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# Distance Learning: A Postgraduate PerCom Program

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Many have attempted to bring the exciting pervasive computing research area into the classroom. Here, we present our experience in organizing and teaching a postgraduate pervasive computing program via distance learning at the Hellenic Open University.

## QUICK FACTS

**Modules:**
- Software and Networking Technologies (SDY50)
- Ubiquitous and Global Computing Systems (SDY51)
- Analysis and Design of Hardware/Software Systems (SDY60)
- Mobile Computing Systems (SDY61)
- Embedded Systems (SDY62)
- MSc Thesis (SDY99)

**Unit:** School of Sciences and Technology
**Institution:** Hellenic Open University
**Level:** Postgraduate
**URL:** www.eap.gr/sdy_en.php

## PROGRAM OVERVIEW

The PerCom Program at the Hellenic Open University aims to cover theoretical and practical issues while training computer scientists to have both software and hardware development skills. The entire postgraduate program is taught via distance learning, which heavily affects the nature of teacher-student interaction and of the assigned homework and projects. To the best of our knowledge, this is the only pervasive computing graduate program based on distant-learning practices.

To complete the program, each student must successfully complete three obligatory modules (or thematic units) and one of two electives. This modular organization is a key difference between this and other, similar programs. A module corresponds to three semester courses. The modular design of the program lets teachers easily adapt it to keep up with scientific and technological advancements.

Teachers have five in-person meetings with students during the year to discuss the students' progress, address any questions, and discuss the homework and projects. Each teacher supervises 20 to 25 students and uses a set of synchronous and asynchronous communication tools to encourage students and help them keep up with each module's timetable. In some modules, these meetings focus on students exchanging knowledge and experiences with each other, unlike more conventional meetings that just focus on student progress.

During their studies, the students use a wide range of distance-learning tools, such as Web forums (for posting and discussing questions), Skype (to meet with teachers), and email (for discussions with teachers and fellow students).

### Modules

Each module's studying material comprises two to three designated textbooks, note booklets that introduce the students to the material covered in each book, and research papers from magazines and the University's digital libraries.

***Software and networking technologies.*** This is the program's introductory module—students must successfully complete it before advancing to other modules. There are three main goals.

First, this module aims to define the basic pervasive computing concepts and introduces the importance of addressing privacy issues. It also discusses how to tabulate positioning technologies and explains techniques for multisensor data fusion.

Second, it discusses the role of distributed systems and middleware in pervasive computing systems, reviewing specialized topics (such as system models, interprocess communication, operating systems, middleware, distributed file systems, peer-to-peer architectures, and Web services). It also analyzes distributed systems challenges, presents case studies, and reviews how to select the most appropriate technologies and tools to implement distributed applications.

Finally, it describes the role of wireless networks as the communications medium in pervasive computing systems. It explains the basic concepts of wireless networking technologies, the operation principles of mobile cellular networks, and the basic principles of ad hoc wireless sensor networks.

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EDUCATION & TRAINING

***Ubiquitous and global computing systems.*** This is the second module that students attend. It introduces students to the various architectures and operational models of pervasive computing systems and the related design principles.

Other significant issues covered include development methodologies for pervasive computing systems, basic HCI principles, tagging and scanning technologies, and the concept of the Internet of Things. A large part of the module aims to guide students in the development of context-aware applications, so it also presents context-representation models and discusses the design and development of context-aware systems. Furthermore, it covers advanced issues, such as ambient intelligence and evaluation methodologies and criteria.

Finally, the module covers a wide range of case studies of applications and lets students experiment with developing systems using low- and mid-fidelity prototypes (mock-ups and Android apps).

***Analysis and design of hardware/software systems.*** This is the third obligatory module. It provides students with the necessary knowledge for designing and building hardware and software for interactive pervasive computing systems. The module begins by explaining the purpose and principles of interaction design and the tools used to build pervasive computing systems.

Then, it addresses program interaction issues for ubiquitous devices and the need to identify user needs and understand the principles of collaboration and groupware. Students are involved with software prototyping with the Processing programming language and Android, and with hardware prototyping with Arduino microcontrollers and shields. The module also covers related case studies in various application areas, such as entertainment, education, work, sustainability, and well-being.

***Mobile computing systems.*** This is one of the two optional modules, and it focuses on the wireless networking infrastructure. Armed with knowledge from earlier modules, it helps students deepen their understanding of design principles related to several wireless networking technologies.

Specifically, the module lets students analyze and assess advanced properties of the various wireless networking infrastructures, such as quality of service and security, and offers the ability to design and experiment with mobile computing services. Implementation aspects of standalone, Web-based, and hybrid mobile applications are also discussed. Finally, it covers some mobile computing case studies.

***Embedded Systems.*** This is the other optional module. Students will specialize in the area of incorporating small-scale devices into pervasive computing systems. Knowledge gained from this module covers the areas of digital systems design and embedded systems. It also covers related case studies.

### Master's Thesis

After completing the three mandatory and one optional modules, students must prepare and present a MSc Thesis, which should be a complete pervasive computing project. Students should use the knowledge gained from their entire study experience in the postgraduate program. State-of-the-art topics are offered each year, most of which enable students who undertake substantially novel work to submit papers based on their results to journals and conferences in the area of pervasive computing.

### Homework

The program is based on the distance-learning methodology, so student progress is mainly assessed via homework assignments. To this end, in all modules, students submit five homework assignments.

A well-prepared student should spend two to three weeks on each homework assignment. Assignments typically address a wide range of the subjects covered and contain both theoretical questions and small hands-on projects. Moreover, students must study related papers to complete their assignment.

As a representative example, the second assignment of the Software and Networking Technologies module typically requires the students to answer several questions after reading a couple of related papers, define the specifications of a pervasive computing project, and turn in a Java-based implementation of a method used to filter out noise from sequential data recorded by a sensor node.

## STUDENT FEEDBACK

We conducted an online survey to gather student feedback on the program's curriculum.

### Demographics

Thirty-nine students have completed the survey. The majority of the students are Greek university graduates, mainly holding electrical/computer engineering diplomas and computer science degrees. The vast majority are also active professionally as full-time employees. The highest percentage of students are informatics teachers in public elementary and secondary education, while many others are public servants or are employed in the IT or telecom industry.

Launched during the 2010–2011 academic year, the program doesn't yet have any graduates. Most students have already successfully completed the introductory module, with a decreasing number of students having completed the remaining modules. Currently, 13 students attend the elective Mobile Computing Systems module and only one is working on the MSc thesis. Seventy percent of the students said they intend to take the Mobile Computing Systems module and 30 percent intend to take the Embedded Systems module. Three quarters of the students expect to successfully complete their studies.

On average, students attended 3.67 out of 5 group meetings. This is regarded as satisfactory, given the fact that approximately 30 percent of the students commute to attend meetings, because they live in cities other than those where the

meetings take place. The mean values for written assignments and final exams were 58.5 percent and 45.77 percent, respectively. As for their motivation for registering in the program, 46 percent stated that it was a conscious choice made after careful consideration (and 92 percent stated no prior exposure to pervasive computing concepts and technologies). The MSc degree was the motivating factor for 41 percent, while 67 percent hoped to gain exposure to cutting-edge technologies and to enrich their knowledge base.

Many also reported that they needed to enhance their background knowledge in several fields (mainly, wireless networking, distributed systems, and Java programming) to understand the pervasive computing concepts and successfully complete the thematic units.

Last, students felt that their exposure to several pervasive computing components (such as mobile technologies, wireless networks and Web services) would prove useful and applicable in the development of their careers.

Regarding their thesis subjects, most students intended to undertake research on mobile applications, followed by subjects related to the deployment and evaluation of wireless sensor networks and HCI issues in pervasive computing.

## Organizational/Educational Model

Most students valued their exposure to scientific pervasive computing literature, but they tended to favor assignments involving application development over tackling theoretical issues. In fact, they argued that such assignments should count more toward the final grades for thematic units.

Access to lab facilities was viewed as essential in gaining practical experience. Most students were satisfied with the use of distance-education tools for teacher-student asynchronous communication (email, forum, and so on). However, they argued that the program's schedule was rather intense, especially for employed students.

The live group meetings were highly valued for getting feedback, addressing questions, and keeping students on schedule. Most found the meetings focusing on teamwork rather than conventional teaching more useful, and they didn't favor Web-based meetings over live meetings.

## Suggestions and Overall Experience

Fifty-seven percent of the students were confident that, after graduation, they'd have the required background and practical experience to get involved in the design and implementation of real-world systems. However, most students were pessimistic regarding the prospects for graduates in the Greek labor market today, although they viewed their prospects in the international labor market more favorably. They still felt that the need for pervasive computing experts would grow in the future in the Greek market. These views are aligned with Greece's current, and unprecedented, financial crisis. Likewise, students felt that pervasive-computing business opportunities will likely appear in the near future.

The majority of the students have found that the knowledge base built through their studies is useful in their current professional activities, while some intend to use the knowledge acquired to seek a relevant job in the industry, undertake a business initiative, or pursue doctoral studies on a related subject. Only a few (8 percent) don't think it's likely they'll use the knowledge gained.

Students suggested additional thematic units that could enhance the program's curriculum, including ad hoc networks, large-scale intelligent systems (recommender systems, artificial intelligence, data mining, and so on), and advanced Web technologies.

Overall, students had a positive view of their study experience. The program met or exceeded their original expectations and captured recent technological developments. Although the curriculum is very demanding and the workload rather high, students indicated no regret in their original decision to pursue postgraduate studies.

Regarding the evolution of the program, a smart classroom and a fully equipped PerCom lab are currently under construction and are expected to further enhance the programs. The development of digital educational materials (multimedia presentations, video lectures, and so on) is also underway. P


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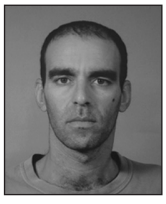

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