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ARTICLE

Distance Training of Mathematics Teachers: The *Early Statistics* Experience

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Abstract

The affordances offered by modern Internet technologies provide new opportunities for the pre-service and in-service training of mathematics teachers, making it possible to overcome the restrictions of shrinking resources and geographical locations, and to offer, in a cost-effective and non-disruptive way, high-quality learning experiences to geographically dispersed teachers. This article focuses on how information and communication tools made available online could be exploited effectively to help improve the quality and efficiency of teacher training in statistics education. First,

it describes the main pedagogical issues and challenges underlying distance education in general, and online teacher training in particular. Then, it provides an overview of *EarlyStatistics*, an online professional development course in statistics education targeting European elementary and middle school teachers, and the main lessons learned from the pilot delivery of it. The article concludes with some instructional implications.

Keywords

statistics education, e-learning, blended learning, teacher training

Formación a distancia para profesores de matemáticas: la experiencia de EarlyStatistics

Resumen

Las potencialidades que ofrecen las modernas tecnologías de internet brindan nuevas oportunidades a la formación inicial y permanente del profesorado de matemáticas, que permiten superar las limitaciones impuestas por recursos cada vez más escasos y por la ubicación geográfica, y que para este colectivo geográficamente disperso significan el acceso a un aprendizaje de calidad, económico y compatible con el resto de actividades. Este artículo se centra en cómo aprovechar eficazmente las herramientas de comunicación e información disponibles en línea para mejorar la calidad y la eficiencia de la formación del profesorado en la educación de estadística. En primer lugar, describimos los principales problemas y retos pedagógicos de la educación a distancia en general, y de la formación de profesorado en línea en particular. A continuación, ofrecemos una visión general de EarlyStatistics, un curso virtual de desarrollo profesional para la educación estadística dirigido al profesorado de educación primaria y primeros cursos de secundaria (de 6 a 14 años), y las principales conclusiones derivadas de la edición piloto del curso. Concluyen el artículo algunas sugerencias educativas.

Palabras clave

enseñanza de estadística, aprendizaje virtual, aprendizaje mixto, formación del profesorado

1. Introduction

In recent years, it has been recognized that for mathematics teacher training to become more effective in producing real changes to classroom practices, it ought to promote continuous, professional development opportunities that are cumulative and sustained over the career of a teacher (Joubert, 2009). The financial and logistic difficulties of engaging teachers in face-to-face training, as well as the need for professional development that can fit with teachers' busy schedules and can draw on powerful resources often not available locally, have encouraged the creation of online professional development programs for teachers (Dede, 2006).

This article analyses the possibilities of information and communication tools made available by modern Internet technologies to improve the quality of initial and in-service teacher training in statistics education. First, it discusses the main pedagogical issues and challenges underlying distance education in general, and online teacher training in particular. Then, it provides an overview of *EarlyStatistics*,

a European Union-funded program that has utilized distance education to offer teacher training in statistics education. The article concludes with some implications for distance teacher training.

2. Distance education: main pedagogical perspectives and challenges

Educational institutions at all levels, including leading research universities, are becoming increasingly involved in distance education initiatives. Online course delivery has become common in a wide variety of disciplines, including mathematics and statistics, and this expansion is likely to continue, owing to ever-greater access to the Internet and emphasis on lifelong learning.

Several advantages associated with distance education have been identified in the literature. Distance education offers flexibility and convenience, allowing learners to determine their own place, pace, time and content of study. Further, the distance option may give students the opportunity to take courses from prominent experts in their field of study (Evans, 2007). Moreover, from the viewpoint of statistics education, network-based training creates some unique opportunities for enhancing statistics instruction. The Internet offers a vast array of tools and resources that can be used for a better understanding of statistical concepts. Interactive Java-applets and virtual statistical laboratory experiments, for example, allow for the visualization of statistical ideas and hands-on simulations with a high pedagogical potential (Vermeire, 2002). Several statistics instructors mention using technological tools and resources in their online courses (e.g., Everson, 2008).

In spite of the undisputed benefits and proliferation in recent years of online programs, concerns remain about their quality, as research suggests that the effectiveness of distance education is variable and inconsistent (Evans, 2007). While most studies indicate that students taking courses with an online component have similar achievement and satisfaction levels compared to students in traditional, face-to-face classrooms (Dutton, 2005), there is growing evidence of many web-based distance-learning courses failing to meet the expectations raised.

Early attempts at Internet-based instruction assumed that setting up an attractive website with interesting online and multimedia applications was sufficient for learning to take place. It is now recognized that the level of success of a distance-learning course is determined by multiple factors. Elements in the design of a web-based course such as the content and structure of the course, the presentation of the online materials and the amount of interaction between instructors and learners – as well as among learners themselves – are important factors affecting students' learning and attitudes (Tudor, 2006). Another important criterion of the level of success of web-based statistical training is the extent to which instruction allows learners to experience the practice of statistics and to apply statistical tools in order to tackle real-life problems (Vermeire, 2002).

In addition to the general issues and considerations regarding distance education in statistics, the distance training of statistics teachers poses special challenges. For example, one of the main challenges for developers of online teacher training programs is how best to take advantage of the variety social networking tools and technologies now available in order to foster the creation of online

communities of teaching practitioners as vehicles for teacher learning and development. Research studies in this area indicate that online communities of practice are indeed a promising model for both pre-service and in-service mathematics teacher training (e.g., Cady, 2009). They have enormous potential to support the professional development of teachers by placing educators at the center of their learning, thus promoting their independence and self-directed learning. Online communities of practice facilitate not only communication, but also the collaborative finding, shaping and sharing of knowledge. At the same time, existing research highlights several difficulties in building and maintaining online communities involving shared professional learning.

Despite the early enthusiasm and encouragement of participants, many online communities of practice fail to thrive (Riverin, 2007). For example, after examining 28 studies, Zhao (2001) reported that there was little conclusive evidence to demonstrate the effective use of reflective online communities of practice. Other studies (e.g., McGraw, 2007) raise several issues that consistently create challenges for community building among participating teachers and for sustainability, including barriers to access, usability, sociability, lack of time to spend in online discussions, and language. In statistics education, while it is well-documented in the literature that incorporating discussion and active learning into the statistics classroom can help students learn to think and reason about statistical concepts, it has proved challenging to bring these important learning approaches to an online course (Everson, 2008).

Gould (2005), in their first offering of INSPIRE, a distance education professional development course targeting new secondary school statistics teachers in the U.S., which had community building as one of its main objectives, experienced disappointment, with a much lower than anticipated level of student-student interaction. A more successful example of a program adopting a community-building approach to the distance training of statistics teachers is *Becoming a Teacher of Statistics*, an online graduate-level course offered by the University of Minnesota that prepares teachers of introductory statistics at college and high school levels (Garfield, 2009). While originally delivered in a face-to-face setting, the course was subsequently converted into an online course to make it accessible to a wider variety of pre-service and in-service teachers. The first online version of the course was offered in spring 2008, with very encouraging outcomes. Evaluation of the course indicated that it was equally successful, and it provided students with parallel experiences to those in the face-to-face class.

3. Experiences of distance teacher training in Europe

In modern, information-based society, statistical concepts are occupying an increasingly important role in mathematics curricula across Europe. The subject, however, has been introduced into mainstream mathematics curricula without adequate attention being paid to teachers' professional development. There is substantial evidence of poor understanding and insufficient preparation to teach statistical concepts among many pre-service and practicing teachers (e.g., Espinel, 2008).

In this section, we provide a brief description of the main experiences gained from implementing the European Union-funded program *EarlyStatistics: Enhancing the Teaching and Learning of Early Statistical Reasoning in European Schools* (226573-CP-1-2005-1-CY-COMENIUS-C21). *EarlyStatistics*

has exploited the affordances offered by Open and Distance Learning (ODL) technologies to improve the quality of statistics instruction offered in European schools. The project consortium, comprising five higher education institutions in four countries (Cyprus, Greece, Norway and Spain) developed, pilot tested and is currently offering an online professional development course targeting elementary and middle school mathematics teachers across Europe. The course, which is the first of its kind in Europe, aims to help 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.

Before being offered to the European educational community, the *EarlyStatistics* course and its accompanying resources were pilot tested locally in three of the partner countries (Cyprus, Greece and Spain). Fourteen teachers participated in the pilot delivery. In order to evaluate the applicability and success of the course, there was also follow-up classroom experimentation. Participating teachers developed and delivered teaching episodes integrating the use of the course tools and resources provided to them. The course was revised based on feedback received from the pilot delivery, and then entered into the European Union Lifelong Learning Training Database for European-wide recruitment. It is offered to the European educational community as a Comenius in-service training course targeting elementary and middle school mathematics teachers. The course has already been offered twice. The consortium intends to continue offering the course in subsequent years, thus facilitating access to larger numbers of mathematics teachers involved in statistics education.

Presented below are an overview of the *EarlyStatistics* course design and a synopsis of the main findings from the pilot delivery of the course.

Design of the *EarlyStatistics* course

EarlyStatistics course content and structure

The *EarlyStatistics* course design focuses on participatory and collaborative learning. Teachers enhance their knowledge about statistics and its pedagogy through hands-on and computer-based practice, experimentation, intensive use of simulations and visualizations, feedback from one another and reflection. Then, being actual practitioners, they apply what they learn to a real classroom setting.

The *EarlyStatistics* course lasts for 13 weeks and is made up of six Modules. In Modules 1-3 (Weeks 1-6), the focus is on enriching the participants' statistical content and pedagogical knowledge by exposing them to similar kinds of learning situations, technologies and curricula to those they should employ in their own classrooms. The conceptual "Framework for Teaching Statistics within the K-12 Mathematics Curriculum" (Franklin, 2007), has been used to structure the presentation of content. Statistics is presented as an investigative process that involves 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. In order to help teachers go beyond procedural memorization and acquire a well-organized body of knowledge, the course emphasizes

and revisits a set of core statistical ideas. Through their participation in authentic educational activities such as projects, experiments, computer explorations with real and simulated data, group work and discussions, participating teachers learn where and how the “big ideas” of statistics apply, and develop a variety of methodologies and resources for their effective instruction.

In Modules 4-6 (Weeks 7-13), the focus shifts to classroom implementation issues. Teachers customize and expand upon provided materials, and apply them in their own classrooms with the support of the design team. Once the teaching experiment is completed, they report on their experiences to the other teachers in their group, and also provide video-recorded teaching episodes and samples of their students’ work for group reflection and evaluation.

Each module involves a range of activities, readings and contributions to discussion, as well as the completion of group and/or individual assignments. Both the dialogue and the assignments are structured so as to explicitly establish links between theory and practice. Reflective questions create situations for the participating teachers to critically examine the subject matter and to make new connections between theory and their personal and professional experiences. The Marijuana Survey task presented in Figure 1, taken from Watson (2010), is indicative of the activities in which teachers engage during the course.

Look carefully at this task:

Decriminalise drug use: poll

SOME 96 percent of callers to youth radio station Triple J have said marijuana use should be decriminalised in Australia. The phone-in listener poll, which closed yesterday, showed 9924 - out of the 10,000-plus callers - favoured decriminalisation, the station said. Only 389 believed possession of the drug should remain a criminal offence. Many callers stressed they did not smoke marijuana but still believed in decriminalising its use, a Triple J statement said.

Is the sample reported here a reliable way of finding out public support for the decriminalisation of marijuana? Why or why not?

1. What are the big statistical ideas in this problem?
2. Please can you give an example of an appropriate response and an inappropriate response that your students might give?
3. What opportunities would this problem provide for your teaching?
4. A student gave this answer: "Yes, because 10000 people is enough to get an accurate average of the view of the public". How would you move this student's understanding forward?
5. A student gave this answer: "No, because it is not everyone in Australia voting". How would you move this student's understanding forward?
6. A student gave this answer: "No, because some people could be lying". How would you move this student's understanding forward?

Figure 1: The Marijuana Survey task (Watson, 2010)

The course activities encourage critical reflection on workplace practice and productive interaction among course participants. Members of the *EarlyStatistics* consortium with expertise in statistics education act as facilitators of a deeper learning experience by guiding discussions, encouraging the full, thoughtful involvement of all participants and providing feedback.

Media and technology choices

The *EarlyStatistics* pilot course is delivered using a blended-learning method. At the beginning of the course, there is a face-to-face meeting with all participants. Teachers from all over Europe gather together to attend a one-week-long intensive seminar (they can finance their expenses by applying for an in-service training grant). They are first introduced to the objectives and pedagogical framework underpinning the course. They then become familiarized with the facilities offered by the e-learning environment and, more importantly, they get the chance to meet and interact with one another.

The remainder of the course is delivered online, through text, illustrations, animations, audio/video and technology-rich interactive problem-solving activities. The instructional content and services of the project's dedicated information base are used for teaching, support and coordination purposes. In addition to the course content, the site (<http://www.earlystatistics.net/>) offers access to various other links and resources:

- *Technologically enhanced instructional materials* for statistics teaching and learning.
- *A digital Video Case Library* containing segments of real teaching episodes, obtained from the classrooms of the teachers participating in the pilot delivery.
- *A database of Student Work Samples* developed through contributions made by the participating teachers.
- *Collaboration tools* for professional dialogue and support, including email, conferencing, chat rooms, discussion forums, wikis, etc.
- *Archived forum discussions*.
- *Reports and articles* arising from the project.
- *Links to statistics education resources* available on the Internet.
- *Multilingual interfaces* (English, Greek and Spanish) to partly overcome language barriers.

In order to offer teachers flexibility and to accommodate different time zones, the largest portion of the course is delivered asynchronously. There is also some synchronous communication through the use of technologies such as audio/video streaming and videoconferencing.

Central to the course design is the functional integration of technology and core curricular ideas, and specifically the integration of statistics educational software (the dynamic software Tinkerplots[®] and Fathom[®]) and a variety of online activities and resources (e.g., simulations, animations, video clips, etc.). The aim of the latter is to stimulate and engage teachers while providing them with the opportunity to model and investigate real-world statistics-related problems.

Evaluation of *EarlyStatistics*

In *EarlyStatistics*, evaluation was an integral part of the project design. It was a process carried out at every stage of project development in order to ensure that all key activities were performed on time and effectively, and that any necessary revisions or improvements to the project's methodologies, products and outcomes were identified in a timely manner. It included both formative and summative assessment tools, protocols and services, and was conducted both internally and externally. The main external evaluation took place during the pilot delivery of the course and the follow-up classroom experimentation. Multiple forms of assessment were used to collect and document evidence of changes in teachers' pedagogical and content knowledge of statistics, in their attitudes towards the subject and in their teaching practices as a result of participating in the course: pre- and post-questionnaires, video-recording of classroom episodes, teacher and student interviews, samples of student work and use of statistics automatically generated by the online information base.

The overall feedback from the target user groups from all partner countries participating in the pilot delivery of the *EarlyStatistics* course, as well as from external experts in statistics education regarding the course content, services and didactical approaches was generally very positive. Key conclusions drawn from the analysis of user feedback were that *EarlyStatistics* was quite successful at helping teachers improve their pedagogical and content knowledge of statistics by offering interactive, technology-rich instructional materials and services that enhance the teaching and learning process, and also by providing course participants with the opportunity to collaborate with other teachers and thus initiate the construction of a community of practice. Moreover, data obtained from the teaching experimentations in the course participants' classrooms suggest positive gains in student learning outcomes and attitudes towards statistics (for more details see Chadjipadelis, 2008).

In the survey administered on completion of the pilot delivery of the course and the follow-up interviews, teachers were asked to indicate "what they liked the most about the *EarlyStatistics* course". The flexibility and convenience associated with distance education was an aspect of the course appreciated by all 14 course participants. They all considered the distance training nature of *EarlyStatistics* to be an advantage of the course, since it made it possible for them to determine their own place, pace and time of study: "It is a form of training that does not place stifling limits and restrictions of freedom on the teacher"; "You decide your own workload"; "You can follow your own pace of work". Further, a few teachers noted that the distance option gave them the opportunity to attend a course in statistics education offered by experts in the field originating from different European countries.

The promotion of communication and collaboration among teachers was an aspect of the *EarlyStatistics* course that was also considered by all of the course participants to be an important strength of the program. Teachers enjoyed the interaction and the sharing of experiences and ideas with the other teachers: "I liked the interaction with the other teachers. It is useful to share your ideas and problems with other teachers from different educational levels". In particular, teachers praised the fact that *EarlyStatistics* had allowed them, through computer-mediated communication, to share content, ideas and instructional strategies with teachers from different countries and educational

systems: "It is good to 'hear' colleagues from other countries that face similar problems like you and sometimes, because of a different view on a point, suggest ideas you didn't think of".

Another aspect of the *EarlyStatistics* course that was also much appreciated by teachers is the fact that the course dialogue and assignments were carefully designed to be learner-centered, and to make explicit links between theory and practice by utilizing participating teachers' own experiences as learning resources. Several of the course participants pointed out that *EarlyStatistics* offered them professional development that addressed their workplace educational needs because it was deeply contextualized in their professional activity: "It is a form of training that respects teachers' professional experience and contributes to the improvement of their educational work through the enrichment of experiences and the exchange of opinions with other teachers that work in different cultural and educational environments."

The *EarlyStatistics* project won, ex-aequo with *Maths4Stats* (a joint project coordinated by Statistics South Africa), the 2009 Best Cooperative Project Award in Statistical Literacy. This prestigious award is given every two years by the International Association of Statistics Education (IASE) "in recognition of outstanding, innovative and influential statistical literacy projects that affect a broad segment of the general public".

Despite the overall success of the pilot course, a number of shortcomings have also been identified. The biggest difficulty experienced by the consortium was in achieving the successful building of an online community of teaching practitioners, which was one of the main objectives of *EarlyStatistics*. From the outset of the project, we were well aware of the challenges in developing such a community, 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, 2007). The experience gained from pilot testing the course further alerted us to the fact that community building, particularly in a cross-national context, is very difficult. Despite the fact that we employed several strategies to promote teacher dialogue and collaboration, we experienced similar disappointment to that of Gould (2005), with a lower than expected level of online interaction among participating teachers (Meletiou-Mavrotheris, 2011).

While at the beginning of the course there was considerable enthusiasm and very high participation in the discussion forums, interaction dropped off over time. A total of 229 messages were sent to *EarlyStatistics* over the 13 weeks that the course lasted (76 messages/month on average). However, the vast majority of the messages (167 messages, 73% of all messages sent) were sent in the first six weeks of the course. In contrast to the vibrant interaction and rich dialog characterizing the earlier part of the course, towards the end of the course it was often the case that only 3-4 teachers would actively participate in the discussion forums, while the rest would make minimal or no contributions.

The analysis of the data obtained from the pilot delivery of the *EarlyStatistics* course and follow-up classroom experimentation has provided the consortium with invaluable insights regarding the course's effectiveness in delivering its stated aims. In particular, findings from the pilot delivery have allowed us to identify a number of factors that adversely affected the online participation of course participants (Meletiou-Mavrotheris, 2011). These factors informed the revision of the course to better support community building among participating teachers.

A main factor contributing to our limited success in building an online community of practice during the pilot delivery was the fact that there was no face-to-face meeting with all course participants. There were a few face-to-face meetings with local teachers, but not with the group as a whole. Course participants got the chance to virtually meet teachers from other countries through videoconferencing, but this cannot be considered as effective as face-to-face interaction. As a result, while teachers built strong local groups, their interaction with participants from other countries was limited. In current offerings of the course, teachers are recruited from across Europe, and at the start of the course there is a face-to-face meeting with all participants. This initial in-person meeting reinforces the online engagement of teachers by helping to mitigate the problem of trust and social presence online.

4. Conclusion

In a world where the ability to analyze, interpret and communicate information from data are skills needed for daily life and effective citizenship, developing a statistically literate society has become a key factor in achieving the objective of an educated citizenry. Recognizing teachers' ongoing professional development and learning as a linchpin of instructional innovation and success for their students (Ginsberg, 2003), *EarlyStatistics* has exploited the affordances offered by open- and distance-learning technologies to help improve the quality of statistics instruction in European schools. 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. 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 their own and on others' ideas and experience.

The *EarlyStatistics* project outputs and services are useful not only to teachers, but also to academic experts in statistics education, to teacher training institutions and to designers of online professional development programs across Europe and internationally. Academic experts and material developers can become more sensitized to the needs of statistics teachers in different countries, supporting the development of new professional development methodologies and materials grounded on a community-building model. Teacher training institutions can gain a clearer understanding of the issues facing statistics teaching and learning, and can use the project outputs for further improvement of their teacher training programs.

A particularly important issue in the online professional development of teachers is ensuring the successful building of an online community of practice. The first experiences with *EarlyStatistics* concur with the research literature, indicating that the successful building of an online community of practice is very challenging. As Gould and Peck (2005) have pointed out, leading a discussion of substance on

a discussion board is more challenging than in a real classroom. For Kling (2003), the transformation of a group into a community is “a major accomplishment requiring special processes and practices” (p. 221). An online community of practice will not automatically take shape through the availability of an online space. Rather, it requires carefully crafted designs – both technical and social (Rourke, 2007).

Teaching online courses is a new, unexplored territory for most statistics instructors. Online instruction is similar yet different from face-to-face learning, and requires new teaching skills and strategies. Online instructors’ new role as course facilitators turns them into both guides and learners (Heuer, 2004). In order to facilitate student success and to foster online participation, they must be trained in this new mode of instruction while developing the art of becoming online guides. Online courses should also be subject to continuous evaluation and enhancement. Garfield (2009), whose distance teacher training course has been quite successful in achieving learner participation and collaboration, explain that their online courses are subject to an ongoing cycle of evaluation and improvement. Each time an online course is taught, changes are made to the way in which discussion assignments are structured and used, based on feedback received from students and on careful examination of the patterns of interaction occurring within different discussion groups. *EarlyStatistics* has also adopted an iterative model of continuous improvement. Evaluation continues to play a pivotal role in each subsequent offering of the course. This allows us to continuously improve the quality and effectiveness of *EarlyStatistics*, which is the first online professional development course in the area of statistics education at the European level.

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