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Public Interactive Displays In Schools: Involving Teachers In The Design And Assessment Of Innovative Technologies

José Lencastre
University of Minho, Portugal
jlencastre@ie.uminho.pt

Clara Coutinho
University of Minho, Portugal
ccoutinho@ie.uminho.pt

João Casal
University of Minho, Portugal
joaocasal@dsi.uminho.pt

Rui José
University of Minho, Portugal
rui@dsi.uminho.pt

The introduction of an innovative technology in schools has the potential to change the education system, bringing major changes in the way teachers work, students learn challenging the way schools are managed. Informed by literature that sustains integration of technological innovations in educational contexts is influenced by instrumental factors such as school leadership and organizational structure (Dix, 2007) and using a development research approach, three hands-on workshops were conducted with a criterion sample of teachers of a secondary school from the north of Portugal in order to elicit expectations towards the use of digital displays to viewing videos, explore possible features for the system design as well as the management of the technological device in the school system. Development research methodology showed to produce usable findings that were born out of the collaborative partnership between researchers and stakeholders focused around inquiry that is of interest to educational leaders and teachers with the intention to inform and transform pedagogical practices. In sum, the development research approach allowed, for one hand, the conception of a new tool pedagogically adjusted to students learning needs as well as to the school organizational rules and structures. On the other hand, our methodological approach aimed to foster the acceptance of the tool as a useful pedagogical instrument for other teachers and for the whole school ecology.

KEYWORDS

Technology-enhanced learning; development research; public displays; participatory design.

1. INTRODUCTION

The introduction of an innovative technology in schools has the potential to change the educational system, bringing major changes in the way teachers teach, students learn and challenges in the way schools are run.

Research about the integration of technological innovations in educational contexts has shown several factors to be instrumental in the implementing of school-wide change: i) related to teachers (beliefs, attitudes, training, technological competencies) (Buabeng-Andoh, 2012; Ertmer & Ottenbreit-Leftwich, 2010; Moersch, 1995; Zhao, 2003); ii) related to school leadership (Billig et al., 2005; Byrom & Bingham, 2001; Ely, 1990; 2005; Staples et al., 2005); iii) related to organization and school structure (Bauer & Kenton, 2005; Billig et al., 2005; Elmore, 1996; Leidner & Jarvenpaa, 1995; Ng, 2008; Wang, 2008); and iv) related to resources and support (Jones, 2001; Sandholtz & Reilly, 2004; Staples et al., 2005).

In this paper we will focus the attention in factors related to leadership and school organization, as we believe, like Byrom and Bingham (2001), they are the core elements for the successful integration of interactive public digital display systems in school communal spaces. Goodyear (2011) points out that there is a shift in our sense of the spaces and contexts in which education takes place, as different learning activities are becoming more commonly distributed across a variety of contexts. Digital displays can provide a simple and effective way to generate shared experiences in public spaces, and when these displays are also interactive, they can be used to foster user-generated content that may enrich learning activities. More specifically, as members of the JuxtaLearn project we were particularly concerned with the use of public displays in school as a form of sharing educational videos created by students as part of everyday learning activities (Adams et al., 2013).

Considering that leadership and school organization are key factors for new technology adoption, we conducted three hands-on workshops with a selected group of influential school teachers (stakeholders). These workshops had the purpose to elicit expectations towards the innovative technology and explore possible features for the system design as well as scenarios for educational uses in school communal spaces.

As we aimed to identify the receptiveness and the main implications of integrating this type of technology into the school, we involved teachers in the design process of the digital display as well as the deployment and testing of the prototype in real settings following the methodological framework of *development research* (Lencastre, 2012; Richey & Klein, 2007; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006; van den Akker, 1999).

In this paper the focus is more on the methodological processes than on the results. We believe we can contribute to the state of the art showing how a well established research methodology – *development research* – can be used to address the challenges that the introduction of an innovative technology poses to schools because each one is a different ecology (Zhao, 2003) and only involving teachers as leaders in the process of integration we accomplish this task.

2. DEVELOPMENT RESEARCH

As a research methodology, *development research* aims to contribute both from a scientific point of view and a practical point of view in order to create a sustainable and effective intervention to a specific problem, which requires not only its analysis, but also the construction of a particular process or product. From the pedagogical point of view, the emphasis tends to be on *development research* as an interactive, cycle process of development and research in which theoretical ideas of the designer feed the development of products tested in school context, eventually leading to theoretical and empirically founded products, learning processes of the developers, and (local) instructional theories (van den Akker et al., 2006). The *development research* aims to give direct contributions to the improvement of educational processes, measuring the impact of these contributions. Therefore, the aim of *development research* is to elaborate successive interventions, in a cycle or spiral process of analysis, design, evaluation and revision activities until a satisfying balance between ideals and realization has been achieved. According to our research plan, we considered four stages that individualize this research methodology: (i) preliminary investigation, (ii) theoretical embedding, (iii) empirical testing, and (iv) documentation, analysis and reflection on processes and outcomes.

2.1 Preliminary investigation

This phase is the foundation for the whole process of research. An intensive and systematic preliminary research of tasks, problems, and contexts is made. It is also relevant to add some activities like analysis of available promising examples for related purposes; case studies of current practices to specify and better understand needs and problems in intended user contexts.

The research team decided to involve teachers with supervision responsibilities because, on one hand, their contributes to design, their verbalized requests of what would be good, tell us whether the design could be successful (or not); and on the other hand, teachers with this profile are in position of motivate other teachers to participate in the project. Thus, in the participatory design process (Schuler & Namioka, 1993), it was decided to tackle two main concerns simultaneously: (a) collect sensitivities regarding suitable design and features, and (b) involve teachers that will facilitate the unfolding of research activities and, in particular, the deployment and testing of prototypes in real settings. This second point seems quite important since it was a belief that the possibility of successfully deploying and testing prototypes is heavily dependent on early adoption and such adoption can only be achieved in school context if we have the active support of key stakeholders. We are also fully aware of the challenges in bringing stakeholders into the design team and manage their role (Scaife & Rogers, 1997).

In this phase it was also important to determine the dates and the objectives of the three workshops, and potential questions to an initial questionnaire:

- General opinion about the first workshop (e.g., Are the scenarios discussed plausible? Can you identify some advantages/disadvantages associated with the use of the system? …)
- The use of digital public displays (e.g., Do you known cases of public displays in school context? What difficulties may arise from the users (teachers and students) regarding the public display and the use of a smartphone? …)
- Ethics (e.g., What kind of ethical issues may arise in this context? …)
- Expectations regarding the public display system (e.g., Do you think that your school community will use the system? …)
- The use of video in the learning process (e.g., Have you ever used video in the classroom? ...)
- The participatory design process (e.g., Do you like the first workshop? Do you change anything?...)

As a result, the team validated the questions of the questionnaire. Analysed the participating teachers list and their respective groups of recruiting. It was also discussed the position of the video cameras to collect data from the workshop.

2.1.1 First workshop – The participatory design model and the goals of JuxtaLearn project

The purpose of the 1st workshop was to present the participatory design model and the goals of JuxtaLearn research project. First we introduced the participatory design model, briefly explained by the following topics:

- Create innovation with added value for stakeholders.
- Design something that everyone wants to use and be able to use.
- The active involvement of users for a clear understanding of user and task requirements.
- An appropriate allocation of functions between users and technology.
- Iteration of design and evaluation processes.

Then JuxtaLearn project and its goals were explained: *Students studying science and technology often encounter barriers to their understanding of complex concepts, and frequently poorly motivated to overcome these barriers. Focusing on 'performance' JuxtaLearn will provoke student curiosity in Science, Technology, Engineering, and Mathematics through creative filmmaking and editing activities* (Adams et al., 2013). It was also explained that the Portuguese research team had the responsibility of designing and developing a

digital public system as a pedagogical tool for teachers to bring digital information into public spaces. Therefore, it was important to realize teacher's perceptions about integration of digital public displays into school context. To understand the possibilities for the use of digital public displays to encourage further exploration of the content and facilitate the creation of groups of interest.

Figure 1 Explaining the JuxtaLearn project

Figure 2 Discussing the possible features of the display sytem

In this process, an overview of the uses of digital public displays was presented. After this initial explanation, the twelve teachers were distributed in groups of three elements and challenged to find in the Internet five examples of public displays that could be transferred to scholar context. Several scenarios of known public displays usage were launched, namely:

- Advertising or informative screens placed at city facilities like tourism posts, pharmacies, football stadiums, museums and banks (with maps, events or schedules). These were pointed to be of low interactivity.
- Touch screens as ticket machines at services.
- Displays that allow users to take pictures and automatically send it by email (the ones known by the participants are at Lisbon Expo and Barcelona train station). This display was pointed to be of high interactivity.
- Big screens that besides advertising film, use the passer-by in order to promote engagement.
- ATM screens used for advertising.
- Wall display placed at University of Coimbra that allows several users to interact directly and simultaneously with it.

Teachers were challenged to describe possible scenarios with the digital displays chosen and the features that they considered more relevant. Because shared displays have ethical issues, the equal access to the digital display was extensively debated. Dialogue about the ethical concerns of the transference of those displays features to the school context was promoted. Teachers said that not all students have computers or smartphones to interact with the display. One teacher said: *"The only difficulty I see is that not all students have a smartphone, which puts each student disadvantaged in relation to others. This approach could emphasize economic differences between students"* (verbalization taken from the video). Other teacher pointed: *"(...) Why not use touchscreens so that all students can use the application without the need of having a smartphone?*" (Prof4). Thus, some teachers suggested the possibility of installing a touchscreen to allow interaction. Although this would solve the problem of access it would not guarantee the same type of interaction since doing something on the mobile phone is different from using a publicly available point of access. Furthermore, the teachers also pointed out that in the school the use of mobile phones is highly restricted: *"I believe that the use of mobile phones by pupils at the school is forbidden"* (verbalization taken

from the video). Hence, the JuxtaLearn solutions need to take into account these issues in order to facilitate the emergence of fairness in access and use.

Another ethical issue had to do with the need of protecting minority groups and facilitating diversity of opinions. Teachers pointed out the need to investigate mechanisms to protect the diversity of the schools' populations and try to promote the expression of different opinions, topics, likes and dislikes.

The participants considered important that the system to be deployed would need to allow some degree of customization in order to reflect potential differences concerning the specificities of schools' rules. That was particularly relevant for the protection of privacy.

Teachers thought important to consider the need to safeguard the diversity of topics and not restrict the content to STEM. Such stance would allow the generation of interest to a wider audience.

Teachers also were very sensitive to the need to find appropriate content control mechanisms. In fact, this is central to the adoption of the system since the general opinion seems to be that any incident would jeopardize the deployment of the system. Some suggestions pointed to the possibility of facilitating access only to registered users.

Other question under discussion was the possibility of the display to provide multiple events simultaneously: *"A student might be seeing the bus schedule and another colleague may be seeing a school sports content"* (verbalization taken from the video).

It was also discussed the option of incorporate a playful and ludic part in the display in order to maintain students motivated, and also some quizzes about the video content could improve student's motivation to interact with the display: *"They (students) like to play cards"* (Prof2) or *"Cards… any game… then we can also arrange games with quizzes (…) Those games that come in PSP's ... or Science quizzes, Chemistry quizzes ... they can interact ... we have to think in interaction, right?"* (Prof5).

It was assembled a section with other information to be performed in conjunction with the videos, such as information from the school board, school schedules, etc. Teachers defined the possible roles to be performed like JuxtaLearn manager (assign the people responsible for the video lists; manage the institutional content; define the rules for video appearance; …), the role of the teacher (check the interactions; manage the video content; ...) and the role of the student (interact with the videos presented: vote, share, comment, pull, respond to quizzes, …).

Teachers were asked to answer an online questionnaire about the activities of this event namely: their general opinion and expectations about the JuxtaLearn project, the use of interactive public displays at schools, the ethical issues that might arise, and about the participatory design process itself. The online questionnaire was fulfilled after the meeting. This allowed the teachers to reflect on the issues presented and discussed.

2.2 Theoretical embedding

This phase is anchored in the previous stage. Concerning the wide variation of possible interventions and contexts, "systematic efforts are made to apply state-of-the-art knowledge in articulating the theoretical rationale for design choices" (van den Akker, 1999, p. 8). It is fundamental that the design could be grounded from a both practical and theoretical point of view. Our options must arise from the knowledge with other experiences and from other actors that had the same dilemmas. Thus, examples of good practices are good benefits.

After the first workshop, the team had a work meeting to analyse the answers from the first online questionnaire and video transcriptions.

2.2.1 Second workshop – Paper prototypes

Building upon the results of the 1st workshop, the goals of the second one were to involve the teachers on concrete aspects of the implementation of those thoughts. Teachers were invited to develop concrete

scenarios for the implementation of the digital public displays from a pedagogical point of view, and its possible uses within JuxtaLearn and the corresponding needed functionalities.

The team started evoking the ideas aroused from the first workshop, and entered into dialogue for approximately 10 minutes. Potential scenarios for the use of public displays were presented and another period of discussion of approximately 15 minutes followed. Teachers were invited to reflect about what functionalities the smartphone, the computer and touchscreen should have. In groups of three elements, the participants were encouraged to create Low-Fidelity Prototypes (paper prototypes) of the design of the technological devices involved. Prototypes are the manifestation of ideas in germination. Low-Fidelity Prototypes are easy to create, easy to manipulate, and good for providing an understanding of the overall system structure (Virzi, Sokolov, & Karis, 1996). Teachers were also invited to simulate a story of interaction using the prototypes designed, and present to other groups the found scenarios solutions. Several dialogues between groups occurred. At the end, teachers were asked to answer an online questionnaire about the activities of this event.

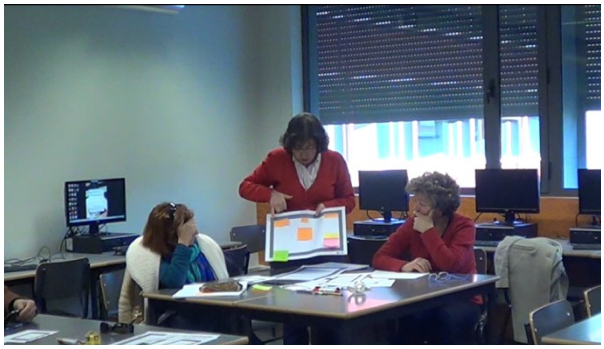

Figure 3 Teachers doing low-fi prototyping

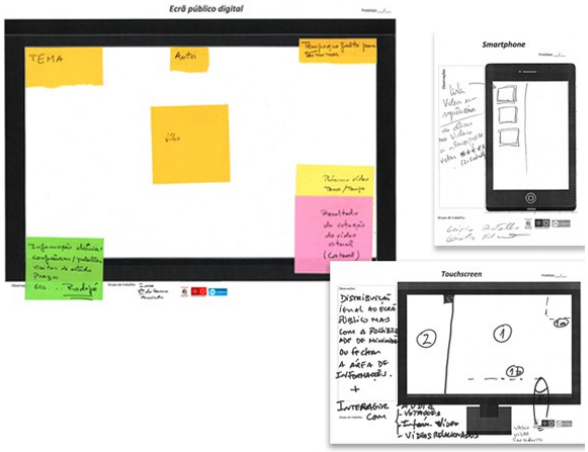

Figure 4 Some examples of low-fi prototypes made by teachers in the 2nd workshop

2.3 Empirical testing

In the development research process, this is the stage to choose the best solution among the several others that emerged in the design process. So, this phase should focus on the development of the approved design followed by the evaluation cyclic process.

The team analysed the data obtained from the previous sessions, particularly from the last one with the paper prototypes, the video records and the questionnaires. These data were studied and discussed in detail. Many interfaces can look good in a sketch or on paper but confounding details can show up when things start to move and interact or constraints are added. Building a prototype can help clarify the reality of how the interface really works (Zdralek, 2000).

It was agreed, at this stage, that it was possible to design a first high-fidelity prototype respecting teacher's inputs and using promising examples for related purposes. A high-fidelity prototype is an artefact that is quite close to the final product, with all details and functionalities. From a user testing point of view, a high-fidelity prototype is realistic enough to be able to test usability questions in detail and make solid conclusions about the system. This lets the team discover which ideas are good and which are not, and also

discover if users can figure out how to use the system. Thus, with a high-fidelity prototype it is possible to make really good usability evaluation tests.

2.3.1 Third Workshop – First high-fidelity prototype

The third workshop was focused on the discussion of the high-fidelity prototype designed from the results of the previous two workshops (opinions, beliefs and context knowledge of the participants). The team discussed with the teachers the advantages and disadvantages of the prototype presented, and the possible scenarios of use. Teachers were invited to discuss the technological possibilities presented by the development team. After the presentation of the prototype, teachers were asked to discuss the design and the features exhibited, and comment whether they reflect the work done in the previous workshops or not. Teachers were also invited to design one last scenario of the use of the system, based on this high fidelity prototype.

The workshop ended with a discussion on how to engage learners to start interacting with the system. From the teachers' point of view there will be no problem to engage students for the JuxtaLearn project, and the usability tests with the prototype can start. One teacher pointed out: *"I would say that the interaction with the videos is fine ... but it is necessary to call their attention to the screen and to the interactive applications with mobile. It is necessary to have challenges, games, dispute anything, a prize, a goal ... initially ... then the educational videos alternated with those applications ... because, in the end, they want to have fun ... "* (Prof5 - 11:45)

The team met again to re-examine the high-fidelity prototype that resulted from the 3rd workshop, now with the teacher's new inputs. Also analyse the data from the questionnaire number 3 and the data obtained from the video records.

Figure 5 High-fidelity prototype

2.4 Documentation, analysis and reflection on processes and outcomes

In this last phase "much attention is paid to systematic documentation, analysis and reflection on the entire design, development, evaluation and implementation process and on its outcomes in order to contribute to the expansion and specification of the methodology of design and development" (van den Akker, 1999, p. 8).

As mentioned, all sessions were videotaped and an online questionnaire was delivered after each session, to be filled at home. This allowed the teachers to reflect on the issues presented and discussed. The data from each questionnaire were analysed between sessions in order to foster the next session. In the end, data gathered from the video records and from the answers to the open-ended questions (of the three questionnaires) were coded in an inductive approach for qualitative data analysis (Bardin, 2013). In order to assure the validity of the coding process, initially, a first coder categorized the corpus. 255 units were identified, and 19 categories emerged from data. For each category, a list of indicators was defined to help a more precise description of each registration unit of analysis. In order to guarantee the reliability of the encoding process (Coutinho, 2013), another coder was asked to categorize all the information according to the list of dimensions obtained in the exploratory content analysis. The second coder was a team researcher, so the two researchers discussed the conceptual categories and rehearsal some examples of encoding different types of evidences (thematic units). After this initial preparation, the second coder categorized the corpus independently and inter-rater percents of agreement were computed. In the end, four main categories emerged from data: (1) motivation for adoption, (2) Pedagogical practices, (3) organizational and (4) ethics. Data obtained are guiding the team in the implementation of the project in the school.

3. CONCLUSION

A high-fidelity prototype has been co-designed with experienced teachers that have the role of planning the educational experience, respecting their inputs but also the school organisation and the power dynamics that exist there.

Case studies about the integration of technological innovations in educational contexts are important and necessary. However, traditional educational research has long been criticized for its weak link with practice (van den Akker et al., 2006). *Development research* is an emerging trend that can contribute to more relevant practice by studying progressive approximations of ideal interventions in their target settings. As we see in this *development research* evidence, it is possible to build increasingly viable and effective interventions, with better articulation of the principles that sustain its impact. If successful in generating findings that are more widely perceived to be relevant and usable, the chances for improving also increased. Development research also has the aspiration of increasing the robustness of design practice. From this kind of research approach there is a necessity to obtain explicit learning that may promote subsequent design efforts.

This paper proposed a *development research* approach that allowed, for one hand, the conception of a new tool pedagogically adjusted to students learning needs as well as to the school organizational rules and structures. On the other hand, our methodological approach aimed to foster the acceptance of the tool as a useful pedagogical instrument for other teachers and for the whole school ecology (Zhao, 2003).

After we collected all the data gathered from the three workshops, the design team developed the display system. To properly test the system from a usability point of view with the end-users, a video context is being promoted at the school. In this process of promoting and stimulate the video contest, another cycle of *development research* begins. It is among these interactive cycles of development and research that this methodology is useful.

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