

A FRAMEWORK FOR THE EFFECTIVE DELIVERY OF ONLINE PROFESSIONAL DEVELOPMENT IN STATISTICS EDUCATION

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ABSTRACT

This article presents the pedagogical framework underlying the design of *EarlyStatistics*, a European Union funded program that aims to enhance the quality of statistics education offered in European elementary and middle schools by facilitating intercultural professional development of teachers using exemplary web-based educational tools and resources. The program adopts best practices in statistics education, adult education, and distance learning. Its development is guided by the Effective Learning Environment Framework (NRC, 2000), a research-based theoretical framework that identifies the components which are essential for the establishment of an effective learning environment. The distance learning environment is carefully designed to respect the tenets of the Effective Learning Environment framework: learner centeredness, community centeredness, knowledge centeredness, and assessment centeredness.

KEYWORDS

Community of Practice, Professional Development, Statistics, Distance Education, Pedagogical Framework

INTRODUCTION

New values and competencies are necessary for survival and prosperity in our modern, knowledge-based society. The expanding use of data for prediction and decision-making in almost all domains of life makes it a priority for mathematics instruction to help all students develop their statistical reasoning. 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), statistical concepts are occupying an increasingly important role in mathematics curricula worldwide. Statistics has already been established as a vital part of the K-12 mathematics curriculum in many countries.

Despite the larger place for statistics in school curricula, the subject has been introduced without adequate attention paid to teachers' professional development. There is substantial evidence of poor understanding and insufficient preparation to teach statistical concepts among both pre-service and practicing teachers (Carnel, 1997; Begg & Edward, 1999). As Lajoie and Romberg (1998) point out, statistics may be as new a topic for teachers as for children. Many of the senior teachers have never formally studied the subject. Younger teachers may have taken an introductory statistics course at college, such a course however does not typically adequately prepare future teachers to teach statistics. College-level statistics courses are often lecture-based, and do not allow future teachers to experience the model of data-driven, activity-based, and discovery-oriented statistics they will eventually be expected to adopt in their teaching practices. As a result, the majority of teachers have weak knowledge of statistical concepts and tend to focus their instruction on the procedural aspects of statistics, and not on conceptual understanding (Nicholson & Darnton, 2003; Watson, 2001). Intuition and mindset about data and variation are systematically ignored in the mathematics classroom (Makar & Confrey, 2003).

A common thread emerging from educational research is the direct relationship between improving the

quality of teaching and improving students' learning in mathematics (Stigler and Hiebert 1999). For it is what a teacher knows and can do that influences how she or he organizes and conducts lessons, and it is the nature of these lessons that ultimately determines what students learn and how they learn it. As teachers play an important role in innovation (Frykholm, 1999) it is critical for them to have rich teaching and learning experiences in order to adapt faster to change (Thompson, 1992).

Technology advances, and especially web-based training, provide new opportunities for teacher professional development in statistics education. Internet technologies make it possible to overcome 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. The web offers the potential for teachers in different countries to collaborate in social constructivist learning environments. Collaborative and participatory communities of teachers have been shown to act as vehicles promoting teacher learning and development (Tinker & Haavind' Concord Consortium 1997).

EarlyStatistics, a project funded by European Union under the Socrates-Comenius action, was designed in response to the high level of interest in statistics and the need for further improving the quality of statistics education offered in European schools. Acknowledging the central role of teachers in educational reform, the project aims to provide high quality online professional development in statistics education to elementary and middle school mathematics teachers around Europe. It harnesses the power of the Internet to provide European teachers with access to a wide array of colleagues, discussions, and resources eluding them in their workplaces (Zern, 2002).

EarlyStatistics adopts best practices in statistics education, adult education, and distance learning. The design of the program is guided by the *Effective Learning Environment Framework*, a research-based theoretical framework that identifies the essential components for establishing an effective learning environment. In the article, we first summarize the components of this framework, and then describe the ways in which we apply the framework to ensure the development of an effective online professional development environment that will support teachers' learning of statistics and its pedagogy.

EFFECTIVE LEARNING ENVIRONMENT FRAMEWORK

The process of improving learning through technology integration is never solely a technical matter, concerned solely with properties of hardware and software (Shamatha et al., 2004). Research on cognition and learning has recently been synthesized to focus on four components that are fundamental for the establishment of an effective learning environment (National Research Council [NRC], 2000):

- *Learner-Centered*: It is now generally accepted that any new information presented to learners is always filtered through their identities, experiences, and perspectives. For learning to be effective, instruction should carefully consider the prior knowledge, beliefs, and cultural practices learners bring into instruction. It should respect and understand learners' prior experiences and knowledge, assuming that these can serve as a foundation on which to build bridges to new understandings. The role of instruction is to act as a bridge between the subject matter and the student (NRC, 2000)
- *Knowledge-Centered*: Effective learning environments have a clear content focus. They aim at building bridges between the prior knowledge and beliefs students bring to the learning situation, and the learning outcomes that instruction aims to achieve. They assist students to go beyond procedural and rote memorization (NRC, 2000), and to acquire a well-organized body of knowledge. Instruction focuses on the "big ideas" of the discipline, rather than on teaching different skills and procedures. Students learn these "big ideas" and where they apply and how, and have opportunities to practice using them in novel situations (Shamatha et al., 2004). This is necessary for learners to make connections among ideas and to build deep conceptual understandings that will enable them to effectively use in society what they learn in the classroom.
- *Assessment-Centered*: The learning environment should provide many opportunities to the learner



Figure 1. Components of Effective Learning Environment Framework (Samantha et al., 2004)

for feedback and revision. Moreover, what is assessed should be congruent with the learning objectives. Helping students to become metacognitive is one of the central tenets of the assessment-centered aspect of effective learning environments. Students should learn to articulate their thoughts and to compare and contrast them to those of other people, and also to provide justifications as why they accept one point of view rather than another. Self-assessment nurtures discovery, teamwork, communication, and conceptual connections (NRC, 2000).

- *Community-Centered*: Research indicates that communication is motivational and helps students to persist in completing tasks and striving for understanding (National Council of Teachers of Mathematics [NCTM], 2000). Community-centered environments encourage and expect learners to exchange ideas with other learners, to provide feedback to each other. They offer a comfortable atmosphere in which students are encouraged and able to articulate their own ideas, challenge those of others, and negotiate deeper meanings (NRC, 2000). When ideas are exchanged and subjected to thoughtful critiques, they are often refined and improved (Shamatha et al., 2004).

These components are essential for the establishment of an effective environment, whether for student or teacher learning. Thus, they form a theoretical framework on which to base an understanding of the necessary characteristics of an effective learning environment (Shamatha et al., 2004).

As Figure 1 indicates, the four components of the *Effective Learning Environment Framework* overlap and mutually inform one another. While learner, knowledge, and assessment are embedded within community, these aspects play a large role in forming the community. Thus, for instruction to be effective there ought to be an alignment among the four perspectives of the Framework.

IMPLEMENTING THE EFFECTIVE LEARNING ENVIRONMENT FRAMEWORK: THE EARLYSTATISTICS PROJECT

Project Description

The overall aim of *EarlyStatistics* (October 2005-September 2008), is to enhance the quality of statistics education offered in European elementary and middle schools by facilitating intercultural professional development of teachers using exemplary web-based educational tools and resources. More specifically, the project consortium comprised of five partner institutions in four European countries (Cyprus, Greece, Norway, Spain), aims to provide professional development experiences for elementary and middle school teachers that will enable them to:

- Learn and/or better understand the main ideas and methods of statistics
- Understand statistics as a comprehensive approach to data analysis
- Develop pedagogical knowledge of statistics (e.g. understand the development of statistical reasoning in children, identify common student misconceptions, etc.)
- Become familiar with a variety of methodologies, tools, and resources for teaching statistics
- Use real data, active learning, and technology to teach statistics
- Develop a long-lasting transnational community of teaching practitioners, who advise and support each other about statistical concepts and pedagogy (Gould and Peck, 2004)

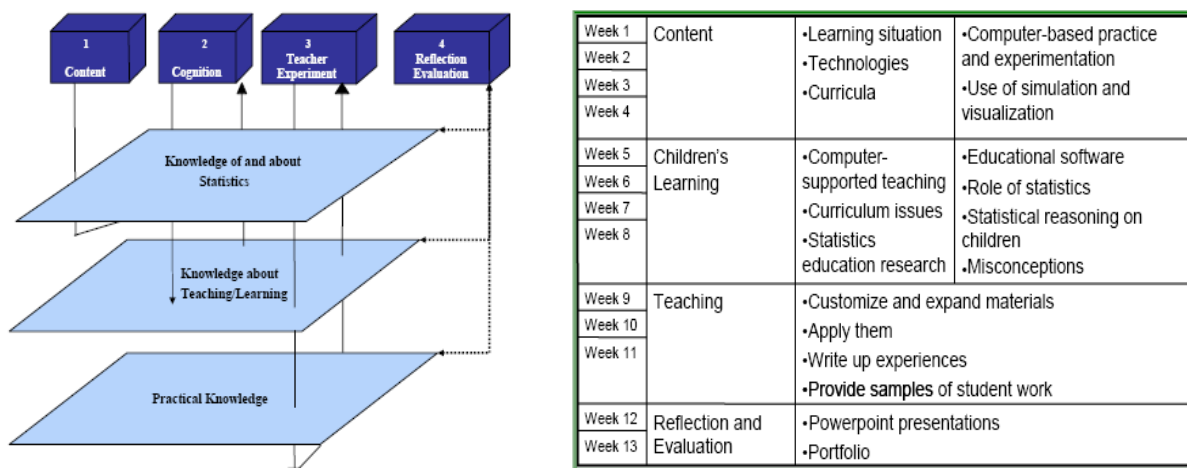


Figure 2. *EarlyStatistics* Professional Development Course Structure (left), and Agenda (right)

In order to achieve the project objectives, the *EarlyStatistics* consortium will undertake the following activities during the project lifetime:

- *Develop and pilot test an intercultural online professional development course in statistics education* targeting elementary and middle school teachers.
- *Conduct a teaching intervention* into the classrooms of the teachers attending the pilot professional development course. The materials and resources developed through the project will be evaluated and revised through real-classroom implementation.
- *Develop a multilingual information base* to support and promote the program's activities and objectives by offering open access to the professional development course content and pedagogical approach, and to various other links and resources.
- *Initialize networking among teachers across Europe* by building an online community for the exchange of ideas, content, tools, and instructional practices relating to statistics education. The long-term objective is to sustain and, if possible, expand this community into a pan-European network of communication.

The project team has/will spend the first two years of the project in designing and developing, 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 is being produced in the partners' national languages, as well as in English.

In parallel to the development of the course content, the team has also been working on the technical design and implementation of the infrastructure and services for the dedicated information base. In addition to a hypertextbook with the course training material, the information base will contain other tools and resources for teacher development. Furthermore, it will offer multilingual interfaces and tools for professional dialogue and support (e.g. discussion forums, chat rooms, etc).

The professional development course will be pilot tested at the final year of the project with a group of 30-40 teachers from the four partner countries. During the course, there will be a few face-to face meetings with local teachers, but the biggest part of the course will be delivered online through text, illustrations, animations, audio/video, technology-rich interactive problem-solving activities, and multilingual interfaces. The instructional content and services of the dedicated information base will be utilized for teaching, support and coordination purposes.

The professional development course will build participating teachers' pedagogical and content knowledge of statistics through a four-stage course that will last for 13 weeks (see Figure 2-left, and

Figure 2-right; Azcárate et al., 2006). During the first stage (weeks 1-4), the emphasis will be on enriching the participants' content knowledge of statistics. Through hands-on and computer-based practice and experimentation, intensive use of simulations and visualizations, feedback from each other and reflection, teachers will come to gain better understanding of some of the bedrock concepts in probability and statistics that should be integrated into the elementary and middle school mathematics curriculum. Teachers will then spend the next four weeks (weeks 5-8) focusing on children's learning and what is required to involve them in learning about statistics. They will explore a broad range of topics of interest to the statistics teacher, including computer-supported teaching (use of educational software, Internet resources etc.), curriculum issues (e.g. role of statistics in the national and European mathematics curricula), and statistics education research (development of statistical reasoning in children, common student misconceptions, etc.). At a next stage (weeks 9-11), teachers will undertake a teaching experiment. They will customize and expand upon materials provided to them, and apply them in their own classrooms with the support of the design team. Teachers will write up their experiences, including a critical analysis of their work and that resulting from their pupils. This will help them to reflect on their practice and apply self-criticism constructively. Finally, once the teaching experiment is completed, teachers will report on their experiences to the other teachers in their group, and will also provide samples of their students' work for group reflection and evaluation (weeks 12-13). Teachers will exchange ideas and insights as to how to further improve their teaching practice and to increase their students' achievement.

At the end of the project, final revisions and enhancements to the information-base content and services will be made, based on feedback received from the pilot delivery of the professional development course and the follow-up classroom intervention. The information base will then be opened to all interested teachers and teacher educators for independent study. It will include:

- *A hypertextbook* with the material, resources, and activities of the professional development course to be used as a self-paced course, in a facilitated online mode, or as part or all of the material used in a face-to-face course or workshop;
- *Technologically enhanced curricular and instructional materials* for the teaching and learning of statistics in elementary and middle school;
- *A Video Case Library* containing segments of real teaching episodes, obtained in the classrooms of the teachers participating in the project, representing the landscape of practice in statistics instruction in Europe, for use by pre-service and in-service teachers and by teacher educators;
- *A database containing Student Work Samples* developed through contributions of participating teachers, providing examples of good practice in European schools that could also be used in teacher preparation and professional development programs;
- *Reports and articles* developed through the project;
- *Links to statistics education resources* available on the Internet;
- *Collaboration tools* for professional dialogue and support (e.g. email, chat rooms, discussion forums).

Design of the *EarlyStatistics* Learning Environment

The Effective Learning Environment Framework guides the design of the *EarlyStatistics* professional development course content and of the dedicated information base. The distance education environment is being carefully designed to be learner-centred, community-centred, knowledge-centred, and assessment centred.

Learner-Centred

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 follow a highly structured format, setting objectives and sub-objectives in detail and designing tasks to fit these objectives. *EarlyStatistics* adopts a very different approach to teacher online professional development. Recognizing the fact that professional development is most effective when deeply contextualized in teachers' professional activity (Smylie, 1995) and that teachers will bring a diverse variety of strategies into the program as a result of their own professional experiences, the project uses an approach that

respects and utilizes teachers' professional knowledge.

The *EarlyStatistics* distance education environment is being 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. Rather than using text-based, static content that tends to be the norm in distance education of mathematics/science courses, teachers participating in the professional development course will be provided with ample opportunities for interactive learning. We will foster a supportive and engaging learning environment, in which the teachers will be actively involved in constructing their own knowledge, through their own experiences and participation. We will engage participating teachers in the process of learning through authentic educational activities such as projects, experiments, computer explorations with real and simulated data, group work, and discussions.

Central to the development of the professional development course material is the functional integration of contemporary multimedia and internet technologies with existing core curricular ideas, and specifically, the integration of new types of tools (e.g. the dynamic statistics software Fathom[®] (Finzer, 1999) and Tinkerplots[®] (Konold, 2005), statistical applets, etc.), which will provide teachers, and subsequently their students, with ample opportunities for experimentation with statistical ideas in varied contexts. These new tools are designed explicitly to facilitate the visualization of statistical concepts by providing a medium for the design of activities that integrate experiential and formal pieces of knowledge, allowing the user to make direct connections between physical experience and its formal representations (Pratt, 1998; Meletiou-Mavrotheris, 2003; Papanastasiou & Noss, 2004). They encourage interactivity and empower learners through exploration, simulation, and dynamic visualization of data, to investigate abstract statistical concepts. Learners can experiment with statistical ideas, articulate their informal theories, use them to make conjectures, and then use the experimental results to test and modify these conjectures. There is evidence that use of such software in the statistics classroom promotes conceptual change in learners and leads to the development of a more coherent mental model of key statistical and probabilistic concepts (Bakker, 2003; Hammerman & Rubin, 2003).

This active, learner-centred environment, 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 classroom. We hope that the exposure to an inquiry-based environment will encourage teachers to adopt instructional practices which will allow their students to develop data literacy skills and competencies through their own thinking and exploration rather than receiving it pre-digested from teachers and textbooks (Rubin, 1999).

Knowledge-Centred

In addition to being learner-centred, *EarlyStatistics* also has a clear focus on learning objectives. The professional development program under construction aims, through hands-on and computer-based practice, real-classroom experimentation, feedback from each other and reflection, to enrich the participating teachers' pedagogical and content knowledge of statistics. It is being built around a number of scenarios that all follow the same structure. Each scenario has the following moments of elaboration and development (Azcárate, Serradó, Cardeñoso, 2006):

- *Initial moment*: Activities to do with teachers, related to (i) knowledge of statistics, (ii) the teaching and learning processes.
- *Experimentation moment*: Activities and reflections during classroom intervention. Building of a teacher portfolio with information regarding (i) students' motivation, (ii) students' actions, (iii) interactions among students, (iv) questions posed to students, (v) kinds of interventions and students' responses, (vi) problems of classroom management and solutions to these problems.
- *Reflection and evaluation moment*: Activities and reflections after classroom intervention in relation to (i) statistical knowledge, (ii) learning, (iii) classroom dynamics.

To help teachers to go beyond procedural and rote memorization and to acquire a well-organized body of knowledge (NRC, 2000), the designed activities emphasize and revisit a set of central statistical

ideas (GAISE, 2005), rather than presenting statistical content as a sequenced list of curricular topics. The conceptual “Framework for Teaching Statistics within the K-12 Mathematics Curriculum”, developed by a group of leading statistics and mathematics educators (GAISE, 2005), is being used to structure the presentation of content. This framework uses a spiral approach to statistics curriculum, so that instructional programs from pre-kindergarten through high school encourage students to gradually develop understanding of statistics 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. This spiral organization of content will help teachers understand statistics as a comprehensive approach to data analysis. Using real data, active learning and technology, participating teachers will learn where the “big ideas” of statistics apply and how, and will develop a variety of methodologies and resources for their effective instruction at different levels of schooling. Finally, being actual practitioners, they will be supported in applying what they learn in the course to a real classroom setting.

Community-Centred

A central conviction underlying the design of *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 (Barab & Duffy, 2000). While the project employs innovative technological tools and resources to support educationally useful human-computer interactions, its focus is on exploiting technology to support human-human interactions (Barab et al., 2001a). Teachers participating in the program will interact and learn about statistics by engaging in joint activities and discussions, helping each other, and sharing best pedagogical strategies. Through these interactions, they will build relationships and form a self-sustaining online community of practice within which they will improve their content and pedagogical knowledge of statistics by connecting and learning from each other in ways that would not have been possible in a more traditional, face-to-face professional development program. This virtual network of practitioners, which will promote the sharing of multiple, multinational perspectives, will shape not only the teachers’ identity as practitioners, but also the identity of the practice itself (Gray, 2004).

The project information base will target long-term sustainability and maximum dissemination of innovative statistics curricula and teaching practices in different cultural contexts through supporting multilingual interfaces, transnational collaboration of teachers, and accumulation of collective knowledge from end-users. The system will provide a virtual space where European teachers of statistics with a broad range of experiences and expertise will come together to reflect upon pedagogical theory and practice, to exchange ideas and resources, and to build collaborations. It is expected that a network of education practitioners will be formed which will attract knowledge from teachers, but also from trainers and experts in the area of statistics education. The objective is that, after the end of the project, the information base will continue to be enriched by users that find added value in visiting the website for information and in publishing their experiences for other users to take advantage of new developments.

Assessment-Centred

Assessment is an integral component of *EarlyStatistics*. It is aligned with learning goals, focusing on understanding of key ideas and not just on skills, procedures, and computed answers (GAISE, 2005). The online learning environment is being designed so as to enable the research team to continuously monitor teachers’ progress and to provide timely feedback. Moreover, teachers will be provided with multiple opportunities for self-assessment. Most of the hands-on and technology-supported instructional activities developed through the program require teachers to first make conjectures about the expected results, then to test these conjectures through computer simulations or other data explorations, and finally to reflect on and to evaluate on their results and to compare and contrast them to those of other people. There will also be several low-stakes assessments included for participants to monitor their own progress (Gould and Peck, 2004).

Implementation Considerations – Meeting the challenges of distance education

The main outcome of the *EarlyStatistics* project will be the professional development course that will be pilot tested during the final year of the project with a group of 30-40 teachers from the four participating countries. Since the course will be offered online, there are special challenges that ought to be met in order to provide an effective learning environment. In designing the course, we are taking into account a number of pedagogical, but also technical considerations (e.g. limitations in terms of equipment, software, protocols, and network bandwidth).

It is expected that there will be great variety in teachers' experience and comfort with technology. Also, participants will be fairly demographically diverse, across several time-zones. They will work under fairly diverse environments (small private schools to large, inner-city public schools). To meet the needs of this diverse group, a number of features are being incorporated into the design of the *EarlyStatistics* course and its related services (adopted from Meyer & Thille, 2006):

- A variety of approaches towards the content so that participants can "pick and choose" what works best for them
- Infrequent, but regular, "milestone" assessments for instructors to monitor progress and provide feedback
- Low-stakes assessments for participants to monitor their own progress
- Discussion forums to enhance community and to provide quick feedback to problems and concerns
- An easily navigated, user-friendly interface
- Availability of course material in CD/DVD format to overcome potential bandwidth limitations

To offer teachers flexibility and to accommodate different time zones, the largest portion of the course will be delivered asynchronously. Asynchronous means of communication will include discussion groups and mail groups. There will also be some synchronous communication through use of technologies such as digital blackboards, audio/video streaming, and videoconferencing. One-way informational postings such as articles and videos will also serve as objects for supporting interaction (Barab et al., 2001a). Additionally, there will be a small number of face-to face meetings with local teachers to support community-building.

While there will not be specific 'classroom hours,' teachers will work in teams according to a loose schedule. Each week will typically involve a range of activities, readings and contributions to discussion, as well as completion of group assignments. Some weeks will also require teachers to create something, e.g. a PowerPoint presentation, which will be posted on the information base. Online moderated discussions will allow teachers to share content, ideas, and instructional strategies.

As pointed out, the course will give special consideration to sociability issues that are important in establishing a functional online community of teaching practitioners. It will employ pedagogical and technology structures that will support the community's shared purpose and will encourage online dialogue and collaboration among community members. The project information base will offer a variety of tools for professional dialogue and support (e.g. discussion forums, chat rooms, application sharing etc.). A number of strategies will be employed to encourage online dialogue and collaboration among community members, including the following:

- Participants will be assigned to small groups and each group will be facilitated by an instructor
- Participating groups will receive periodic milestone group assignments
- Group, as well as whole class, discussion questions will be assigned
- Monitored chat rooms and/or discussion forums will allow teachers to discuss and share content, ideas, and instructional strategies.

The aim will be to build an open knowledge-building and sharing environment that will foster sustained participation and will allow teachers to take an active role and ownership for the creation of their community (Barab & Duffy, 2000).

The course will be facilitated by members of the research team with expertise in statistics education.

Their role will be to guide discussions, to encourage full, thoughtful involvement of all participants, and to provide feedback. Facilitators will help to deepen the learning experience for course participants by encouraging productive interaction and critical reflection on workplace practices (Gray, 2004). They will employ moderating strategies for building social connections that will extend beyond the level of social interaction and sharing of information (Gray, 2004). This will assist in developing and sustaining the online community of participating teachers over a period that will extend beyond the project lifetime.

DISCUSSION

Acknowledging the fact that teachers are at the heart of any educational reform effort, the European project *EarlyStatistics* aims to enrich European children's learning of statistics by offering their teachers an innovative professional development course that seamlessly combines best pedagogical practices in statistics education, adult education, and distance learning. Contemporary visions of web-based instruction and computer-mediated communication which support more participatory and collaborative models of education (Barab & Duffy, 2000; Barab et al. 2001b) guide the program design. The distance learning environment is carefully designed to respect the tenets of the Effective Learning Environment framework (NRC, 2000): learner centeredness, community centeredness, knowledge centeredness, and assessment centeredness.

The ideas of collaboration and reflection, and of inquiry and exploration as processes of knowledge construction (Ponte, 2001), underpin *EarlyStatistics*. The program will facilitate intercultural professional development of teachers using exemplary web-based educational tools and resources. Particular care is being taken to build on teachers' knowledge and experiences and to promote interactive learning and cross-cultural exchange of experiences and ideas. Teachers from different countries will 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 online information base will offer access to usable and validated pedagogical models, didactic approaches, and innovative instructional materials for the teaching and learning of statistics, resulting in a complete and flexible teacher professional development program. This information base will be of use not only to the teachers participating in the course, but also for independent study by teachers across Europe and beyond.

The project outputs and services will be useful not only to teachers, but also to academic experts in statistics education, to national and European Education boards, to teacher training institutions, and to designers of online professional development programs. Academic experts and material developers will get more sensitized to the needs of statistics teachers in different countries, supporting the development of new professional development methodologies and materials. Teacher training institutions will gain clearer understanding of the issues facing statistics teaching and learning and will be able to utilize the project outputs for further improvement of their teacher preparation programs. Online professional development designers will benefit from access to a pedagogical framework for effective professional development in statistics education via the emergence of an online space designed to support teachers in sharing and evolving their teaching practices. The ultimate beneficiaries will be students, who will eventually benefit from improved from improved curricula and teaching practices.

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