TEACHER PROFESSIONAL DEVELOPMENT IN STATISTICS: NEW VENUES THROUGH DISTANCE LEARNING

Maria Meletiou-Mavrotheris
European University Cyprus

Efstathios Mavrotheris
Open University of Cyprus

Efi Paparistodemou
European University Cyprus
Cyprus

Abstract

EarlyStatistics, an EU funded program, aims to enhance statistics instruction in European schools by harnessing the power of the Internet to provide teachers with access to a wide array of colleagues, discussions, and resources eluding them in their workplace. The project consortium has developed and is currently pilot testing an online professional development course in statistics education targeting elementary and middle school mathematics teachers around Europe. The course facilitates intercultural collaboration of teachers using contemporary technological tools and resources. An online knowledge base offers access to standards-based pedagogical models, didactic approaches, and instructional materials, resulting in a complete and flexible teacher professional development program.

Introduction

In a world where the ability to analyze, interpret and communicate information from data are skills needed for daily life and effective citizenship (César, 2004), developing a statistically literate society has become a key factor in achieving the objective of an educated citizenry. Statistics education is becoming the focus of reform in mathematics education as a vital aspect of the education of citizens in democratic societies (National Council of Teachers of Mathematics [NCTM], 2000). Recognizing teachers' ongoing professional development and learning as a linchpin of instructional innovation and success for their students (Ginsberg, 2003), the EU-funded project *EarlyStatistics* exploits the affordances offered by open and distance learning (ODL) technologies to help improve the quality of statistics instruction offered in European schools. The project consortium, comprised of five higher education institutions in four countries (Cyprus, Greece, Spain, Norway), has developed and is currently pilot testing an online professional development course targeting elementary and middle school mathematics teachers around Europe. The course aims at helping teachers improve their pedagogical and content knowledge of statistics through exposure to innovative learning

methodologies and resources, and cross-cultural exchange of experiences and ideas. More specifically, the course aims at enabling participating teachers to:

- learn and/or better understand the concepts and methods of statistics;
- understand statistics as a comprehensive approach to data analysis;
- develop pedagogical knowledge of statistics;
- become familiar with a variety of methodologies, tools, and resources for teaching statistics;
- use real data, active learning, and technology to teach statistics; and
- develop a long-lasting trans-national community of teaching practitioners, who advise and support each other about classroom practices, pedagogy, and statistical concepts (Gould & Peck, 2004).

In this article, we provide an overview of the *EarlyStatistics* ODL course design. We describe the pedagogical and didactical approach underlying *EarlyStatistics*, the course development strategy, and the course content and structure. We also present an overview of the quality assurance processes used in the project. By July 2008, we will be able to present a synopsis of the main findings from the pilot delivery of the course and the follow-up classroom intervention.

Pedagogical and Didactic Approach

The *EarlyStatistics* program has adopted "learning" and "community" rather than "instructional" models of professional development (Barab & Duffy, 2000). Contemporary visions of web-based instruction and computer-mediated communication which support more collaborative and participatory models of education underpin the course design.

Recognizing that teachers would bring a diverse variety of strategies into the course as a result of their own professional experiences, and that professional development is most effective when deeply contextualized in teachers' professional activity, *EarlyStatistics* adopted an approach that respects and utilizes teachers' professional knowledge. The distance education environment has been designed as a framework for flexible learning (Collis & Moonen, 2001), regarding teachers as the main agents of their professional development, supported by an environment rich in challenges and interactions.

A central conviction underlying *EarlyStatistics* is that learning is a social act best supported through collaborative activities (Vygotsky, 1978), and thus learning as part of a community of practice can provide a useful model for teacher professional development. The *EarlyStatistics* course promotes intercultural awareness and exchange of experiences and ideas among European teachers. Teachers interact and learn about statistics by engaging in joint activities and

discussions, helping each other, and sharing best pedagogical strategies. Through these interactions, they build relationships and construct a multi-national community that supports best practices and innovation in statistics instruction.

EarlyStatistics participants are provided with ample opportunities for interactive and collaborative learning through use of a wide array of tools, artefacts and resources (Gordon et al., 2007). They are actively involved in constructing their own knowledge, through their participation in authentic educational activities such as projects, experiments, computer explorations with real and simulated data, group work and discussions. Central to the course design is the functional integration of technology with existing core curricular ideas, and specifically, the integration of new types of tools (e.g., the dynamic statistics software Tinkerplots©), which provide teachers, and subsequently their students, with the opportunity to model and investigate real world problems of statistics. The hope is that this inquiry-based, learner-centred approach, will serve as a model to the participating teachers as to the kind of learning situations, technologies and curricula they should employ in their own classrooms.

Key Stages of Course Development

In the 3-year timeframe of the project (October 2005–September 2008), the following key stages of course development have/will take place:

Development of pedagogical framework for online professional development: At the initial stage of the *EarlyStatistics* project, the pedagogical and technical experts in the consortium worked jointly to develop the pedagogical framework to guide the design and delivery of the professional development course. This framework provides expert and practitioner recommendations for the effective delivery of online professional development to statistics teachers; it incorporates both pedagogical and technical considerations (e.g., limitations in terms of equipment, software, protocols, and network bandwidth).

Development of instructional content for professional development course: Following the development of the pedagogical framework, the project team spent the first two years of the project designing and developing content, using contemporary web-based tools and resources, a line of research-based curricular and instructional materials on statistics for elementary and middle school teachers and students to be used during the professional development course. The course material has been produced in the partners' national languages, and in English.

Design and development of information base infrastructure and services: In parallel to the development of the instructional material, the team worked on the

technical design and implementation of the infrastructure and services for the dedicated information base that will support the project activities and outputs.

Pilot delivery of professional development training course and follow-up classroom experiment: A pilot delivery of the professional development course is currently (February–May 2008) underway. The online course is being pilot tested with a group of around 20 teachers from the partner countries. To evaluate the applicability and success of the course, there will also be a follow-up classroom experiment. Participating teachers will develop and deliver teaching episodes integrating the use of the course tools and resources provided to them.

Final revisions and enrichment of information-base content and services: At project completion, final revisions and enhancements to the information-base content and services will be made based on feedback from the pilot delivery of the professional development course and the follow-up classroom intervention.

Course dissemination: After the pilot testing and course revision, the course will enter the Comenius Training Database for EU-wide participation. This will increase the course's visibility, and provide greater access to large numbers of teachers beyond the participating countries.

The *EarlyStatistics* Course Content and Structure

The *EarlyStatistics* course design focuses on activity-based learning. The course aims at enriching teachers' (i) knowledge of and about statistics; (ii) knowledge about teaching and learning; and (iii) practical knowledge (Azcarate et al., 2006), through hands-on and computer-based practice, experimentation, intensive use of simulations and visualizations, feedback from each other, and reflection. Teachers participate in a number of collaborative and participatory activities that help them improve their content and pedagogical knowledge of statistics and, being actual practitioners, then apply what they learn to a real classroom setting.

The course lasts for 13 weeks, and is made up of six modules. In Modules 1–3 (Weeks 1–7), the focus is on enriching participants' statistical content and pedagogical knowledge. To help teachers go beyond procedural memorization and acquire a well-organized body of knowledge, the course emphasizes and revisits a set of central statistical ideas rather than presenting statistical content as a sequenced list of curricular topics. The conceptual "Framework for Teaching Statistics within the K–12 Mathematics Curriculum" (GAISE, 2005), has been used to structure the content presentation. This framework uses a spiral approach so that instructional programs from pre-kindergarten through high school encourage students to gradually develop understanding of statistics as an investigative process with four components: (i) clarifying the problem at hand and

formulating questions that can be answered with data; (ii) designing and employing a plan to collect appropriate data; (iii) selecting appropriate graphical or numerical methods to analyze the data; and (iv) interpreting the results. Using real data, active learning and technology, participating teachers learn where the "big ideas" of statistics apply and how, and develop a variety of methodologies and resources for their effective instruction at different levels of schooling.

In Modules 4–6, the focus shifts to classroom implementation issues. Teachers customize and expand upon materials provided (Module 4; Weeks 8–9), and then apply them in their own classrooms with the support of the design team (Module 5; Weeks 10–11). Teacher then write up their experiences, including a critical analysis of their work and that resulting from their pupils. This helps them to reflect on their practice, and to apply self-criticism constructively. Finally, once the teaching experiment is completed, teachers report on their experiences to the other course participants, and provide video-taped teaching episodes and samples of their students' work for group reflection and evaluation (Module 6; Weeks 12–13).

EarlyStatistics uses a blended learning approach. There are a few face-to-face meetings with local teachers, but the biggest part of the course is being delivered online by utilizing the project information base for teaching, support and coordination purposes. In addition to the course content, the site offers access to various other links and resources:

- *Technologically enhanced instructional materials* for the teaching and learning of statistics in the elementary and middle school
- *Manuals and guides* related to the course: study calendar, assignment guides, including how to prepare a portfolio of evidence, software manuals etc.
- *A digital video case library* containing segments of real teaching episodes, obtained in the classrooms of the teachers participating in the pilot delivery of the course, representing the landscape of practice in statistics instruction throughout Europe
- *A database with student work samples* developed through contributions of the participating teachers, providing examples of good practice in European schools
- *Collaboration tools* for professional dialogue and support including email, conferencing, chat rooms, discussion forums, wikis, etc.
- *Archived forum discussions*
- *Reports and articles* developed through the project
- *Links to statistics education resources* available on the Internet
- *Multilingual interfaces* (EN, EL, ES) to partly overcome linguistic barriers.

The course material is also available in CD/DVD format to overcome potential bandwidth limitations, and to ensure maximum accessibility of learning materials.

In order to offer teachers flexibility and to accommodate different time zones, the largest portion of the course is delivered asynchronously. Asynchronous means of communication include discussion forums and mail groups. There is also some synchronous communication through use of technologies such as audio/video streaming, and videoconferencing. One-way informational postings such as articles and videos also serve as objects for supporting interaction.

Teachers work according to a loose schedule. This has been deemed necessary for balancing the amount of freedom available in the course with a sense of structure. Each module involves a range of activities, readings and contributions to discussion, as well as completion of group and/or individual assignments. Online moderated discussions allow teachers to share content, ideas, and instructional strategies. Teachers are provided with a space to discuss and grapple with the complexities of teaching and learning, to foster alternative perspectives, and to apply educational theory to practice (Kayler & Weller, 2007).

The *EarlyStatistics* Strategy for Quality Assurance

There are a number of possible risks that could adversely affect the quality of the *EarlyStatistics* course. This section discusses possible failures in the quality of course content and teaching effectiveness and in learner support, and provides an overview of the quality assurance (QA) processes used in *EarlyStatistics* to avoid such failures and ensure the provision of a high-quality distance education course. It also outlines the evaluation processes employed to assess the project's effectiveness in delivering its stated aims.

Quality of Course Content and Teaching Effectiveness

Teachers participating in *EarlyStatistics* work full-time jobs with fairly limited resources, and are under much pressure to learn a new discipline while simultaneously teaching it. They would be willing to invest time on the course only if it stimulates and engages them, and addresses their specific educational needs and preferences. A number of features have been incorporated into the design of the *EarlyStatistics* course and its related services in order to motivate and meet the needs of a diverse group of teachers having different cultural and professional backgrounds, different aspirations, and different learning styles and approaches:

- Use of a variety of media in order to appeal to individual learner circumstances, needs and preferences (Simpson, 2002).

- A variety of approaches towards content so that participants can "pick and choose" what works best for them.
- Regular assessments for instructors to monitor progress and provide feedback, and for participants to monitor their own progress.
- Careful scheduling of course calendar to accommodate for the main national or religious holidays in different EU countries.
- Careful scheduling of course activities to offer teachers flexibility and to accommodate different time zones.
- Setting of realistic work expectations — ensuring that the workload associated with the course is not overwhelming.

Since the course is being offered mostly online, there were special challenges to be met in order to provide an effective learning environment that will motivate and support this diverse group of learners. A number of pedagogical, but also technical issues have been taken into account to best help learners meet the challenges of distance education. Principles of instructional design guided the development of the course online environment:

- choice of accessible media in terms of reasonable cost and time taken, which add "study value" (Simpson, 2002)
- user-friendly interface and navigation services
- user friendly content addressing workplace educational needs
- multimedia content presentation (audio, video, text, images, etc) to ensure effective knowledge transfer
- effective structuring of educational material
- activities and resources (simulations, animations, video clips, etc.) that stimulate and engage teachers participating in professional development, and address a variety of teaching and learning styles
- a variety of distance collaboration tools (e.g. discussion forums, chat rooms, application sharing etc.) that allow interaction with peers and tutors
- multilingual interfaces to support learners not fluent in English.

A main area of concern for the *EarlyStatistics* course design has been in ensuring the successful building of a European community of teaching practitioners, which is a main objective of the project. We were well aware of the challenges in developing a virtual community of inquiry, and of the fact that the availability of discussion forums does not lead to the establishment of group cohesion (Gordon et al., 2007). A number of strategies have been employed to encourage online dialogue and collaboration, and to ensure that all teachers actively contribute to group discussions:

- Making participation in group and whole class activities a compulsory element of the course, and establishing a clear set of criteria to help

teachers better understand the academic expectations and increase the intellectual depth of their contributions
- Providing sufficient time for teachers to make meaningful interpersonal connections before the assignment of the first cognitive task (Beuchot & Bullen, 2005)
- Asking teachers to self-assess their contributions to online discussions
- In group tasks, assigning each member of the discussion group to serve as moderator and/or scribe at least once during the course

The course is being facilitated by members of the research team with expertise in statistics education. The facilitators' (or tutors') role is to guide discussion, encourage full, thoughtful involvement of all participants, and provide feedback. Facilitators help to deepen the learning experience for course participants by encouraging productive interaction and critical reflection on workplace practices (Gray, 2004).

The nature of the group task in which the learners are engaged is an important motivational factor. Merely forming a discussion group and providing the technology does not automatically lead to the development of a community of practice that supports well-managed, conducive to learning conversations (Doolan et al., 2006). In order to help teachers make connections between their personal and professional experiences, and the course readings and theory, discussions have been structured to explicitly make ties among theory and practice. Both the dialogue and the assignments are based on experiential learning, i.e., they make use of the learners' own experiences as learning resources (Aalto & Jalava, 1995). Reflective questions create situations for the participating teachers to critically examine the subject matter through additional research or carefully reading over their course materials, thus giving them the opportunity to make new learning connections to their personal and professional lives.

Quality of Learner Support

Student support is not a compensatory, but an essential component of the instructional process — one that has the learner as the central focus (Reid, 1995). In ODL, learner support assumes an even more vital role, given the isolation from their peers and tutor often experienced by online learners (Simpson, 2002). In *EarlyStatistics*, learner support is an integral component of the ODL scheme, and is being designed as part of the students' course experience.

At the beginning of the course, there was a face-to face meeting with local teachers for community-building/networking purposes. The meeting set the scene for the course which would be offered through distance. Teachers got the chance to get to meet and interact with one others, share issues and problems, as well as exploit the tutors' presence to ask questions about things they were unsure of

(Simpson, 2002). During this meeting, teachers got familiarized with the course and its objectives, and with the facilities offered by the project e-learning system they would be using during the course. Three more face-to-face meetings have further contributed to community building and learner support.

Monitoring of teacher participation is being done both at the course level, and the learner level. Monitoring at the course level allows the consortium to detect problems that might affect learners as a whole (e.g., a very high drop-out rate, a much lower average learner performance on a specific assignment, etc.). Monitoring the individual progress of learners helps determine whether they need additional help or support. A number of tools are being used to track learner participation and progress, including statistics automatically generated by the course learning platform (e.g., level of frequency and duration of login for every learner, turn-around time for an assignment, number of assignments completed to date against target, etc.).

Role of Evaluation

Evaluation plays a major role in a QA system, since it is the process by which the quality of content, teaching effectiveness and administrative efficiency of an online learning environment are assessed. In *EarlyStatistics*, evaluation is an integral part of the project design — it is a process carried out at every stage of the project, in order to ensure that all key activities are carried out on time and effectively by the consortium partners, and that necessary revisions or improvements to the project's methodologies, products, and outcomes are timely identified. It includes both formative and summative assessment tools and protocols for evaluating the quality of the project products and services.

In evaluating the success of the professional development course, researchers use a hierarchical model proposed by Guskey (2002), according to which professional development evaluation should move from the simple (reactions of participants), to the more complex (student learning outcomes), with data from each level building on the previous. Guskey's model consists of evaluation at five levels: (1) participant reactions; (2) participant learning; (3) organization support and change; (4) participant use of new knowledge and skills; and (5) student learning outcomes. A variety of both qualitative and quantitative data collection techniques are being employed to gather information about each level. The analysis of these data will inform the revision of the course pedagogical frameworks, instructional and curricular materials, as well as the tools and resources of the course information base. After final revisions, and updating of the information base with the latest version of all content, the course will enter the EU Lifelong Learning-Comenius database for European wide recruitment.

Conclusions

The direct relationship between improving the quality of teaching and improving students' learning is a common thread emerging from educational research (Stigler & Hiebert, 1999). Recognizing the central role of teachers in educational reform, the EU-funded project *EarlyStatistics*, aims to enhance the quality of statistics education offered in European schools through developing, pilot testing, and offering a high-quality intercultural online professional development course in statistics education targeting elementary and middle school teachers across Europe.

The project consortium has incorporated into the course design best pedagogical practices in statistics education, adult education, and distance learning. The course is based on current pedagogical methodologies utilizing collaboration, statistical investigation, and exploration with online interactive problem-solving activities. Particular care has been taken to build on participating teachers' knowledge and experiences, and to promote collaborative and participatory learning (Barab & Duffy, 2000). Teachers from different countries have the opportunity to improve their content and pedagogical knowledge of statistics through open-ended investigations, simulations, visualizations, collaboration and reflection on one's own and on others' ideas and experience.

An important consideration of any model of professional development is whether teachers feel the project is useful and supportive of their efforts to improve their teaching practice (Whitaker et al., 2007). Historically, professional development efforts have largely been ineffective in producing reform-based classroom change (Templin & Bombaugh, 2005). As Robinson (1998) points out, staff development often fails to transfer to the learners' 'real-work' situations, because it might be too remote from 'real-work' needs or organizational realities. The consortium has been working hard to avoid this danger by designing a course relevant to teachers' work context. Meeting the individual workplace goals and of a multinational group of teachers characterized by diversity in a number of different parameters (pedagogical and content knowledge of statistics and mathematics, educational level and grade they teach, national mathematics curricula, cultural and professional backgrounds, etc.) is quite challenging but necessary if course participants are to make the difficult leap from professional development to classroom practice (Huberman, 2001).

References

Aalto, P., & Jalava, M. (1995). Implementing experiences from small-scale courses to large education systems. In F. Lockwood (Ed.), *Open and distance learning today* (pp. 255–264). London: Routledge.

Azcárate, P., Serradó, A., & Cardeñoso, J. (2006). *Pilot course structure, content and delivery plan* (Internal document. Project: *226573-CP-1-2005*).

Barab, S. A., & Duffy, T. (2000). From practice fields to communities of practice. In D. Jonassen, & S. M. Land (Eds.), *Theoretical foundations of learning environments* (pp. 25–55). Mahwah, NJ: Lawrence Erlbaum Associates.

Beuchot, A., & Bullen, M. (2005). Interaction and interpersonality in online discussion forums. *Distance Education*, *26*(1), 67–87.

César, M. (2004). Come away with me: Statistics learning through collaborative work. *Proceedings of the Tenth International Congress on Mathematical Education (ICME-10).* Copenhagen, Denmark.

Collis, B., & Moonen, J. (2001). *Flexible learning in a digital world: Experiences and expectation*s. London: Kogan Page.

Doolan, M., Hilliard, A., & Thorton, H. (2006). Collaborative learning: Using technology for fostering those valued practices inherent in constructive environments in traditional education. *Journal for the Enhancement of Learning and Teaching, 3*(2), 7–17.

GAISE. (2005). *Guidelines for assessment and instruction in statistics education (GAISE) report: A curriculum framework for PreK–12 statistics education.* Alexandria, VA: American Statistical Association. Retrieved September 30, 2007, from http://www.amstat.org/education/Gaise.

Ginsberg, M. B. (2003). *Motivation matters: A workbook for school change*. San Francisco: Jossey-Bass.

Gordon, S., Petocz, P., & Reid, A. (2007). Tools, artefacts, resources and pedagogy — Stories of international statistics educators. In *Australian Association for Research in Education 2006 Conference Papers*, compiled by P. L Jeffery, AARE, Adelaide. Retrieved March 25, 2008, from http://www.aare.edu.au/06pap/gor06358.pdf.

Gould, R., & Peck R. (2004). *Preparing secondary mathematics educators to teach statistics.* Paper presented at the International Association for Statistical Education 2004 Roundtable. Lund, Sweden, 28 June–3 July.

Gray, B. (2004). Informal learning in an online community of practice. *Journal of Distance Education, 19*(1), 20–35.

Guskey, T. R. (2002). Does it make a difference? Evaluating professional development. *Educational Leadership, 59*(6), 45–51.

Huberman, M. (2001). Networks that alter teaching: Conceptualisations, exchanges and experiments. In A. Craft, H. Burgess, & J. Soler (Eds.), *Teacher development: Exploring our own practice*. London: Paul Chapman in association with the Open University.

Kayler, M., & Weller, K. (2007). Pedagogy, self-assessment, and online discussion groups. *Educational Technology & Society*, *10*(1), 136–147.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Research Council. (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Reid, J. (1995). Managing learning support. In F. Lockwood (Ed.), *Open and distance learning today* (pp. 265–275). London: Routledge.

Robinson, B. (1998). A strategic perspective on staff development for open and distance learning. In C. Latchem, & F. Lockwood (Ed.), *Staff development in open and flexible learning* (pp. 33–44). London and New York: Routledge.

Simpson, O. (2002). *Supporting students in online, open and distance learning*. London and New York: Taylor and Francis Group.

Stigler, M., & Hiebert, J. (1999). *The teaching gap*. New York: Free Press.

Templin M. A., & Bombaugh, M. (2005). An innovation in the evaluation of teacher professional development serving reform in science. *Journal of Science Teacher Education, 16*, 141–158.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University.

Whitetaker, S., Kinzie, M., Kraft-Sayre, M. E., Mashburn, A., & Pianta, R. C. (2007). Use and evaluation of web-based professional development services across participant levels of support. *Early Childhood Education Journal*, *34*(6), 379–386.