSO is a mixed-method longitudinal study of online science courses for K-12 teachers offered during the 2004-2005 academic year. The criteria for inclusion in the study were (a) a focus on science content (as opposed to pedagogy), (b) courses are offered for at least one graduate credit, and (c) the majority of interactions are online. LSO collected data from program coordinators at institutions offering courses, course instructors, and students. Pre- and post-course questionnaires from instructors and students are the primary data sources reported here, with program coordinator interviews and instructor reports of student performance woven throughout.

All six program coordinators, 40 of the 47 courses (85 percent), and 296 of the 800 students (40 percent) provided complete information and were included in these

analyses. Courses targeting high-school science teachers and students who performed well in the courses are over-represented in this study—two limitations central to interpreting the findings.

Findings on Students

The rapid growth of online learning for teachers raises the question of whether or not there is equity and broad participation in this new phenomenon. Do students in online science courses for teachers reflect the broader teaching population, or are these courses reaching an audience of teachers different from the audience reached by other forms of professional development? The typical student enrolled in an online science course for teachers is:

- A white female, aged 25-45
- a high school teacher with less than 10 years of teaching experience
- holds a bachelor's degree in a science field
- took the course for personal learning and professional advancement
- has taken at least one other online course
- accessed the course from a home computer
- spent 8 or more hours a week on coursework
- visited the course web site 7 or more times per week.

Students in online science courses differed from the general teaching population in most demographic considerations. Panelists speculated on possible reasons for some of these disparities.

Gender: Two-thirds of the students in LSO courses were women. The number of women in the teaching force decreases dramatically between elementary school and high school, particularly in science. The LSO study had a larger percentage of courses geared for high school teachers, suggesting the overrepresentation of women may have been much higher had we studied more courses for elementary school teachers.

The high proportion of females in these courses goes against a popular belief that women are intimidated by science courses or are more technology-phobic. Further LSO data showed that women were just as likely to report frequent participation in online discussions, debunking the idea that women are silenced in scientific discussions or in online communication.

Race: Minority teachers are 40 percent of the U.S. teaching force, but constitute only 10 percent of the online student population in science courses. The most probable explanation for this is the underrepresentation of minorities teaching in science fields in general, particularly in rural and small-town locations which are over-represented in this sample. When considering most of these courses targeted high school teachers, the percentage of minorities in these online courses (10 percent) is comparable to the percentage of minorities in the high-school science teaching force (10-15 percent, depending on the field) (CCSSO, 2005).

It is possible that minority teachers are not being reached by advertising/recruiting methods or that online learning is not attractive to minority teachers. Panelists suggest that in schools where other forms of professional development take precedence, teachers may not attend NSTA or read publications where these online programs are advertised. Some programs have had more success with networks within school districts, particularly between an urban museum and the local public schools.

Teaching Experience: Students in LSO courses were more likely to have less than 10 years of teaching experience relative to their counterparts in the general teaching population. Since the majority of students in these courses were seeking professional development, most often through a master's degree, it is sensible that they are in the early stages of their careers. It is also possible that younger teachers represent the wave of native technology users as opposed to older and more experienced teachers who are more typically new immigrants to technology.

Panelists suggest that institutions should take advantage of the new generation of online learners to utilize this medium for rich content delivery. The need for professional development often comes just at the busiest time of teachers' careers and often when they are also juggling family responsibilities at home. Online courses often make it possible for young teachers to fit in professional development when they otherwise would be unable to, especially if it demanded a long commute.

Geography: Although most students in the study taught in suburban and urban communities, they were more likely

to be teaching in rural communities and small towns than teachers in the general teaching population. Teachers in rural areas and small towns may not have ready access to face-to-face professional development opportunities—online education seems tailored for these students. While Internet access is still lower for people in rural areas, the gap between rural and urban Internet usage is narrowing. Active recruitment to rural school districts might prove fruitful for programs looking for more students.

Implications for the Field — Students

At the end of the discussion of the LSO findings on students, conference participants were asked to discuss three questions:

1. *Are online courses reaching their target student population?*
2. *How are students recruited?*
3. *What changes would you suggest in student recruitment and retention?*

Panelists suggest that online education may reach be reaching out to and connecting with women in new ways, which should be fostered. The higher than anticipated percentage of women in these online courses may be because online learning opportunities are more suited to women's lifestyle needs as they may be fitting their education in among their regular work and home duties. It is also conceivable that the emphasis on communication in online environments is an attractive feature for female learners. Research is needed to understand how positive practices in this area may be transferable to other learning environments.

Although minority representation was of concern to all panelists, several of the program representatives explained that their recruitment priorities must first focus on ensuring the class is viable before ensuring the diversity of the students. Although some of these programs are over a decade old, not all are filling their classes to capacity, and some are struggling financially. Classes typically have less than 25 students, some less than 10, with one or more instructors. On the other hand, one rural university program that recruits to rural teachers is quite successful at serving that population, and a large university that offers an online masters program for teachers through a science department has no financial woes at all and is in fact, a recognized revenue generator for the university.

When recruiting, LSO programs typically reach teachers directly through web sites, advertising in the literature of NSTA and similar organizations, teacher listservs, and word of mouth. They report that print ads are not so effective, and direct mail is costly and mostly unsuccessful. The consensus among participating programs was that, among these direct advertising techniques, word of mouth works best.

Another recruitment technique used by programs is to approach state professional development departments for assistance in recruiting. Programs report that there are problems with "top down" dissemination—school districts often create hoops to jump through to get information about course availability to teachers. One urban museum program has established a long-term institutional relationship with a local school district that has provided a steady stream of students.

Programs also find that cost of taking an online science course may prohibit enrollment of some teachers. Teachers hear about online course offerings and become enthusiastic but may shy away when they hear the cost unless they are reimbursed for tuition by their district. In urban settings where professional development offerings are plenty, it may be less expensive for students to attend a face-to-face course than to enroll in an online science course.

Findings on Instructors

Online courses also offer fresh opportunities for faculty that may lead to a new breed of instructor that diverges from traditional science or science education faculty. The same matters of convenience and proximity that are argued as an advantage for students apply for instructors as well, and online courses may attract instructors who would not ordinarily consider teaching in a traditional face-to-face setting. Do instructors in online science courses for teachers represent the typical science professor, or are these courses tapping a different group of potential instructors? In the LSO study, the typical instructor of online science courses for teachers:

- is a white male, aged 50–65
- holds a Ph.D. in a science field
- has no K-12 science teaching experience
- has taught more than one online course
- has taught the current course several times

- feels well prepared to teach online
- spent 8 or more hours per week teaching the course, with the most time spent reading student posts (2–5 hours per week).

In university programs, instructors of online science courses for teachers resemble the broader science professoriate—predominantly male, mid-fifties, a Ph.D. in science, little K-12 teaching experience. There is one notable difference between the online instructors in university programs and typical university science professors—no instructor of an online course was actively pursuing tenure. Instead, instructors were either already tenured faculty or were non-regular faculty (part-time, adjunct, lecturer). This seems to suggest tenure-track faculty would not tend to see teaching online science courses for teachers as valued by their institution.

In non-profit programs, instructors of online science courses for teachers did not resemble the broader science professoriate—they were predominantly female, were less likely to have earned a Ph.D. in science, and had considerable K-12 teaching experience. All of them had had experience teaching online and had taken a formal facilitation course.

Implications for the Field — Instructors

After reviewing these results, panelists were asked to focus on the following discussion questions:

1. *What makes someone a highly qualified instructor for online science courses for teachers? What is the balance between:*
   - science expertise
   - K-12 teaching experience
   - online facilitation skills and experience
2. *Are there other skills that are important?*
3. *How do programs recruit instructors with the right balance of skills?*

Qualifications for Instructors: Panelists agreed that along with a strong grounding in the science content, the ideal online instructor is someone who is a natural communicator of ideas and is comfortable enough with technology and the nuances of online communication so that the new medium is not a problem, and may even open new opportunities for teaching. Some programs find that instructors who use a rich, layered approach that synthesizes science content expertise, classroom experience, and technology skills hit upon a powerful "best practice" combination and in some cases, it takes a team of people to bring the best of these strengths together. Representatives of one university program reported that their mission is to teach the science content, not pedagogy. Since they felt K-12 classroom experience has little to do with the way they teach science, their instructors had much less background in that area.

Instructor Recruitment: Although university and non-profit programs defined "qualified" in a different ways, neither had trouble finding qualified instructors. Instructors were typically selected from a known group, not recruited. Programs felt that they already had the opportunity to draw from people they trusted to do a high-quality job teaching the courses, so they did not feel the need to look at a broader population.

Compensation: Administrative support for online instructors varies greatly across institutions. In university departments where professional prestige comes from publications and graduate students, working with teachers and/or teaching online is typically not a high priority among those pursuing tenure, nor those making decisions about advancement. The costs to a career are high as matched to the level of effort perceived. Online teaching is still believed to be a time consuming endeavor, daunting to some, and possibly for good reason. LSO instructors typically reported spending 8-10 hours per week teaching their online course. The compensation for instruction varied widely in LSO courses from no compensation at all, to being recognized as part of a normal teaching load, or to being paid up to $9000/semester per course.

Findings on Teaching and Learning

The online environment offers new tools and different social structures in which learning can take place. Many inquiry-based models of science professional development for teachers advocated by national standards and educational research involve collaboration and other social ways of learning as well as authentic scientific contexts and hands-on investigation. Do online courses for science teachers take advantage of the new learning environment to promote inquiry-based science learning? In the LSO study, the typical online science course:

- was offered on one of the major course online learning platforms
- was at least partially designed by the instructor
- made extensive use of online discussion boards and limited use of hands-on activities, field experience, and computer simulations
- had students frequently articulating and reflecting upon scientific ideas, as well as posing scientific questions, analyzing data, and drawing conclusions from evidence
- used almost exclusively asynchronous discussion boards, email, or synchronous chat for communication
- had instructors choosing the topics, but had most students participating frequently in discussions
- used a combination of assignments, projects, papers, and exams for assessment
- had students who feel that they received helpful and frequent feedback from their instructors.

Course Design: The design and development of an online course includes the writing and orchestration of all assignments, communications, and all teaching components (e.g. readings) within an online course environment. The platform used for online courses may influence the content of the course and some developers/instructors find they have to change platforms when the goals/nature of their course changes. In the LSO study, the typical online science course for teachers was offered through a pre-existing course platform such as WebCT, Blackboard, or eCollege. Online courses may include not only conventional instructional tools such as readings (from web pages or text books), but also asynchronous and synchronous communication tools (discussion boards and chat), assignment drop boxes, whiteboards, email, and other technologies.

LSO courses were typically taught by one instructor with no teaching assistants and were at least partially designed by the instructor. Often in university courses, an instructor develops a course of interest to them. In non-profits, however, the course is usually designed and then instructors are hired to teach it. Costs associated with the design and development of these courses revealed a huge range: from $3,000 at a university to $150,000-$200,000 estimated by a non-profit institution (under an external grant).

Because the design and development of online course materials is usually completed before students start the course, there may be increased opportunity for enhanced foreshadowing and storytelling with the content and less content-delivery burden on the instructor. But what does the instructor do during the course if there is no content left to deliver? Many use their time facilitating online discussions and spending more time on student work. Some have office hours online where the instructor conducts private e-mail conversations with students.

Instructional Methods: The typical instructional methods used in LSO courses made extensive use of discussion boards and very limited use of problem sets, journaling of ideas, physical materials, and computer simulation. Other instructional methods such as use of real-world problems, data analysis, group work, and reading of science publications, varied among courses.

Students reported high frequencies of articulating and reflecting on their own ideas and the ideas of others, reading and responding to discussion postings from their instructor and peers, raising questions with other students about scientific ideas, as well as analyzing data and providing evidence to support ideas. These are all indicators of a very social learning environment, and possibly what could be called a community of scientific inquiry. Panelists suggest that further examination of the quality and nature of the science being discussed in these online communities may reveal interesting information about the social construction of knowledge.

Courses varied in their extent of hands-on activities, but they were generally rare. There was also very little fieldwork or laboratory experience associated with the

LSO courses. Panelists suggested that it is difficult to design authentic field investigations that are suitable for people at any geographic location. They also recommended that online courses might need supplementary enrichment, such as partnerships with laboratories for teacher research experiences.

Surprisingly, computer simulations are rarely used in the LSO online courses. Panelists explained that the development costs to create good simulations are a barrier for most programs, and the ones available on the web are not necessarily suited to their particular need or audiences. In the recent past, and still in some places today, bandwidth was also a consideration.

Panelists suggested that the online environment challenges people to think more deeply in an investigative way, They noted that material is covered more slowly online, but students seem to "get it" just as well, or better, by the end if there is a lot of time for reflection and digestion of material online. They also noted that online education in some ways is more public, and thus social, than face-to-face classes. Everyone typically sees everyone else's posted research/assignments and there is a visible "paper trail" documenting the students' ideas as they progress.

Communication: Nearly all of the communication in LSO courses occurred in asynchronous discussion boards, email, or synchronous chat. Panelists argued the merits of asynchronous discussion—that it affords students more wait-time to craft their ideas, it is public and very conducive to sharing of ideas, and it is archivable so that it can be used for reflection and monitoring progression of learning. They noted that in contrast, chat tends to be spontaneous and not carefully crafted. It can become disjointed if too many people are involved. Email is sometimes used for private office hours, but lacks the collaborative aspect of online discussion.

Within discussions in LSO courses, instructors tended to choose the topics for discussion and students followed their lead. Most students participated in discussion at least once a week and reported that they felt supported and valued within the discussions. Interestingly, these reports did not vary by gender.

Panelists noted the importance of building community within an online course. This includes approaches such as icebreaker activities and/or having students create a homepage. Instructors need to model standards of discourse, both social standards such as respecting everyone's contribution, as well as scientific standards like using proper terminology and reasoning.

Feedback and Accessibility: Most online courses use a combination of assignments, projects, papers, and exams for assessment. Online discussion contributes to 0-50 percent of the grade in LSO courses. Most instructors use either frequency of participation or some informal evaluation of the general discussion in order to assess discussion. Panelists agreed that there are no clear methodologies used to grade online discussion, but that the discussion does have powerful potential to assess student learning. More research and development is called for in this area.

Students in LSO courses reported frequent and helpful feedback from instructors, but less so from peers. Peer evaluation is not used frequently as a means of assessment, which is interesting given the social nature of learning that is apparent in these courses. Students also reported that their instructors were accessible. This goes against some opinions that online learning is isolated and students are left feeling abandoned

Conclusions and Further Questions

As panelists discussed the LSO findings on the whole, they were left with several important questions for the field.

Is online learning meeting serving all of its potential audience or are there barriers that are excluding some learners even in this booming new mode of education? As programs move from situations where they are still trying to "fill seats" by recruiting to new and diverse audiences, they must also keep in mind that not all learners will be attracted to or served by new technologies for learning. A close eye should remain on how to use the affordances of online environments to open doors for learners, particularly to those typically marginalized in science education.

Are online courses utilizing the technology to its fullest potential, or are there untapped ways of learning that may be possible with the new tools available? The panel was surprised at the dearth of computer simulations and hands-on activities across online science courses for teachers. The former seems like a natural fit with online learning, as web-based computer interactives are only a click away when working in an online environment, and can be a

highly useful way to present sophisticated phenomena and scientific models. Hands-on activities are often the bread and butter of face-to-face science teacher professional development workshops and their absence from online courses is a bit disconcerting. Techniques should be sought and promoted to integrate hands-on work with the online discussion that does take place in these courses.

Overall, panelists were encouraged and enthusiastic about the prevalence of many indicators that suggest social and inquiry-based learning in these courses. It appears that collaborative and discussion-oriented learning models have replaced a teacher-based lecture style science course. It also appears, however, that some valuable elements of typical face-to-face science professional development courses, such as hands-on activities and fieldwork, have not yet made it to the online science courses for teachers, which is of concern. The online professional development field is still young, but holds great potential for embracing inquiry-based instructional methodologies as it becomes a greater and greater force in the educational arena.

[i] *Because of the confidentiality of the LSO study, program representatives are not identified in this report. Advisors included Gwyneth Boodoo, Jane Butler Kahle, June Foster, Sarah Haavind, and Karen Sheingold.*

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