Studying Human-Computer Interaction for Social Good: the Case of Digital Government Evaluation and Re-Design Project

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ABSTRACT

Inclusion of social good in computer science education has been proposed as an approach that demonstrates computing's social relevance and potential for positive societal impact, thus providing students with a motivating vision over the subject. This is particularly important in the context of human-computer interaction courses that can relate to real life situations more easily than other theoretical or more technical subjects. This paper presents a teaching intervention in the context of a master's level course of Human-Computer Interaction and Design of Interactive Systems, during which a group of students were asked to address a critical problem, i.e. to evaluate and re-design typical Greek e-government sites. Given the importance of efficient and effective public sector services for the society's cohesion and citizens' inclusion, and the demand for improving their usability, in particular for the Greek case, it is argued here that this approach of teaching human-computer interaction, situates the theory and methods of the course in a socially relevant context, motivating the students and increasing the learning effect of the teaching intervention.

CCS CONCEPTS

• **Social and professional topics** → **Student assessment**; *Government technology policy*;

KEYWORDS

Teaching human-computer interaction, design and evaluation of interactive systems, e-government services evaluation

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1 INTRODUCTION

The pedagogies used in teaching computer science are a matter of ongoing discussion. A trend of a growing demand for computing professionals worldwide and an increase in the use of computing in any field of human activity have been observed during the last years. At the same time, the public view of the computer science field remains that of a discipline that focuses just on technology and avoids social interaction [13]. One approach that has been proposed for changing this, is to make evident the social relevance of the discipline, something that will also influence current or future students of computer science [5]. The ACM-IEEE Computing Curricula [1] states that the inclusion of core hours in the social issues and professional practice, under the *Social Context* knowledge unit, helps to promote a greater understanding of the implications of social responsibility among students. This should encourage students in being aware of social issues, in order to become socially responsible throughout their careers, influencing the public view of the field.

It has been argued that the infusion of ideas of '*computing for social good*', through implementing the ACM-IEEE curriculum recommendation, will increase students' motivation and learning outcomes. Computing for social good is an umbrella term meant to incorporate any educational activity, that endeavors to convey and reinforce computing's social relevance and potential for positive societal impact [9]. A teaching and pedagogical framework has been proposed by Goldweber et al. [9] that promotes this idea. In this context, there have been various attempts to introduce teaching interventions in the form of student projects in different computer science subjects of study, like software engineering, programming, etc. (e.g. [9, 18]).

The study of human-computer interaction (HCI) is part of the core of computer science curricula (see ACM-IEEE recommendation [1]). It relates to design sciences, cognitive psychology and sociology, ergonomics, communication and media studies, artificial intelligence and other disciplines, addressing issues relating to user interaction with computing technology. The HCI subject is suitable for introducing the idea of computing for social good to computer science students, as it can be related to real life applications and case studies, and involve students in the evaluation and design of them, associating the theoretical notions of the HCI field to the practice of computer science and the required professional skills. An example of making HCI courses socially relevant is the one proposed by Ritter [18], according to which, student groups were asked to perform an analysis of real systems (typically web sites) as part of the course projects, that have led to changes in real-world systems. It was argued that through the students' work, a service to the community was performed, helping local companies, non-profits, and university units to improve their web sites.

These previous studies inspired the teaching intervention discussed here. In particular, using a project-based learning approach

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[14], in a recent edition of an HCI course, we shifted the subjects of students' project work from little '*s*' (i.e., socially interesting projects that relate to their personal interests) to capital '*S*' (i.e., socially interesting projects that relate to society at large), as discussed by Buckley et al. [5] who make a distinction of the different kinds of socially relevant projects that can be used to address both the solipsistic and altruistic sides of students. Project-based learning approaches are considered beneficial to learning. However, since they require increased resources from educators, they are less commonly used compared to other approaches, like lectures, tutorials and practical work.

This paper presents the design of a socially relevant teaching intervention, that took place in the context of a degree course in Electrical & Computer Engineering at the University of Patras, Greece during the academic year 2017-18. In the following, we discuss the experience of introducing project-based learning in the course, with a particular focus on the evaluation and re-design of existing public sector services in Greece. The methodological approach, the organization of the activity, the results of the project work of the students, and discussion on how this influenced the students' attitude towards the subject matter and towards their social responsibility as computer engineers are included in the following sections.

2 ON SELECTING A SOCIALLY-RELEVANT THEME

The key aspects of the teaching intervention presented here were the following:

(a) The students had to evaluate the usability of web sites and propose improvements of their design.
(b) The services the students had to evaluate are publicly available, so any suggested improvement would have a strong societal relevance.
(c) The students were encouraged to work in small groups, within which they had to plan their activities and define their roles by themselves.
(d) The design and evaluation approach to use was only partially prescribed, so the students had ownership of their study and the produced results.
(e) The students were provided with the opportunity, if they wished, to publicly present the results of their work.

A key aspect of this intervention was the selection of a project work theme with strong impact on the society at large. We discuss next the rationale for selecting the specific theme in the realm of e-government and, in particular, evaluation and re-design of widely used Greek e-government sites.

According to the UN Survey on e-government [21], digital government has '*ushered in significant and enduring changes in the way people live and interact with each other, their environment, and public services*'. The latest survey (idem) confirms through case studies that exploiting digital government has far-reaching potential for countries, beyond efficient and effective public service delivery, also ensuring inclusion, participation and accountability. According to the UN Survey [21], Europe has the most advanced e-government development index, however Greece is one of the least developed countries, despite heavy European and national investments in the sector of digital government. According to the recent Digital Economy and Society Index Report of the EU, Greece, with a score of under 40%, ranks last among the 28 EU member states on the digital public service dimension [8].

Given this background, we felt that there is ground for improving the e-government services in Greece. We also expect that future practitioners will face the challenge of improving this situation in their professional life. In the context of the particular course, we thought therefore, that we ought to design an intervention that exposes the future computer scientists to the issues and challenges of measuring the quality of e-government services from the point of view of usability, and investigate the feasibility of improving their quality.

The quality of e-government services has been a matter of research for a number of years. Various models have been proposed [4, 10, 17], in which user experience is measured through dimensions like portal's usability, forms structure and quality of the provided information. Arias and Maçada [2] recently reported on a survey of the literature in the field. They analyzed 28 studies and approaches covering theoretical aspects, developed models and suggested techniques for evaluating the quality of e-government services, highlighting the fact that, contrary to private sector service quality models, in the public sector the missions and criteria of quality for a particular service are not always clearly identified. 95 constructs were discovered in these studies as independent variables. Among them, the most widely used are usability, reliability, content, security and privacy.

On the methods for applying the proposed quality models, there have been various approaches. Among others, the e-government benchmark framework [7] is applied through the 'mystery shopping' approach, that models interactions with specific services across European countries by typical users (e.g., issuing a birth certificate, moving house). Other methods include checklists and user surveys, and studies of international organizations like the UN. The proposed here teaching intervention is grounded on these models, focusing mainly on user experience issues, and applying a number of evaluation methods from the perspective of the body of knowledge of human-computer interaction, that is part of the theoretical part of the course.

3 CONTEXT OF THE STUDY

The objectives of the master's course '*Human-Machine Interaction and Design of Interactive Systems*' are: (a) To introduce theoretical concepts of interaction between humans and technology, derived from cognitive psychology and social psychology, and (b) to relate them to the practice of design and evaluation of interactive systems.

Linking these two objectives is achieved through practical lab exercises and project activities. Lab exercises involve short experiments for collecting data and using techniques for measuring user experience during the interaction with technological artifacts (e.g., web sites, mobile applications), as well as participation in workshops for ideation and conceptual design of interactive systems, as discussed for example by Avouris et al. [3] and Sintoris et al. [20]. These lab activities complement lectures throughout the academic semester.

Table 1: E-government online services that were evaluated and re-designed.

#	e-Service	Complexity	Typical users
s1	Doctor appointment	low	public
s2	Annual car tax	low	public
s3	Doctor prescription	medium	specialist
s4	National chemical lab	medium	public, specialist
s5	Service fee payment	low	public
s6	Real estate value estim.	high	public, specialist
s7	Property tax	medium	public
s8	National cadastre	high	public, specialist
s9	National register office	low	public
s10	Urban planning	high	public, specialist

At the second half of the semester, a six-week project activity takes place, where the students, in small groups, tackle problems of a common theme. They are asked to apply the theoretical and methodological background of the course in their given problems and to present their work and discuss it with fellow students and tutors at the end of the semester. The themes of the projects over the years have varied. They were either related to specific problems (design a ticket vending machine, design a university portal, etc.) or to wider areas of applications (measuring accessibility in the healthcare sector, design of mobile games, etc.) The aim of having students work under a common theme, was to cross-fertilize their experience during the phases of requirements analysis, evaluation and design, through discussion sessions and the final presentations. In the most recent edition of the course, the common theme of the project work has been that of evaluation and re-design of e-government portals.

18 students participated in the activity (4 female, 14 male), with an age range between 23 and 24. They formed 10 groups of 1 or 2 members each (the recommendation was for 2-member groups). Each group selected a distinct public online e-government service from a given list.

The project activity requested the students to undertake the following tasks:

(a) To evaluate the usability of the service, using at least two different techniques and identify major issues;
(b) to suggest a re-design of the web site, showing their proposal through a sketch, a wireframe or a prototype and prove that the proposed solution had advantages over the existing solution, and
(c) publicly present the main points of their project work, following a given template (optional).

As shown in Table 1, the services to be evaluated were related to a cross-section of public life, healthcare sector (#1, #3), financial transactions (#2, #5, #7), real estate and planning (#6, #8, #10), registry (#9), chemicals (#4). They were drawn from a list of e-government services in Greece and there was no previous experience of interaction with them or known usability issues to the course instructors or the students. The complexity of the user tasks related to the services varied, as shown in Table 1. Some of them were of informational nature, others of transactional nature. Some services were full portals, including many associated services (e.g., the National chemical lab, the Urban planning portal). The students in these cases were advised to select some typical scenarios of use for the services and focus on them. In terms of typical users of the services, five of them were related to specialists, and nine to the general public, with just one service exclusively designed for specialists' use.

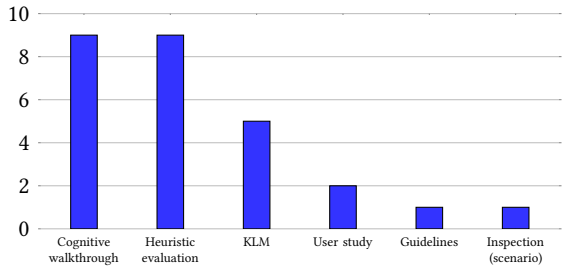

Figure 1: Evaluation methods used in the 10 projects.

4 RESULTS

In this section the e-government sites evaluation and re-design project work is presented and discussed.

4.1 Evaluation phase

During the evaluation phase, the students applied techniques that were introduced in the course in order to identify usability issues. These were mostly expert-based techniques (heuristic evaluation, cognitive walkthrough and KLM analysis), while in some cases user-based techniques were applied, that necessitate more resources. In various cases, the analysis of the tasks and users resulted in contacting expert users, e.g. doctors, planners.

As shown in Figure 1, the most widely used methods were the expert-based methods cognitive walkthrough [23] and heuristic evaluation [16], while the analytic method Keystroke-Level Model (KLM) [6] was used in five projects. Two groups used a user-based method (user interview and think-aloud protocol). In one case the evaluators used a scenario-based inspection method and in another case they used guidelines, that also helped the re-design phase.

We should mention that numerous usability evaluation methods can be used for such tasks (see the *Usability Body of Knowledge* in [22]) and they vary in terms of complexity, resources required and degree of required expertise. The students often did not provide a rationale for the selection of a particular technique, however we observed that the applied techniques are widely used, have been presented and discussed in the practical labs of the course and necessitate limited resources.

In terms of issues and suggestions for improvements, the most effective approach was that of *Heuristic Evaluation*, that guides the evaluator in inspecting the design based on typical scenarios of use, in order to examine violations of the heuristics. These violations were then presented through screenshots and verbal descriptions, leading directly to suggestions for re-design. An interesting finding is that in terms of group members' task allocation, the students often decided different group members to take responsibility of

Table 2: Heuristic rules violations per e-government service, based on the reports of eight student groups.

	Heuristic rule	Rules violations per e-government service								Total of rules violations	Occurrence per # of services
		s1	s2	s3	s4	s5	s6	s7	s8		
H1	Provide feedback	2			1			1	2	6	50%
H2	Speak the user's language	2			1	1			1	5	50%
H3	Provide clearly marked exits	1		1	2	1	2		1	8	75%
H4	Be consistent		3	1			2			6	38%
H5	Prevent errors	1	1				2			4	38%
H6	Minimize user memory load	1	3	1	1			1	2	9	75%
H7	Provide shortcuts	1		1		1				3	38%
H8	Aesthetic and minimalist design	3		1	1		3	1	2	11	75%
H9	Good error messages			1	1	1	1	1		5	63%
H10	Help and documentation	1	1	1	1	1			1	6	75%
	total of rules violations:	12	8	7	8	5	10	4	9	63	58%
	% of violated rules:	80%	40%	70%	70%	50%	50%	40%	60%		

different techniques (e.g., one member applying heuristics, and the other cognitive walkthrough) and then discuss the findings. This however contradicts the recommendation that heuristics should be applied by different evaluators in order to confirm the validity of the observed violations.

In terms of the heuristic rules that were violated in different e-government services, a summary is shown in Table 2, based on the eight student projects that reported details of the study, in terms of violated heuristics. The heuristics that were more often violated, were H3 (Provide clearly marked exits), H6 (Minimize user memory load) and H10 (Provide help and documentation), that appeared in six of the studies. We also note that all ten heuristic rules have been applied in the various studies, while the percentage of heuristics that were violated in the various studies varied between 40% and 70%.

Cognitive walkthrough, on the other hand, which is another effective discount evaluation method [11], was used complementary to the *Heuristic Evaluation* technique. Through this approach, for certain typical scenarios, the students identified cases of poor feedback or bad layout that confused the user about the next step in the scenario. These issues lead to recommendations for re-designing the layout or improving the provided feedback.

KLM is an evaluation technique that can be used to measure the typical time required for a given task by an ideal faultless user. This technique has been used in five studies, however the findings of this approach are mixed. In three cases this approach has been used in order to measure improvement of the re-designed service, which produced impressive and convincing proof of the quality of the re-design, as discussed in the next section. In other cases, this expected performance measure provided limited insight on the quality of the service, as it was not compared to any expected performance measure.

User studies were performed less often than expected, mainly because this method necessitates resources, like recruiting and involving typical users. In the two cases where users were involved (N=7 and N=10), the findings were richer, as the users expressed their view and informed the re-design decisions. A typical example is the case of an online fee payment service, in which four inexperienced users failed the task and declared that they '*rather went to the government office instead of using the online service*'. We should observe here that the students belong to a demographic that has little experience of use of public services. So, recruitment of typical users necessitates access to a different demographic, that was sought in the circle of their relatives and family members or family acquaintances with the necessary profile, a rather tedious process.

Other evaluation methods that were used, were scenario-based inspection and guidelines for the design of online forms [19]. This latter approach was particularly relevant to the specific site under evaluation that was an online form. It was interesting that most groups used standard heuristics and not specific guidelines for e-government sites, except in this particular case.

4.2 Services re-design

In all ten cases, the students presented re-designs of the evaluated sites. The complexity of the redesign varied, as well as the representation used and the presentation tools, that were not specified in the project instructions. Five groups produced prototypes with limited functionality, implemented with frameworks such as *Bootstrap*, to reproduce the concept of the proposed design, paying special attention to responsive design of the sites, a feature often missing. They often used tools like *Photoshop*, in combination to HTML, in order to depict their version of the site. Three groups used prototyping tools (e.g., *Pencil* and *UXPin*) and two groups sketched the proposed layout in static images.

The proposed re-designs were linked to the findings of the evaluation studies and in particular the violations of the heuristic evaluation or inspection evaluation. Special emphasis should be given to the validation of the proposed re-designs. In three cases, a measure was provided through KLM analysis for the improved efficiency of the proposed design. In one case, the average estimated improvement was of 36% (122 sec improvement for three tasks), in a second study the improvement was of 58% (41 sec for a specific scenario), and in a third the improvement was of 44% (24 sec for a given scenario). Finally, in another case, KLM analysis was used for calculating the saved time due to the new design, that resulted in

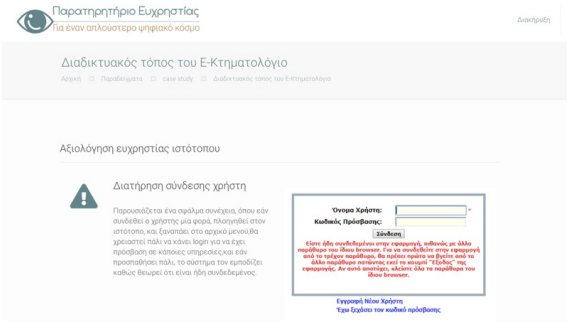

Figure 2: Example of presenting a usability issue.

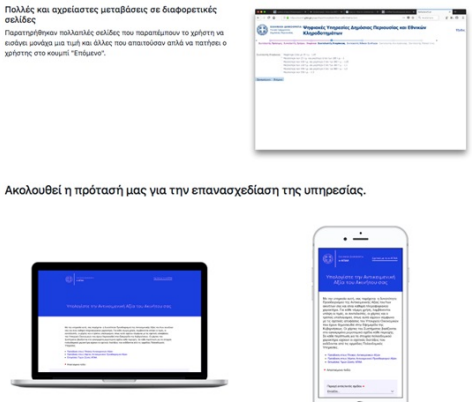

Figure 3: Example of presenting a re-design proposal.

an improvement of 3.5 sec for a given task. These projects were of higher value, as the students, using analytic tools, produced evidence of projected savings, in terms of time, that if applicable in large scale, could lead to savings to the national economy. For example, reducing the time to insert a new prescription to the e-prescription service would enable a doctor to examine more patients per day, which translates to better serving the public and economic savings as the same number of doctors will be able to serve more patients in the long term.

4.3 Public presentation of the project work

In five cases the student groups proceeded in publishing their report in a public site, specialized in making recommendations on usability of public online services in Greece, the '*Usability Observatory*'. This site is maintained by a network of academic and research groups focusing in user experience studies with the objective to advocate usability practices and user-centered design. Each presentation has the form of a web page, with the summary of observations and recommendations for the specific service that were made by the students. Examples are shown in Figures 2 and 3 for presenting a usability issue and a re-design proposal respectively. This exposure of the student project work to the public had a positive impact on the quality of the produced work, while it also increased the visibility of the course and the field of human-computer interaction overall to a wider audience.

5 DISCUSSION

The results of the project work produced during our teaching intervention bear some interesting characteristics, that are briefly discussed here.

As reported, the students used various techniques for evaluating the web sites. The techniques were mostly expert-based discount methods, while, in some cases, they even involved typical users. Despite the limitations and the lack of experience of the evaluators, they managed to identify some crucial usability issues and to propose improvements.

It should also be observed that the task of evaluation of the e-government web sites by the students presented them with some inherent difficulties. They had to understand the task model of the typical use of the service, often a complex and specialized one that the students had no previous experience on. In addition, they had to gain access to the service, as in many cases authorization was required. These problems were addressed in different ways by different student groups.

The public presentation of the project work contributed to increasing the quality of the results, as it has been observed in other similar teaching interventions (e.g., [18]). The public presentation of the results by half of the groups, is an indication of the quality of the results.

In three cases, the re-designed web sites were compared to the original ones using KLM [6], showing considerable improvement in terms of typical task completion time, a measure associated to task complexity and ease of use.

By inspecting the proposed re-designs by the students, one may observe that they are characterized by improved layout and aesthetic design, that made the sites look more fresh and up-to-date. A particular feature that all groups insisted on was responsive design, focusing on use cases involving mobile devices. This finding is attributed to the fact that the evaluated public web sites were most often old (in some cases over 10 years old) so responsive design was not a high priority when they were first designed, while on the other hand, the personal experience of the students relates strongly to access to online services through mobile devices. As discussed in a recent study [1], in the demographic of 18-34 years old, only 3% were found to use just desktop for accessing the internet, compared to 26% for the 55+ age group. So the designers in our case focused more than the original designers on this requirement, based on their own personal experience.

Another common characteristic of many of the student designs, has been that the new designs reflected the task models that the web sites served and not the structure of the organization that run the service. This is due to the fact that the students approached the design as users of the service, following an inherently user-centered design, something that was not done in the original design, where the web site followed the organizational view of the service.

Finally, another issue that the students had to address was related to user authentication. The Greek e-government services are known for not having addressed yet the issue of the citizens' digital identity. The tax office authentication mechanism (*taxisnet*) is often used for user authentication. This results in many security issues, especially

[1] https://www.smartinsights.com/mobile-marketing/mobile-marketing-analytics/mobile-marketing-statistics/

considering that the password policy used in *taxisnet* relies on 5-character password, which is much smaller than the standard length (8-characters) used by popular online service providers as it provides an acceptable level of security [12]. The students in more than one case suggested a single id access service instead.

6 CONCLUSION

Overall the presented teaching intervention was evaluated by both the students and the teaching staff as a positive and rewarding experience. The project-based approach provided the students with an opportunity of a hands-on experience with a real life problem in which they had to apply knowledge on the evaluation and design of interactive technologies that they had acquired during the course.

The group-members role allocation was also a task that the students themselves had to tackle. During the evaluation phase, the workload was often divided per evaluation method, especially when using discount methods, while more effort was required when user testing was involved. Finally the re-design phase was divided according to the required skills (programming, wireframing, etc.)

The quality of the work was considered high, in terms both of the design faults found, and the proposed ways of rectifying them. This was demonstrated by the willingness of some groups to present their work publicly. Some groups opted not to do so, not because of poor quality of their work, but rather because of lack of time for presenting their work in the appropriate format. Overall, the learning effect of the project work was considered very satisfactory.

The second objective of the teaching intervention was to raise social awareness and empower the students, increasing their self-esteem as prospective computing professionals for social good. This objective was also met, as it was evident in the students' comments during the focus group discussion on the experience. The students felt that they had the capacity to intervene and solve problems that can improve the experience of their fellow citizens when using public e-services. In some cases, they made rough estimations of the human power that would be saved by the improved design and acknowledged new user groups that would be served by their design (e.g., senior citizens), as well as new situations in which the services will be used (e.g., users on the move).

Another result of this study was that it can offer a public service, by increasing public awareness on the issues of usability of public online services, and affect the public services design. In the future, the students will be urged to contact the organizations who own and run the services that they evaluate, in order to obtain an insight on the service development and operational processes, and to contribute more directly to improvements.

Finally, of interest was that the students questioned the process of building and maintaining online digital government services. They assumed that the poor quality of some of these services is not due to a lack of skill of their designers, but is due to the process that led to their design. As discussed by [15], the specification of user-centered design process should be an upstream concern in the project life-cycle. The fact that the students have come to this conclusion through their own experience, has been an interesting outcome of the teaching intervention. We hope that these kind of teaching approaches will lead to socially aware computing professionals, that will contribute to improved citizens' experiences.

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