TEACHERS' PROFESSIONAL DEVELOPMENT IN STATISTICS: THE *EARLYSTATISTICS* EUROPEAN PROJECT

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The EU-funded project EarlyStatistics aims to enhance the teaching and learning of early statistical reasoning in European schools by utilizing distance education to offer high-quality professional development experiences to teachers across Europe. The project consortium has developed and is currently pilot testing an online professional development course in statistics education targeting elementary and lower secondary school European teachers. The article provides an overview of the EarlyStatistics course design. It describes the pedagogical and didactical approach underlying EarlyStatistics and the course content and structure. It also outlines the quality assurance processes used in the project to avoid quality failures and the evaluation processes employed to assess the course effectiveness in achieving its objectives.

INTRODUCTION

Distance education is a useful framework for in-service teacher training, but it can represent a large variety of pedagogical perspectives. The most common approach is to provide teacher training and support mainly through a well-designed and predefined course package. The consequence of such an approach is that Open and Distance Learning (ODL) could potentially be very authoritarian, with pre-packaged course material that could present only a particular perspective (Simpson, 2002). The expansion, however, in modes of communication enabled by recent advances in communications and information technologies is revolutionizing distance education and is driving the development of support-led rather than package-led forms of ODL. The fact that interpersonal interaction may now take place through a very wide range of media enables the development of new forms of online professional development settings in accord with socio-constructivist views of learning (Vygotsky, 1978).

This paper provides an overview of EarlyStatistics, a project funded by the European Union under the Socrates-Comenius action, which takes advantage of the new possibilities for communication and professional sharing enabled by internet technologies to adopt a non-conventional approach to online professional development. The project consortium, comprised of five universities in four countries (Cyprus, Spain, Greece, Norway), has developed and is currently pilot testing an online professional development course targeting elementary and middle school mathematics teachers around Europe. The aim is to help teachers improve their pedagogical and content knowledge of statistics through cross-cultural exchange of experiences and ideas and exposure to innovative learning methodologies and resources.

In this paper, we provide an overview of the EarlyStatistics course design. We describe the pedagogical and didactical approach underlying EarlyStatistics and the course content and structure. We also outline the quality assurance processes used in the project to avoid possible quality failures and ensure the provision of a high-quality distance education course.

PEDAGOGICAL AND DIDACTICAL 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 that support more collaborative and participatory models of education underpin the course design.

Recognizing that teachers will 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.

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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. A community of practice consists of a group of individuals with a shared domain of expertise, who engage in a process of collective learning about practices that matter to them (Gray, 2004). The EarlyStatistics course promotes intercultural awareness and exchange of experiences and ideas among European teachers, offering an environment in which participants collectively generate knowledge for their professional lives (Gordon, Petocz & Reid, 2007). 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 community that supports best practice and innovation in statistics instruction. This online community of practice, which supports the sharing of multiple, multinational perspectives, shapes both teachers' identity as practitioners and the identity of the practice itself (Gray, 2004).

EarlyStatistics participants are provided with ample opportunities for interactive and collaborative learning through use of a wide array of tools, artefacts and resources (Gordon, Petocz & Reid, 2007). Teachers 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. We hope that this inquiry-based, learner-centred approach, will serve as a model for the participating teachers as to the kind of learning situations, technologies and curricula they should employ in their own classrooms.

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 (Azcárate 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" (Franklin et al., 2007), has been used to structure the content presentation. This framework uses a spiral approach so that instructional programs from pre-kindergarten through to 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 provided materials (Module 4; Weeks 8-9) and apply them in their own classrooms with the support of the design team (Module 5; Weeks 10-11). They write up their experiences, including a critical analysis of their own and their pupils' work. 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 also provide video-taped teaching episodes and samples of their students' work for group reflection and evaluation (Module 6; Weeks 12-13).

MODE OF DELIVERY

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 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 curricular and instructional materials for the teaching and learning of statistics in the elementary and middle school;
- Manuals and guides related to the course: including study calendar, assignment guides, including how to prepare a portfolio of evidence, software manuals;
- 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 the 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;
- Archived forum discussions;
- Reports and articles developed through the project;
- Links to statistics education resources available on the Internet; and
- 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 the 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

The EarlyStatistics consortium constitutes a multinational group of experienced statisticians, mathematicians, mathematics and statistics educators, distance education instructors, authors of technology supported courses, and technicians. Undoubtedly, this synergy of collaboration among partners with complementing expertise and specialization contributes to improved quality in each area of the course production and delivery process (Rowntree, 2005). Moreover, the cross-fertilization of cultures leads to higher quality outputs compared with a purely national approach. Nonetheless, there are still a number of possible risks that could adversely affect the quality of the EarlyStatistics course. This section provides an overview of the Quality Assurance (QA) processes used in EarlyStatistics to avoid possible failures in the quality of instructional effectiveness and learner support. It also outlines the evaluation processes employed to assess the course effectiveness.

Quality of Instructional Effectiveness

Teachers participating in EarlyStatistics have 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 objectives and preferences. A number of features have been incorporated into the course design to motivate and meet the needs of a diverse group of teachers characterized by diversity in a number of different parameters (including pedagogical and content knowledge of statistics, educational level and grade they teach, national mathematics curricula, cultural and professional backgrounds, learning styles and approaches):

- A combination of different media options in order to appeal to individual learner circumstances, needs and preferences (Simpson, 2002; Gordon, Petocz & Reid, 2007);
- 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; and
- 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 are special challenges to be met in order to provide an effective learning environment that motivates and supports 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 have 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 (incorporating audio, video, text, images) to ensure effective knowledge transfer;
- Effective structuring of educational material;
- Activities and resources (e.g., simulations, video clips) that stimulate and engage teachers 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; and
- 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, of the fact that merely forming a discussion group and providing the technology does not automatically lead to the establishment of relations and group cohesion (Gordon, Petocz & Reid, 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; and
- In group tasks, assigning each member of the discussion group to serve as moderator and/or scribe at least once during the course.

Members of the research team with expertise in statistics education facilitate the course. The facilitators' (or tutors') role is to guide discussions, 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).

Quality of Learner Support

In ODL, learner support assumes an even more vital role than in face-to-face settings, given the isolation from peers, their tutor, and the institution 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.

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). 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).

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 implemented at every stage 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, we 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, an updating of the information base with the latest version of all content, the course will enter the European Union Lifelong Learning-Comenius database for European wide recruitment.

CONCLUDING REMARKS

Data literacy has become a fundamental skill for living in an information era, where important decisions are made based on available data. In order for students to develop a data-oriented mindset and robust data literacy skills, there ought to be significant changes to the instructional methods and tools typically employed in the classroom to teach statistical concepts. Recognizing teachers' ongoing professional development and learning as a linchpin of instructional innovation and success for their students (Ginsberg, 2003), EarlyStatistics exploits the affordances offered by technology to provide European teachers with access to a wide array of colleagues, discussions, and resources eluding them in their workplace (Zern, 2002). The

program facilitates intercultural professional development of teachers using contemporary web-based educational tools and resources. Teachers from different countries have the opportunity to develop their content and pedagogical knowledge of statistics through open-ended investigations, use of real-data, simulations, visualizations, collaboration and reflection on one's own and on others' ideas and experiences.

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 (Whitetaker et al., 2007). Historically, professional development efforts have largely been ineffective in producing reform-based classroom change. They often fail to transfer to the learners' 'real-work' situations because they might be too remote from their 'real-work' needs or organizational realities (Robinson, 1998). The EarlyStatistics consortium has been working hard to avoid this danger by designing a course relevant to teachers' work context. Meeting the individual workplace goals of a multinational group of teachers with diverse cultural and professional backgrounds and working environments is very challenging but necessary if course participants are to make the difficult leap from professional development to classroom practice.

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