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ICT in Education

Multiple and Inclusive Perspectives

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Preface

ICT in Education—Multiple and Inclusive Perspectives contains a selection of revised and extended versions of the best papers that have been presented at the 15th edition of the International Symposium on Computers in Education (SIIE) that took place in the Polytechnic Institute of Viseu, Portugal, in November 2013. SIIE is an international forum that joins researchers, institutional representatives, and educators for presenting, discussing, and reflecting on research, development, and practices in the field of Information and Communication Technologies (ICT) in Education, with a special focus on the Ibero Latin American context, that has been held alternately and mostly in Spain and Portugal.

The symposium always encourages the submission of original contributions of high quality in a vast set of thematic areas. The 2013 edition from which these papers have been selected focused on design, development, and evaluation of educational software; interaction design for education; design and standardization of educational technologies; modeling languages and metadata; data mining and Web mining for education; semantic Web in education; intelligent educational systems; personal learning environments; tools and Web-based educational resources; games and simulations in education; virtual laboratories; ubiquitous/mobile computing and education; robotics and education; free/open software; open knowledge and open educational resources; technology, knowledge, and skills management in education; emerging technologies in education; use and evaluation methodologies of ICT in educational contexts; innovative experiences of ICT in teaching/learning; social aspects of ICT in educational settings, gender, cultural diversities, and specific audiences; ICT applications for special education needs; teacher education and ICT; distance education; social Web; collaborative systems; and learning communities.

The selected papers were chosen from the highest rated by the Scientific Committee of the symposium and from an additional on-conference rating done by the chairs of the several sessions that composed the symposium. They give an idea

of the main areas and levels of education covered and of diversified approaches where ICT can be used to foster learning. They provide also contributions from researchers of diverse countries presented at the symposium.

A final word to thank the Program Committee of the 15th SIIE, the session chairs, and the authors who with their effort and extra work contributed to this volume.

Coimbra, Portugal — Maria José Marcelino
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Viseu, Portugal — Maria Cristina Azevedo Gomes

Contents

The Use of Communication Technologies in Higher Education in Portugal: Best Practices and Future Trends

Lúcia Pombo, Nídia Salomé Morais, João Batista, Marta Pinto, Dalila Coelho, and António Moreira

Abstract This chapter presents and discusses best practices and future trends in the use of Communication Technologies (CT) in Portuguese public Higher Education Institutions (HEI), from a literature review between 2008 and 2013, triangulated with the opinion of Higher Education teachers, using interviews. This contribution emerges from the project "TRACER—Portuguese Public Higher Education Use of Communication Technologies", which aims to contribute towards the characterization of HEI according to their adoption and use of CT in educational contexts.

The literature review reports best practices, although with different approaches, such as the frequency and satisfaction of using CT as learning support, the design of teaching strategies, the roles and responsibilities of students and teachers, among others. Current trends indicate the progressive integration of CT, namely Web 2.0 and LMS/VLE tools, in teaching and learning processes, containing a potential for innovation, as well as motivation. Future trends are related to the increasing use of CT for educational processes, highlighting the growing incorporation of mobile devices, used at the service of collaboration between educational actors. Training for the pedagogical use of CT is stated as relevant, considering the fast technological change and principles advocated by the Bologna Process.

Keywords Communication technologies • Higher education • Best practices • Trends

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1 Introduction

Over the last decade, Higher Education has been experiencing an exponential increase in the use of Communication Technologies. This is verified worldwide, and specifically in Europe since the implementation of the Bologna Process, which gave institutions recommendations towards a rise of students' autonomous work, enhanced by the use of CT. The rapid access to Internet made the massive use of CT tools and environments that support a networked, participatory web (OECD 2007a) possible, consequently triggering many changes at the levels of teaching and learning practices, and institutional practices towards supporting educational processes and structures.

CT are ubiquitous in Portuguese HEIs, and research concerning their use shows the different types of CTs used both by students throughout their training process, by teachers integrated in their teaching practice, and also in the institutions in general.

Aiming to provide up-to-date knowledge on Portuguese Public Higher Education Institutions, this paper reviews national studies, analysing the types of CTs used and their different perspectives of use, as far as educational practice is concerned. This paper's focus lies within a project that was developed at the University of Aveiro (2011–2014): "TRACER—Portuguese Public Higher Education Use of Communication Technologies" (http://cms.ua.pt/TRACER). TRACER aimed to contribute towards a large-scale and comprehensive study in Portugal, characterising HEIs according to their adoption and use of CTs in educational contexts. The data collected within this project would be presented through an online interactive Information Visualization tool, whose main goal was to contribute towards valuable and up-to-date information concerning the use of CTs in Portuguese HEIs, highlighting research that might support innovation towards a new stage of technology-enhanced teaching and learning practices. The main goal of this paper is to make an overview of the studies published on the use of technology in Portuguese HEIs, between 2008 and 2013, in order to update information in the scope of the project. This overview will be triangulated with the opinion of Higher Education teachers as to: (1) current trends, (2) future trends and (3) measures to promote the use of ICT.

TRACER's main research questions were:

- What technologies are being used in Portuguese Higher Education Institutions?
- What are the purposes underlying CTs used? and,
- What is the impact of the use of CTs in the teaching and learning process?

These questions allowed the formulation of the following objectives:

- To identify the CTs that are recently being used in Higher Education in Portugal;
- To analyse the purpose of use of CTs in educational contexts;
- To examine the main results of the use of CTs as to their impact on the teaching and learning process.

The vast emerging and disperse body of literature justifies the relevance of the present literature review, aiming to provide a synthesis of the research conducted in the field, and to draw the impact of these technologies in teaching and learning contexts, illustrated with empirical examples of CTs use in HEIs. The remaining part of this paper is organized into three sections: (1) the methodology used; (2) the main results, including a brief reference to the selected documents and their qualitative analysis; and finally (3) some concluding remarks.

2 Methodology

The present literature review, which covers documents published in the last 5 years on the use of CTs in Portuguese HEIs, has no ambition of being comprehensive and complete. Its analysis and synthesis followed three phases: first, the documents were selected for analysis taking into account the main aim of this paper—to select studies (empirical or theoretical) that describe concrete experiments in the use of CTs in educational contexts, in Portuguese Higher Education, from 2008 to 2013. All the studies that did not match these criteria were excluded. In the second phase, in an attempt to synthesize findings, the identified documents were listed and organized on a grid for description purposes, which included: (1) the kind of publication of the selected documents (journal papers, conference proceedings, Ph.D. theses, Masters dissertations, or other), (2) the categories of CTs, according to the taxonomy of Morais, Batista and Ramos (2011); and finally (3) the perspective of the use of CTs that were the object of the documents themselves (teacher or trainer; student or trainee; the institution); the third phase of the study consisted of a qualitative analysis in terms of results and impacts—e.g., if the experience was favourable towards technology-enhanced teaching and learning practices.

The search strategy began as a broad online search, in the Portuguese open scientific repository RCAAP (*Repositório Científico de Acesso Aberto de Portugal*),[1] and Portuguese open access journals, such as *Indagatio Didactica*,[2] *Educação, Formação & Tecnologia*,[3] given the knowledge of the researchers, that they are relevant search locations for national publications concerning the theme. The keywords used for searching these databases were: Communication Technologies, Higher Education, Learning, Internet, Web 2.0, Blogs, Social Networks, among others, combined using appropriate Boolean operators. The keywords were searched in the Portuguese language.

After identifying the preliminary set of documents, each reference was analysed in order to identify their correspondence towards the defined criteria of: (1) date:

[1] http://www.rcaap.pt/

[2] http://revistas.ua.pt/index.php/ID

[3] http://eft.edu.com.pt/index.php/eft/index

documents published between 2008 and 2013; (2) context: documents related to the Portuguese reality; (3) domain: Higher Education; and (4) aim: documents that describe the use of CTs in educational contexts.

To reach teachers' opinion about current and future tendencies of the use of CT, eleven Higher Education teachers were interviewed. Regarding the context of the data collection six distance interview sessions were performed through Skype. The remaining five sessions took place face to face. In three cases, the interview session was supplemented with written information through the script and filling in of their return to the electronic address of the TRACER project. Under prior informed consent, all interview sessions were recorded. In the case of face to face sessions a recording audio was made as a support. In interviews made at a distance, recording audio and video was made by screen capture systems. The full transcript of the interviews was based on the following criteria: (1) the need to give priority to understanding and following the broadcast content. This option implied sometimes the connection of ideas which effectively had been mentioned at different times. An attempt was made, however, to keep as much as possible the original interviewee's speech; and (2) rectification of natural markings of orality (such as repetitions, hesitations or silences) in order to make reading and understanding of the transcript more fluid. The choice for these criteria was duly communicated to the respondents at the time of transcription validation request, and accepted by them. The interviewed teachers were from PPHEI (6), the polytechnic subsystems (3) and college (3). The 11 interviewed teachers were teaching in the academic year 2012/2013 and had extensive experience in research and/or academic supervision in areas related to ICT in teaching and learning. At the time of data collection, three of the respondents had complementary roles in management positions and management in the respective PPHEI.

In the process of collecting and analysing data, the following understandings were made: (1) a trend is the orientation or common options in terms of the use of CT; (2) a good practice is considered as the extent to which a resource, infrastructure, group or other existing or anticipated element in the institution promotes the use of CT in teaching and learning, or in streamlining of academic, administrative and communication procedures; (3) a teaching practice is considered the practice of others or of oneself intentionally directed to the development of knowledge of some other persons who are learning.

Following is the data and the respective analysis methodology which generally combined qualitative and quantitative options.

3 Main Results

The main results of the search produced a limited number of documents that were subjected to scrutiny. These will now be addressed as to kind of publication, the categories of CTs referred to in the documents, and the perspective of their use in HEIs, as explained above.

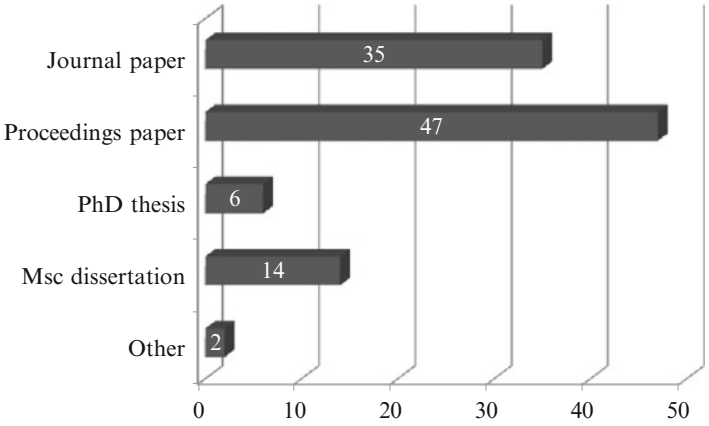

Fig. 1 Type of publication of selected documents

3.1 Type of Publications Selected

The literature review resulted in 104 key documents (see Fig. 1) categorized by type. Most of them (47) were published in conference proceedings, 35 in journals, 14 were Masters Dissertations, 6 Doctoral theses and 2 belong to other kinds of publications, such as book chapters.

3.2 Type of CTs Described

The selected documents were organized according to the type of CTs referred in the texts, on the basis of Morais et al. (2011) taxonomy. In this taxonomy CTs presuppose the use of Internet as a communication platform. The categories presented are not mutually exclusive, given the possibility of some including characteristics that allow to mark them in more than one category (Batista 2011), thus their sum is higher (137) than the total number of analysed documents (104). The categories and the number of documents per category are illustrated in Fig. 2.

3.2.1 LMS/VLE

Most of the documents (23) report the use of Learning Management Systems (LMSs) in Portuguese Higher Education. According to Gomes et al. (2011a, b), this category of CT is available in the vast majority (86.6 %) of the Portuguese HEIs. In fact, these platforms are probably the most recognized and dominant CTs in the academic context and HEIs have heavily invested in their implementation (OECD 2007b). In terms of their features, LMSs enable the sharing of content, synchronous

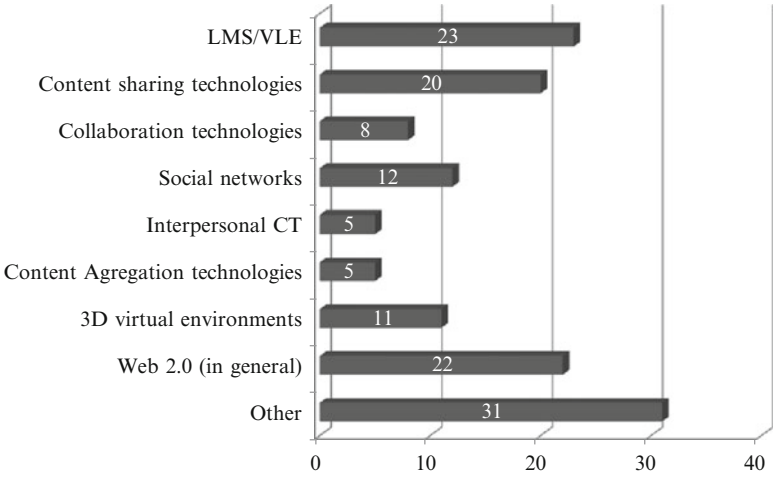

Fig. 2 Number of documents per categories of CTs, according to Morais, Batista and Ramos (2011) taxonomy

and asynchronous communication, the conducting of academic exams, handing in assignments, among other possible tasks (Marques and Carvalho 2009). According to our review, it appears that platforms are one of the CT categories most used by students (Morais et al. 2011) and teachers (Batista 2011), in learning contexts in HE. The Moodle platform is the most referred one (Loureiro and Barbas 2008; Lopes 2011).

In general, studies show that the users classify the use of LMSs as a positive experience, with gains at an educational level, namely in communication activities and in the clarification of doubts (Batista 2011; Fernandes and Maneira 2008; Morais 2012). Students and teachers also report frequent use of LMSs in providing educational content, delivering information, as well as publishing work and conducting evaluation exams (Morais et al. 2011). Duarte and Gomes (2011) list the following most common uses for LMSs in HE:

- Supplement for classroom activities;
- Training in e-learning and b-learning scenarios;
- Supervision of academic research;
- Promoting the creation of communities.

3.2.2 Content Sharing Technologies

Publication and content sharing technologies are used to put content online, in the form of text, pictures, audio or video, to be shared with other individuals. Examples of these technologies are blogs, wikis, podcasts and platforms such as YouTube® or Flickr®. The use of content sharing technologies was reported in 20 documents: 2 Ph.D. theses, 5 journal papers and 13 conference papers. Most of these documents

present results from the students' perspective of use (16), 4 also present the teachers' perspective and 3 are about the use, in general, of these technologies. Some of the documents (5 from Morais, Batista and Ramos) are about the use of these technologies as a category, showing that, apart from LMSs and interpersonal communication technologies, content sharing is one of the most used categories of CTs. Other documents are about the use of specific technologies, mainly presenting the research results of Carvalho et al. (2010) work on the use of podcasts. One of those documents shows that students are keen to use podcasts, especially when they are short in length (Carvalho et al. 2010). Research about the use of wikis, blogs or web radio technologies, were also found. Finally, one document focused on the use of YouTube from an institutional perspective (Figueiredo et al. 2011).

3.2.3 Collaboration Technologies

As to collaboration technologies we have found eight studies that focussed on several collaboration technologies, like the use of Del.icio.us to promote research in education (Coutinho and Bottentuit Junior 2008), blogs, podcasts and Google Sites as educational applications in teacher training courses (Coutinho 2009), and a study on the opinion of post-graduation teachers as to the use of Social Bookmarking in higher education. To allow for the remainder of the studies that compose these eight studies, another five focus on the institutional perspective of the use of collaborative tools (Batista 2011; Batista et al. 2011), this last one more focussed on frequency and satisfaction of the use of learning collaborative tools to support learning; another attempts to characterise the learning activities promoted by CTs in general (Morais et al. 2011); still another, this time focussing on the issues of gender in the perception and assessment of CTs used as a learning aid in HE (Morais 2012), and a description of an on-going project about the use of CTs by HE students (Morais et al. 2011).

3.2.4 Social Networks

From the 12 studies that focus on Social Technologies, 5 correspond to studies also categorised under Collaboration Technologies, as could be expected, in fact, the above-mentioned studies (Batista 2011; Batista et al. 2011; Morais et al. 2011). Morais (2012) also pays attention to this issue of social networking within the use of CT in institutions among students, teachers and non-teaching staff. Seven of the studies tackle social networking issues like pedagogical presence in Facebook (Gomes et al. 2011a, b) and Facebook in the learning process, as a learning network and its use in HE (Patrício and Gonçalves 2009); social networks, in general, as they are used by students in Higher Education contexts (Miranda et al. 2008) and in learning (Miranda et al. 2011); and finally a similar approach as to the use of social networks, this time focussing on activities developed in social networks at HE level (Morais et al. 2011).

3.2.5 Interpersonal CTs

Interpersonal CTs are technologies that allow direct personal communication between individuals. The most paradigmatic example is electronic mail, which allows asynchronous private communication. Other examples of interpersonal CTs are VoIP, such as Skype, or chat tools existing as stand-alone applications or integrated in other tools.

Five documents approach the use of interpersonal CTs: 2 Ph.D. theses, 2 conference papers and 1 journal article. All of these 5 documents present results of a project from the University of Aveiro. These documents deal with the use of interpersonal CTs from the point of view of the student (Morais 2012), the teacher and the institution (Batista 2011). They have found that this category of CTs is almost universally used in the public Portuguese HE context, which is evident in the three perspectives mentioned. Very high levels of satisfaction with the use of these technologies were also found (Morais et al. 2011).

3.2.6 Content Aggregation Technologies

As regards technologies that allow content aggregation, we found five documents reporting the use of this type of CTs in learning contexts in HE. These CTs allow users to obtain information provided by a particular website, without having to visit it (Conole and Alevizou 2010). Although there are numerous studies (22) addressing the use of Web 2.0 tools in HE, in general the use of aggregation technologies is still limited in learning contexts. In fact, the results of a nationwide study in Public Portuguese HEIs (Morais et al. 2011) revealed that both teachers and students still make little use of this type of CTs in learning contexts, although many students perceive their usefulness (Morais 2012).

3.2.7 3D Virtual Environments

With respect to 3D virtual environments, although mentioned in 11 documents, only 6 specifically addressed their use in the educational context. The social environment Second Life is one of them. Its huge success registered among the public and amongst media communication is mainly due to its markedly social nature and its potential interest for the fields of business and education (Pita 2008). Generally, documents refer to the virtual environment Second Life, a 3D technology with about five million inhabitants, from different parts of the world, as promoting the students' motivation and interest in learning (Esteves et al. 2008). One study describes the results of a project developed by a large team of teachers and students, who collaboratively built all the 3D objects that became part of the virtual space of a Portuguese HEI (Loureiro et al. 2008). The studies conclude that the interaction promoted within virtual worlds induce a more frequent and better participation from students, due to the absence of hierarchical barriers and conventions, as long as you are an adult and comply with the environments' rules.

3.2.8 Web 2.0

Other documents deal with Web 2.0 (22), not specifying what kind of CT has been used in HE environments, but mentioning pedagogical experiences in the use of Web 2.0 tools (Marques and Carvalho 2008) or analysing the use of Web 2.0 tools in b-learning contexts (Marques and Carvalho 2009) or even in learning communities (Aresta 2009). Other documents analyse the use of Web 2.0 tools in pre-Service Teacher Education Programs (Coutinho 2008, 2009; Patrício and Gonçalves 2009). Generally, the literature agrees that Web 2.0 opens up a space of informality and playfulness that motivates children, youth and adults and develops skills which are essential to any informed citizen in the twenty-first century, such as to be engaged, to produce contents, to empower critical skills, to be part of communication networks, to work collaboratively, among others.

3.2.9 Other CTs

It is possible to point out that the category "Other CTs" comprises the highest number of documents (31), because it includes documents related to specific technologies that were not included in the taxonomy adopted in this paper. Other CTs include personal learning environments, digital resources, Google pages, videoconferencing technologies, web radio, etc. This category also includes general documents about reflections on e-learning or mobile practices, or general practices on the use of CTs, most of them (Morais et al. 2009) evaluating the perspectives and the enhancement of the use of technologies in teaching and learning practices.

3.3 Perspectives of CT Use

Research concerning CTs and their use in HEIs embraces different foci of analysis, meaning the different types of actors involved in the use of the CTs, such as teachers, students, the institution. Figure 3 shows the perspective or opinions that were the object of the paper (teacher or trainer; student or trainee; and the institution) of the analysed documents. The majority of selected documents (78) concern the study of specific uses of CTs by students in the learning process and the approaches to teaching and learning, as studied by Lemos (2011) or Silva (2012), among many others. Other studies concern the perspective of the teacher or trainer (37) to evaluate the use of a certain CT as a means for technology-enhanced teaching and learning practices, such as Chagas (2012). Twenty-one of the total documents present the institutional perspective—current academic and administrative strategies and practices—of the use of a specific set of emerging tools covered by Web 2.0, as well as studies of the institutional perspective in the context of public Portuguese HEI (Batista 2011; Morais et al. 2011; Moreira and Balula 2010), or studies about the institutional adoption of e-learning (Gomes 2008; Gomes et al. 2011a, b).

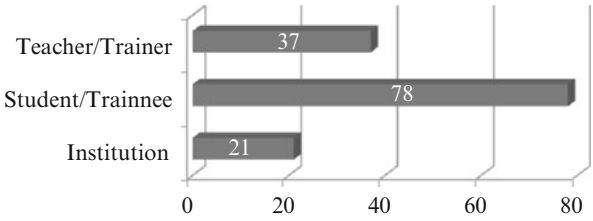

Fig. 3 Perspectives of CT use

3.3.1 Tendencies and Best Practices in the use of CT in Teaching and Learning—teachers' Perspective

The teachers' perspective regarding current and future trends and best practices in the use of CT in teaching and learning was obtained by analysing data collected through 11 semi-structured interviews (5 face to face and 6 at a distance, using Skype). The teachers were from 6 public Portuguese HEI (3 polytechnics and 3 universities).

The interviews were based on four questions whose analysis explored several dimensions and categories specially prepared for the purpose, to be presented alongside the presentation of the results retrieved in each question. A detailed description of the content analysis approach used can be consulted in Batista et al. (2014). In the following points a brief analysis of the results obtained is presented, per question, according to the sequence of questioning.

Question 1

Currently, which trends do you identify in teachers' use of CT in teaching and learning in your Higher Education Institution?

The responses obtained to this question informed about three distinct dimensions: the type of CT used, the type of pedagogical activities conducted and qualitative information about the predominance or scarcity of such use.

Regarding the type of CT used, a global amount of 61 evidences was found in the 11 interviews, mentioned in the Table 1. The dominant tendency referred was the use of *learning management systems* (n = 17, all corresponding to the *Moodle* platform) and *interpersonal communication technologies* (n = 12, where *email* is the most frequently used).

The learning management platform Moodle is the CT category in which teachers mentioned more diversity of types and subtypes of pedagogical activities. A possible explanation for such use might be connected to the wide institutional adoption of this platform, as well as the diversity of functionalities allowed within the Moodle environment.

The *nature* of the use was analysed regarding four categories of pedagogical activities. Evidence about the nature of the use was observed in 10 of the 11 teachers interviewed, in 49 references (see Table 2). The current tendencies correspond to a dominant use of CT in dissemination activities (n = 24), particularly in the *learning management platform* Moodle. In the remaining CT types of activities, references were usually made regarding broader categories, and the specification per activity subtype is scarce.

Table 1 Current tendencies in the use of CT in teaching and learning by teachers, regarding CT type—number of evidences

CT types	Type of use			Total
	Rare	Moderate	Dominant	
Learning management systems (LMS/VLE) (*Moodle*…)	1	1	15	**17**
Content sharing technologies (*Dropbox Blogs*, *Wikis*, *Flickr*, *YouTube*, *Podcast*, *Social Bookmarking*, *videoconference*…)	0	1	8	**9**
Collaboration technologies (*Google Docs*, *Social Bookmarking*, *Mind Maps*, *Wikis*, *Blog*…)	2	1	3	**6**
Social networks (*Facebook*, *Twitter*, *LinkedIn*, *Ning*, *Academia.edu*,…)	4	1	1	**6**
Interpersonal CT (*email*, *MSN*, *Skype*…)	1	0	11	**12**
Content aggregation technologies (*RSS feeds*, *Netvibes*…)	0	0	0	**0**
3D virtual environments (*Second Life*, *Habbo*…)	0	0	0	**0**
Mobile devices and tools	1	0	3	**4**
Other	3	1	3	**7**
Total	**12**	**5**	**44**	**61**

Table 2 Current trends in the use of CT in teaching and learning by teachers, regarding type of activities—number of evidences

Type of activities	Type of use			Total
	Rare	Moderate	Dominant	
Dissemination activities (providing class and extra-class materials; propose class or extra-class activities; dissemination of other elements…)	2	1	21	**24**
Discussion activities (clarifying doubts; commenting learning activities; proposing and moderating discussion topics…)	3	3	10	**16**
Discovery activities (search, collection and selection of information; individual and collective creation of content; using simulation environments…)	1	1	2	**4**
Evaluation activities (assessments tests; publication of assignments; building portfolios; participating in collaborative environments)	3	0	4	**7**
Total	**9**	**5**	**35**	**49**

Table 3 Best practices regarding the use of CT—number of evidences

Categories	Total
1. Adoption of innovative teaching and learning methods supported in CT (e.g. personal learning environments)	3
2 Continuous following of the student's learning process by CT	1
3. Development of useful competences for the student's future working contexts (digital, linguistic…)	4
4. Creation of CT for supporting pedagogical practice (e.g. software, app, website…)	5
5. Integration of CT in pedagogical practice (e.g.. software, app, website…)	8
6. Researching pedagogical practices that resort to CT	1
7. Creation of digital educational resources (e.g. video-records of classes)	1
8. Sharing digital educational resources (e.g. video-records of classes)	1
9. Creation of educational content for mobile (e.g. tablet…)	0
10. Integration of mobile technologies in pedagogical practice (e.g. tablet…)	0
11. Promotion of collaborative work between students	2
12. Promotion of collaborative work with teachers	2
13. Promotion of accessibility	5
14. Others	9
Total	**42**

Question 2

Which best practices do you identify in your Higher Education Institution regarding teachers' use of CT in teaching and learning? Please explain why you consider them to be best practices

In the answers provided to this question, 42 best practices were identified and the respective content was codified against 13 thematic categories (see Table 3). These categories were adapted from a previous survey conducted online with teachers from Portuguese public higher education institutions regarding the use of CT. It was possible to identify practices respecting nearly all categories. The majority of the practices mentioned (n = 13) concern the *creation* and *integration of CT in pedagogical practices* (categories 4 and 5). No evidence was found about the creation of educational contents (category 9) for mobile technologies and the integration of mobile technologies in pedagogical practice (category 10).

Some examples of best practices identified refer to the use of e-learning platforms for promoting the debate in communities of practice, sometimes involving external experts; transferring new methods used in e-learning to face-to-face classes; and the development of competencies in the use of CTs such as blogs and wikis.

Question 3

What future trends do you see for your HEI, regarding teachers' use of CT in teaching and learning?

Regarding this question, teachers were invited to share what they foresee for CT use in teaching and learning and within their HEI. 58 codifications were produced

Table 4 Future trends in the use of CT in teaching and learning by teachers, regarding CT type—number of evidences

CT types	Type of use			Total
	Rare	Moderate	Dominant	
Learning management systems (LMS/VLE) (*Moodle*…)	0	2	1	**3**
Content sharing technologies (*Dropbox Blogs*, *Wikis*, *Flickr*, *YouTube*, *Podcast*, *Social Bookmarking*, *videoconference*…)	0	5	2	**7**
Collaboration technologies (*Google Docs*, *Social Bookmarking*, *Mind Maps*, *Wikis*, *Blogs*…)	0	0	7	**7**
Social networks (*Facebook*, *Twitter*, *LinkedIn*, *Ning*, *Academia.edu*…)	2	2	3	**7**
Interpersonal CT (*email*, *MSN*, *Skype*…)	2	4	3	**9**
Content aggregation technologies (*RSS feeds*, *Netvibes*…)	0	0	1	**1**
3D virtual environments (*Second Life*, *Habbo*…)	0	0	0	**0**
Mobile devices and tools	0	1	13	**14**
Other	0	7	3	**10**
Total	**4**	**21**	**33**	**58**

about the type of CT, 33 of which refer to a strong dominant use of CT, 21 to a moderate use and 4 to a rare use (Table 4). The strongest future trend identified by teachers (n = 14) were the use of *mobile devices*, such as *tablets*, cell phones, *e-books* or laptops, considered as leading trends by 13 teachers. Collaborative technologies are also presented as a strong trend. *Other* CT categories are also identified, such as the mention of future trends technologies like interactive television, migration to cloud computing or the use of free computer apps. There were no references to trends related to 3D virtual environments, also a technology, nor to motivation or students interest in learning (Esteves et al. 2008).

In the remarks of 9 teachers there were 16 references made to the nature of the use of CT (Table 5). Highlights focus on the use of CT in *discussion activities* (n = 5 dominant), and dissemination and discovery activities (n = 3 moderate in each case). Some of the examples given by participants about the future trends include a stronger work and discussion about collaborative work, the use of geocaching and QR codes as possible ways to extend class and computer into other spaces.

Question 4

Considering the goals and possible difficulties deriving from the Bologna Process, what actions do you consider should be taken to promote the use of CT in teaching and learning?

There were 27 actions identified, to promote the use of CT in teaching and learning, distributed by the categories in Table 6. Fifteen of those actions are from the diverse categories considered and 12 actions correspond to the category *Others*.

Table 5 Future trends in the use of CT in teaching and learning by teachers, regarding type of activities—number of evidences

Type of activities	Type of use			Total
	Rare	Moderate	Dominant	
Dissemination activities (providing class and extra-class materials; propose class or extra-class activities; dissemination of other elements…)	0	3	0	**3**
Discussion activities (clarifying doubts; commenting learning activities; proposing and moderating discussion topics…)	0	2	5	**7**
Discovery activities (search, collection and selection of information; individual and collective creation of content; using simulation environments…)	0	3	1	**4**
Evaluation activities (assessments tests; publication of assignments; building portfolios; participating in collaborative environments)	0	0	2	**2**
Total	**0**	**8**	**8**	**16**

Table 6 Actions to promote the use of CT—number of evidences

Category	Total
Accessibility CT	3
Training offered in *blended learning*	1
Training offered in *e-learning*	1
Training offered in *mobile learning*	0
Sustainability of CT	0
Interoperability of systems	0
Adopting *cloud computing* solutions	0
Offering open educational resources (e.g. MOOC)	0
Offering digital educational resources	0
Creating services of technical support, for teachers use of CT	0
Creating services of pedagogical support, for teachers use of CT	1
Creating infrastructures for the use of CT (e.g. videoconference rooms)	0
Offering technological equipment and resources (e.g. computers)	0
Teachers training and professional development	4
Extracurricular training for students	5
Offering institutional services regarding the use of mobile technologies	0
Investment in educational resources and mobile technologies	0
Strategic planning about CT	0
Management of institutional presence on the **web**	0
Protection of students and teachers data	0
Use of security services on the web	0
Others—detail	12
Total	**27**

Some of the actions indicated include the development of use of Web2.0 technologies and social networks in educational contexts; communication sharing and collaboration made easier by using social networks; the development of blended learning approaches; teacher training, mainly regarding adequate pedagogical approaches to use CT; the use of CT to follow students activities and promote their autonomy. Additionally actions more focused on an institutional nature were identified, such as the creation of a technological observatory.

4 Final Remarks

The literature review triangulated with the opinion of Higher Education teachers had no intention of being exhaustive or complete, as some analysed documents are limited in time, such as those which are based on academics' aims, as doctoral thesis and masters' dissertations. The documents analysed revealed some trends in the use of CTs in Portuguese HEIs which are in line with the opinions of the Higher Education teachers interviewed. The triangulation of data shows a strong occurrence of the use of technologies that allow their users to share and publish educational content, the featured use of Web 2.0 tools and of learning management systems (LMS). The use of Web 2.0 and LMS/VLE tools and environments is a trend in teaching and learning practices in HE as revealed by numerous studies analysed from this very same angle. Accordingly, teachers report they use mostly LMS/VLE platforms, such as Moodle, for dissemination. The use strongly anchored in the Moodle learning management platform to disseminate information and as a contents repository is highly reported by HE teachers, and also reported by Batista (2011); however, there are positive signs of the exploitation of other features of the system (such as for discussion and evaluation) and the incorporation of more open CT, enhanced by Web 2.0, promoting more collaborative practices.

In spite of there being fewer studies focused on the use of collaboration technologies, interpersonal CTs, and content aggregation technologies, the practices reveal that these CTs are being highly used by most HEI (e.g. email, Skype, wikis). Some of these categories also fall under the Web 2.0 technologies that lead to strengthening the use of web tools and environments in the teaching and learning practices. Although international studies relate this use to the change in the roles played by teachers and students, in a disruptive approach of more traditional ways of learning, this was not clear in the present review or in the testimony of HE teachers, despite the many examples of best practices reported. Nevertheless, CTs appear as promoters of key elements in teaching and learning, such as motivational (Garris et al. 2002), containing a potential for innovation.

The collected data reinforce the interdependence between institutional and individual practices, making this interdependence important so as to promote concerted actions on these two perspectives. A growing organization of courses in learning management platforms is observed, as well as other administrative systems in the

digital environment. These systems appear to occupy a prominent place in the teaching practice, which reveals the weight of the institutional adoption of CTs in the individual practices of teachers, and the need to change strategies grounded in the knowledge and involvement of both perspectives (Bates and Sangrà 2011; Batista 2011). However, the existence of certain CTs in HEI does not necessarily imply their use by teachers, and even less their adoption into educational practices.

There are several studies reporting good practices, although with different approaches, such as the frequency and satisfaction of using CTs as learning support (Batista et al. 2011), the design of teaching strategies (Lopes 2011; Pombo et al. 2009), the roles and responsibilities of students and teachers in distance or blended learning contexts (González et al. 2011), the interaction in distance communication contexts (Israel and Moshirnia 2012), among others.

CTs seem to be an important ally in individual processes and adjusted to the reality of students, by allowing new ways of training offer at a distance or streamlining the management of educational activities in the classroom training. The use of CT, such as mobile devices, is increasingly present in the daily lives of students and teachers (Peters 2007), increasingly being brought to the educational situation at the service of the construction of knowledge, and it should be the object of increasing attention from educational actors and the academic community (Dahlstrom and Difilipo, S 2013; Difilipo 2013).

To promote the use of CT, both by teachers and students, and in the light of the Bologna Declaration, particularly with regard to supporting the organization of independent work of students, teachers report that it is important to invest in the training of teachers and students, to help support and manage the hours of autonomous work. For example, they mention schedule management tools (e.g. Doodle) and implementation of group work (e.g. Google Drive®). The collaborative technologies can still be an important aid in the fulfilment of self and peer designs recommended by the Bologna reform, facilitating the systematization and monitoring of work within hours of autonomous work (e.g. group), helping students to register time spent per task, the work performed by each member of the group, difficulties, the results of each meeting, among others.

Several international studies (e.g. JISC 2012; Johnson et al. 2011) relate the use of CT with changing roles played by teachers and students, as well as reporting disruptive approaches to more transmissive teaching perspectives in HE. However, in the literature review (Pombo et al. 2013), it was not possible to conclude that these changes are common in the Portuguese context. In general, if one considers that CT is being used mainly for "delivery", which derives mostly from a transmission perspective, and aims specially at the acquisition of knowledge, it is not being used to prepare students to face the challenges of the information society and new labour markets (JISC 2012).

Keeping up-to-date with the information related to the adoption of CTs in Portuguese HEIs and their impact on the teaching and learning practices is a difficult task, due to a vast and fragmented number of publications, leading to the need of a serious and expedite systematisation. This brings us to the ultimate goal of the online information visualization tool U-Tracer, proposed by the project TRACER,

aiming to systematize this information and make it accessible online in order to facilitate access to such data. Through information visualization techniques of interaction with the information, and its graphical representation, the U-Tracer will enhance the national overview of the use of CTs in HEIs, with up-to-date data directly provided by the HEIs.

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The Participatory Management Process of the Coordination Team of a Postgraduate Distance Education Course Supported By the Use of Interaction and Communication Technologies

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Abstract This chapter aims to describe how Interaction and Communication Technologies (ICT) have supported some important interactions between the subjects of a distance education postgraduate course in computers in education. Highlighting the interactions among the multidisciplinary team members, in a participatory management model, through a shared educational leadership, focusing on improving the teaching-learning. For each communication channel it will be described the subjects involved, the resources used, how communication occurs and the support to participatory management.

Keywords Communication • Interaction and Communication Technologies (ICTs) • Participative management • Distance education

1 Introduction

A particularity of Distance Education (DE) is that the team, teachers, tutors and students are, for the most part, in different times and places, which makes the teaching and learning process more complex. However, Moore and Kearsley mentioned that the biggest problem is not the physical distance between them, but the transactional distance, defined by them as "the gap of understanding and communication between teachers and students caused by the geographical distance that needs to be supplanted by differentiating procedures in the development of the directions and by facilitating the interaction" (Moore and Kearsley 2008).

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One way to reduce this transactional distance is to increase the dialogue and interactions between the people involved. However, it is a great mistake to think only in transactional distance between students and teachers/tutors because in distance education the students are shut out from the institutions as well as its management, and it is from this thought that major problems arise in the method. There are many individuals involved in the process, so that communication between student and tutor-teachers take place in the best possible way, the interactions among the other team members should also be thought out, planned and executed.

However, as Mattar mentions (Mattar 2009), a major problem of institutions that offer distance courses in the aspect of the interactions is that they stop there. That is, build a model that emphasizes the "who" of the interaction, leaving aside the "what". Or to put it another way, they focus on individuals who interact, but do not define the nature, the objectives of these interactions. We add here that besides the need to define the "who" and "what", you must define the "how" i.e., how you can implement these interactions effectively.

It is essential, therefore, to define the existing communication paths and the means used for this to happen, through Interaction and Communication Technologies (ICT).

It is worth noting also that for this goal to be achieved, we consider it important that the institution and especially the course management team work according to the principles of participatory management in a shared educational leadership.

"In addition to the control, which aims greatly to ensuring the basic performance standards, stimulation to reach higher, broader, new and more advanced results is needed. Therefore, while the control practices are performed, it is essential to link them to the dialogue, the feedback, the guidance and self-reflection as a means of inspiration and awareness […]." (Lück 2010)

The use of participatory management in distance education aims to meet the challenges posed by this type of teaching that requires a creative management, therefore their educational and management processes are distinct from the traditional process of regular education, being more dynamic and complex.

The purpose of this chapter is to describe some of the important relations of communication between the multidisciplinary team of the postgraduate course in Computers in Education, offered at a distance by Instituto Federal do Espírito Santo (IFES), highlighting its objectives, the individuals involved and the main technological resources used in order to reach a participatory management. It will be cited also some evidences that point to positive impacts on the course due to this format adopted and the acceptance of the team.

2 Some Interactions of the Course Multidisciplinary Team

To carry out a distance learning course, it is necessary the presence of several individuals who, in various ways, act to promote quality education, efficiently and effectively. We have to understand this individual as one who: "Recognizes itself as

different from objects, creates and discovers meanings, establishing senses, develops concepts, ideas, judgments and theories. It is endowed with ability to know himself in the act of knowledge, i.e. is capable of reflection" (Chauí 2000).

In the distance education model in the postgraduate course in Computers in Education from IFES, we have as participants in the process, among others, the following professionals: course coordinator, mentoring coordinator, pedagogue, text reviewer, instructional designer, academic advising coordinator (or thesis coordinator), training teacher, content teachers, distance tutors, presence tutors, thesis advisor and, of course, the student, the central focus of the entire process.

At present the course have completed three classes (the first with 120 pupils, the second with 250 and the third with 160), two running (with 160 students each) and another starts this year (160 students), currently in the selection process. The current team consists of eight content teachers/trainers, 14 distance tutors, four present tutors, 43 thesis advisors and the coordination team. This course is the responsibility of the Reference Center for Teacher Training and Distance Education, whose main objectives are: promoting and supporting distance education and the use of technology in education in IFES; develop the training of teachers and other education professionals, through teaching, research and extension.

The coordination team is responsible for planning and execution of the course, and is chosen by the course coordinator, tutoring coordinator, pedagogue, instructional designer and academic advising coordinator.

The content teachers are responsible for the tasks of planning and preparation of the contents as well as the virtual classrooms in the virtual learning environment, while the training teachers are responsible for the discipline management during its realization, and for the adequacy of activities and assessments. In the postgraduate course in Computers in Education from IFES normally these roles are performed by the same person.

The present tutors and distance tutors perform the interactions directly with the students, while the present tutors are available in person at the student service hubs to answer general questions of the course, the methodology and tools used. The distance tutors are responsible for guiding the studies of the students, and evaluate them and answer questions of specific subjects and, for this; they use the virtual learning environment (VLE) Moodle.

To ensure the quality of distance learning courses it should be kept in mind that the social interactions that are so to speak, the "vehicle" of communication in teaching and learning, should be treated with special attention, Fig. 1 shows some interactions between individuals in the postgraduate course in Computers in Education from IFES and with external parties to the course, but many were omitted, as it would create so many bonds that it would make an unreadable figure (Nunes 2012). We can observe interactions: the physical support Hub Coordinator, the Material Production Coordinator, the Infra and VLE-Moodle Coordinator and the Academic Registry Coordinator. It is evident the existing complexity in the various interactions that must exist between the various individuals seeking the planning and the execution of the course.

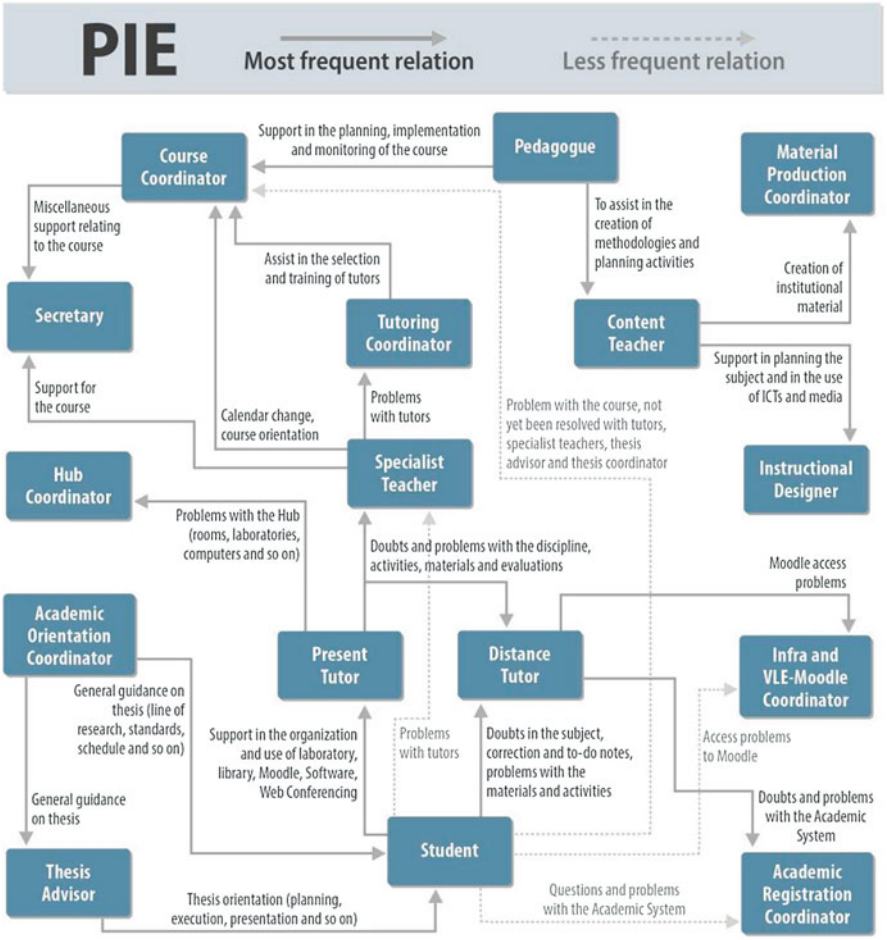


Fig. 1 Some interactions between individuals of a postgraduation distance course (Nunes 2012)

3 ICT Communication Support

Moore and Kearsley (2008) point out that "in all education must be communication between the educational organization and the student. In distance education, this communication takes place through some form of technology." The main tools used to support synchronous communications are: the chat, activity that can be made available in any virtual room of Moodle; the web conferencing provided by the National Research Education Network (RNP); as well as communication tools available on the network like Skype and Hangout. In addition to these tools, synchronous moments are promoted through traditional mechanisms such as in-person meetings and telephone contacts. As for the asynchronous moments these features

are used: message and forum, available in Moodle virtual rooms, besides the traditional email. The use of email is not very encouraged when it comes to the process of mediation between tutors and students, as these records are not available for the whole team which may hinder its use as a base for the analysis of the difficulties and the evolution of learning of the student.

In addition to these tools, we have as a great support virtual rooms that serve as a meeting point between various individuals. The main existing rooms in the course are: the virtual classrooms of the subject matters, the planning rooms of the subject matters, the management and communication room between all members of the course team (called team coordination room) and the communication room between the course coordination team and the students (called students coordination room). Each room has a different purpose, but all are important in the communication process and the strengthening of ties between individuals. In addition to these rooms, the postgraduate course in Computers in Education still has a "thesis coordination room" (to monitor the implementation of theses) and the "development rooms" (where teachers prepare their disciplines together with the material production team).

We will outline here the rooms used in the interaction and exchange of experiences among members of the multidisciplinary team and between them and the students.

3.1 The Team Coordination Room

To promote the exchange of experiences among team members and a better management of courses a virtual team coordination room was created, as shown in Fig. 2. In it are present all members of the course multidisciplinary team. In this room are available discussion forums and exchange of experiences and other features such as polls and downloadable files (course design, regulations, meeting minutes, calendars, staff contacts spreadsheet, etc.). It is for the exclusive use of the coordination team, teachers and tutors, and its proposal is to be an open room.

In it are available: the planning of all disciplines in order to facilitate the planning process in an interdisciplinary and transdisciplinary approach proposed by the course design as well as function as a repository of general documents relating to the course. In this virtual room, teachers and tutors can get: minutes of meetings, implementation schedule of courses, team contact list, course design, legislation on postgraduate and distance education, etc. (Passos et al. 2014) The availability of materials in a single place and the possibility of exchanging information and sharing problems and solutions is of great value as a way to ensure the same methodology in geographically distributed hubs (Nobre et al. 2008).

As quoted in Nunes et al. (2009) "[…] this room serves as the meetings of the teachers that occur in the presential teaching, in which they discuss the behaviors and productivity of students, the situation of physical support hubs, problems

Fig. 2 Coordination-team virtual room. *Source*: http://cead.ifes.edu.br/moodle

encountered etc.". Through this room, the tutoring coordinator has access to all the distance tutors and can provide evaluation forms, instructions for tutoring, among others.

3.2 Student Coordination Room

To promote better interaction between the coordination team and the students, Fig. 3, the virtual student coordination room was established. In this room participate: the coordination team (course coordinator, tutoring coordinator, pedagogue, instructional designer, thesis guidance coordinator and secretary) and all the students of the course. To promote greater freedom of communication, teachers and tutors do not participate in this room.

The virtual student coordinating room is the course team connection space with students, a place where there is information exchange possibilities and questions

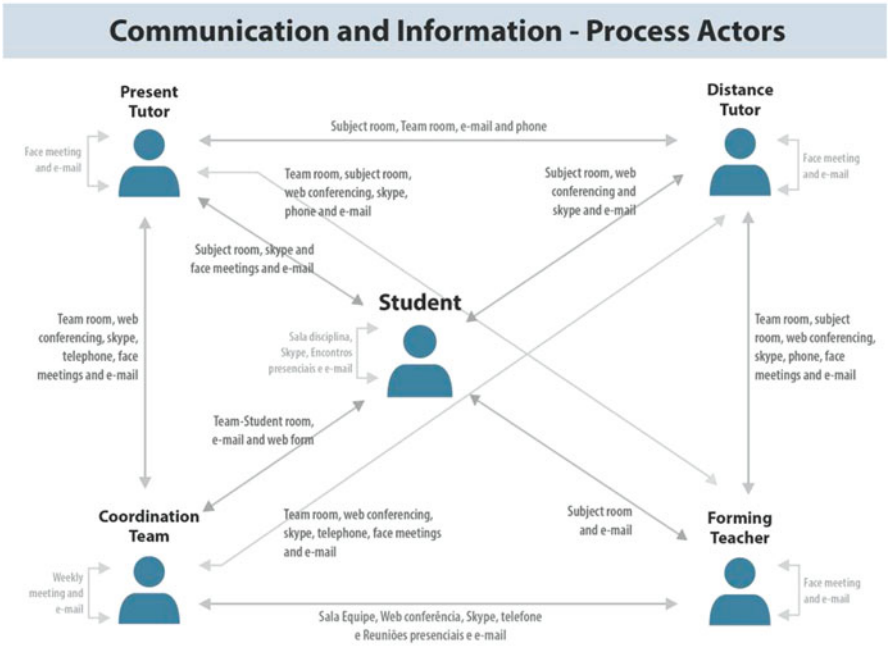
Fig. 3 Virtual coordination—student room. *Source*: http://cead.ifes.edu.br

from students. This is where the administrative matters of the courses are addressed which may occur through the use of discussion forums, where it is possible to have questions, suggestions and even raise problems that may occur in the disciplines, at the physical support hubs, etc., always taking into account the student code of ethics of IFES (Passos et al. 2014).

> Making a comparison with the presential mode, it is like a coordinating body room with open doors in which the student enters, asks for a document he needs, clarifies a question, complains about something while the work of the coordinator is to get from room to room to give the messages. The difference is that here everything is done in a single virtual location (Nunes et al. 2009).

In this coordination room documents are made available such as: course project, calendar, code of ethics, rules etc. In addition, it aims to encourage student participation in some discussions, even contributing about methodologies adopted in some of the disciplines. It is very important also for the tutoring coordinator, who has access to the entire group of students and can, for example, probe the problems related to tutors.

In addition to the rooms, interaction also occurs by the use of several synchronous and asynchronous tools, as can be seen in Fig. 4, which aims to explain the various tools used for interaction and communication, highlighting the participating subjects of the teaching-learning process of a distance learning course—present tutor, distance tutor and training teacher, directly responsible for the conduct of the subject matters. In addition, it is worth highlighting the interactions carried out by



Ferramentas	Synchronous	Asynchronous
Subject Room	Chat	Message and forum
Course Team Room	Chat	Message and forum
Course Team-Student room	Chat	Message
External support	Web conferencing, skype, phone	E-mails and social networks

Fig. 4 Interaction and communication process (Passos et al. 2014)

the coordination team of the course responsible for performing the pedagogical support during the offer of disciplines. Figure 4 shows the key tools and support rooms used in interaction and communication processes.

4 The Communication Process in the Postgraduate Course in Computers in Education

Moore and Kearsley (2008) and Mattar (2009) highlight some types of interactions in distance courses. Despite the already mapped out by these authors, we have some important interactions that have not yet been discussed. Recuero states that "[…] the more cooperative interactions, the stronger the social bond of this structure becomes, which can generate a cohesive and organized group" (Recuero 2005). Given the relevance of these interactions, we will try to describe them in the way that they

occur between individuals in the postgraduate course in Computers in Education from IFES and the resources used.

The effectiveness of the adopted model has been perceived through existing formal instruments of evaluation in the course, and applied frequently to students and members of the staff, and also through virtual observations in the learning environment and face observations in subject meetings, team meetings, encounters with students, among others. Some statements obtained through these means will be presented below as evidence.

4.1 Communication Between the Individuals of the Coordination

It is essential that interaction occurs between members of the coordination team. In the postgraduate course in Computers in Education from IFES, communication stems mainly from performing weekly in-person meetings. Such meetings reinforce the existing shared leadership of the course, with information sharing and decision making, based on the analysis of the various nuances coming from distance education. This communication also occurs by e-mail, for surveying points for meeting agendas, provision of minutes, referrals from these and even to solve simpler issues or emergencies. It is also made use of phones.

To convey messages to the members of the multidisciplinary team and the community in general, we use a specific email for the course. All coordination team have access to this email account, which enables them to be aware of what happens in the course and that any team member can read and/or send emails through it. As Lück quotes, through shared leadership, "the empty spaces left by a person may legitimately be filled by another […]" (Lück 2010).

Another tool also widely used is Google Drive, a virtual disk maintained by Google that lets you keep a repository of files, as well as shared text, spreadsheets, presentations, etc. editing. The coordination team may, for example, be working on changing the course project, on preparing the list of books for the libraries, the administrative material list, etc. This often happens by shared editing of those files, where each coordination team member can make a contribution.

All documents considered relevant to be shared with the entire team (coordination team, teachers, tutors and thesis advisors) are available in the virtual room—"Coordination Team Room" (Nunes et al. 2009).

This form of coordination team's performance in a shared leadership is positively perceived by the rest of the staff, as shown in the following tutor statement:

"Every decision you take together. No one is better than anyone else, everyone is there together. […] it must be that way, it truly is a democratic management. You participate along with others, to make a decision (Tutor)."

4.2 Communication Between Coordination Team × Teacher

The main form of interaction between the course coordination team and the content teachers and/or training teacher is through in-person meetings to get reports, policies, and experience sharing. This is an example of shared leadership, in which, as Lück cited (2010) the participants are free and feel free to act creatively in order to achieve the goals.

In the case of the content teachers, the interaction takes place from the meetings for the planning of the disciplines in which the course coordinator participates with the instructional designer and the pedagogue. During this period, the meetings are more frequent in accordance with the meeting schedule presented by the instructional designer and agreed with by the participants. The coordination team also interacts with the training teachers in-person meetings of the disciplines, which will be discussed below, by email and through the team coordination room in order to monitor and give effective support in the teaching-learning process.

From team meetings held by the course coordination specific demands on the planning and/or review of disciplines take place, that lead to other specific meetings between the instructional designer and the pedagogue, to discuss and propose to the content teacher and/or training teacher possible changes and/or adjustments in their discipline or group of disciplines in order to favor the teaching-learning process.

The instructional designer also carries out meetings with the more specific objective of reviewing together with the teacher or group of teachers of concomitant disciplines, the accumulation of content and/or activities in the weeks of the realization of the course, the development of interdisciplinary activities etc. Again, shared leadership proves itself and brings positive results, as we can see in the statement from the instructional designer (ID) of the course:

"The disciplines became more consistent with the reality of the students. […] Sometimes the students were overwhelmed with activities that did not add much. […] Another issue that was greatly improved was the interdisciplinarity. We can do some activities and even interdisciplinary tests. […] And a lot has changed, thoughts were improved, disciplines too, the group was improved." (ID)

Losso and Sartori say that "To renew pedagogical practices, we need to renew concepts. Teachers should get out of the comfort zone they are in and seek at technology an ally in formulating educational strategies […]" (Losso and Sartori 2011).

The instructional designer also mediates between the content teachers and the material production team. He oversees the filling out of forms to request resources and/or activities by the teacher, as well as the edition of the room on the virtual learning environment and the creation of animations, videos and other resources by the production team.

The "Planning Room" offers good support for this interaction, because it can be used to provide the various planning and monitoring tools, as well as, of course, forums in order to discuss the methodologies adopted and encourage collaboration between colleagues by supplying various materials.

In addition to in-person meetings and the planning room, the instructional designer also interacts with teachers through email and telephone.

4.3 Communication Between Course Coordinators and Tutoring Coordinators × Classroom Tutors and Distance Tutors

The course coordinator and the tutoring coordinator, along with the teachers, are responsible for managing the tutoring. The interaction between these individuals happens at various times and in different ways. One way is through face meetings to get reports, define policies, report problems and solutions, as well as for sharing experiences. Individual face meetings are also held when it is necessary to address any specific point with a tutor, such as problems identified in his performance. However, despite being a very effective solution, face meetings can only be done sporadically due to the need to travel, especially for the classroom tutors, who generally live in cities from the countryside. Another option are the meetings held by means of the use of tools like Skype or web conferencing environments, these work well when there is the participation of only a small number of people.

As during the course there is the need for many punctual communications, or solving emergency situations, email, phone and Moodle messages show themselves to be very useful. Another feature also widely used is the "Team Coordination Room," in which coordinators teachers and tutors perform several tasks, discussions, provide materials and share experiences, which greatly favors the communication between them. The importance of this space is explicit in this statement from a tutor:

> *The Coordination Room helped me a lot with respect to documents, to check what was the function of a distance tutor, of a classroom tutor* […]. (*tutor*)

The tutoring coordinator is responsible for conducting follow-up work and evaluation of the work done by classroom and distance tutors and gives them feedback for continuous improvement of their performance. As stated by a tutor on the feedback of the evaluations:

> *If you understand your role and how to perform, the return of this evaluation will be a positive. Now if the return is to follow another path, it may be that my role was not well understood and this* (*the feedback*) *made me stop, rethink*. (*tutor*)

Since in this interaction and monitoring process, tutors and the coordination itself will be improving their practices, we can say that this is an initial approach to educational leadership, which, according to Lück, is focused on the formation of learning organizations and is expressed in:

> i) modeling, by the use of example, according to the principle that "words move, but the gesture drag"; ii) monitoring, by follow-up, observation, observing presence and the feedback given to the task; and iii) dialogue, opportunity for expression, joint construction of meanings, exchange of experiences and ideas (Lück 2010).

4.4 Communication Between Training Teacher × Distance Tutor

The training teacher is responsible for the fulfillment and the quality of the mediation of the process of teaching and learning between distance tutor and pupil in a particular discipline. It is he who defines the activities to be carried out, assessments, criteria. On the other hand, it is the distance tutor who mediates the process, since it is he who interacts with students, correcting their assessments and clarifies their doubts. Thus, for the process of teaching and learning to occur properly, the postgraduate course in Computers in Education from IFES adopts a strong interaction between teacher and distance tutor (Nobre et al. 2008). The tutor can give the teacher valuable information for improvement of content and available activities through a shared leadership work.

In order to reduce transactional distance between teachers we highlight the challenge of establishing communication, especially between the training teacher and distance tutor. Following are some reports:

> *The conflicts that I've been through were because the tutor did not dialogued with me. I have never denied a dialogue towards the tutor. And I also have been a tutor and never faced dialogue problems as a tutor with my training teacher.* (*distance tutor*)
>
> *Now in some situations where the student comes into direct contact with us because they have tried with the tutor and failed it would be a "fire outbreak" situation, But then I usually tend, perhaps the key of the business, act with great transparency. That message that the student sent me I answer him with a copy to his tutor, putting 'look I'm copying your tutor' for him to be aware of what's going on.* (*Training teacher*)

For these interactive challenges to be overcome we must promote communication and interaction both through in-person or distance meetings, and through chats, web conferencing, e-mail or the virtual coordination room, etc.

In the coordination room, each discipline has a specific forum (Fig. 5) in which teachers and classroom tutors and distance tutors can interact, as to report best practices and issues. So they can discuss, answer questions and find solutions together.

Fig. 5 Experience exchange forum in team coordination room. *Source*: http://cead.ifes.edu.br

In addition, the forum can also be easily monitored by the coordination team, so that their reports can serve as support to the redesign of the disciplines in a new edition of the course. The use of email for this case would make it difficult to search for the information. As stated by a tutor:

> *I think this space is worth it, because by e-mail there are several mixed subjects Thus, having a centralized coordination space in the room is useful, if well utilized. Because it is our area of discussion.* (*tutor*)

The face meetings reinforce important aspects to start, monitor and close the disciplines and, therefore, at least three are required, one for each of these moments: the initial meeting, the intermediate meeting and the final meeting.

The main purpose of the initial meeting is for the teacher to explain to distance tutors all necessary guidelines regarding the discipline, such as methodology, calendar, activities and assessments to be carried out, the literature and the teaching material used, among others. That meeting came to be accompanied by the pedagogue of the course in order to also give a more pedagogical approach to the beginning of the course. This should occur at least 2 weeks before the start of the course (Passos et al. 2014).

The intermediate meeting will be attended by the tutoring coordinator and aims to adjust the running of the discipline, especially in relation to tutoring activity performed in addition to facilitating the exchange of experience with tutors on the difficulties encountered and the solutions adopted. The moment of the meeting is also appropriate to make the correction of physical tests, since the teacher can instruct tutors in order to use uniform criteria. In it referrals are given to the final stage of the discipline (Nunes 2012). It must occur at half the time allotted for the duration of the discipline, enabling even some intervention in it before closing (Nunes et al. 2013).

The final meeting is aimed at closing notes and evaluation of the conduct of the discipline. In this way, we seek to better understand the classes and students, to be able to be better in the next offered courses. In addition, the collection of best practices and setting of dates for the closing of issues and guidelines are made. In this meeting the coordination itself takes part in addition to the teachers and tutors. This meeting should take place at the end of the course (Nunes et al. 2013).

By the statements of the teachers of the course, one can see the effectiveness of these meetings to establish a time for reflection, exchange, and dialogue:

> *The meetings that have been scheduled are excellent. I think that before you even have a better cooperation with colleagues, you seek a different look at what you suddenly planned. And the relationship is also important. Having a close relationship with whom you will work. Nothing better than a look at the other, to know each other a little better.*
>
> *With my tutors we did that initial meeting, which I found very interesting, because you clearly realize who is who. Because besides the involvement, attendance, from the beginning I had already given access to the room and asking for contributions. So I had those tutors who told me about individual items, even a little mistake in Portuguese, and some information that was not clear.*
>
> *The intermediate meeting is the most important* […]. *Much that sometimes I spoke, but that was in the air, in the middle meeting they realized the importance.* […] *I also made web conferencing and it worked fine.*

Some teachers highlight the initial meeting, others the intermediate, but it is evident the importance given to these three moments for reflection, exchange of experiences and finding solutions together. In the case of the postgraduate course in Computers in Education from IFES, whose disciplines are planned and executed in an interdisciplinary way, such meetings positively impact the teaching-learning process.

During the courses, the training teacher monitors the progress of students in the physical support hubs through reports delivered by the distance tutor on the group of students under his responsibility. It is possible also to follow the tutor's work through the access reports on Moodle environment, as this access should be daily. The teacher can also make samples in classes accompanied by the tutor.

4.5 Communication Between Classroom Tutor × Distance Tutor

In the postgraduate course in Computers in Education from IFES, the distance tutor is a learning manager for a given subject of a certain physical support hub. The classroom tutor, in turn, is from a specific presence support hub, but not from a specific discipline. So it is the distance tutor that has specific knowledge in the discipline to serve the students, but it is the classroom tutor who is in the attendance support hub, has face meetings with students and therefore knows them better. This work in which distance and classroom tutors make decisions jointly aiming at a common goal, which is student learning, again walks towards shared leadership.

Thus it is very important the interaction between distance tutor and classroom tutor, to try to avoid or solve problems. The distance tutor can, for example, inform dates of activities and assessments, pass information from the teacher, suggest the assembly of study groups on more complex issues. The classroom tutor can tell the distance tutor about the profile of the students, identified learning disabilities, students who are not attending the support hub, those who are not dedicated enough etc. As stated by a classroom tutor:

> […] *When I met the distance tutors* (*in person or virtually*) *I passed information to them about the students*. […] *I am not only the classroom tutor*; *I am the eye of the distance tutor*, *the eye of the teacher*, *for them to try to understand here*. (*Classroom tutor*)

There are several tools used for this communication. The first highlight is to the disciplines forums in the team coordination room. But also the use of Moodle messages, emails, chats, web conferencing etc.

4.6 Interaction Between Training Teacher × Classroom Tutor

Students interact directly with the distance tutor and the classroom tutors. Detected problems, in person, may be informed by the classroom tutor to the distance tutor and, if necessary, the training teacher and course coordinator. The teacher solves the

problems that are his responsibility and informs the distance tutor, that they then announce to the classroom tutors and students.

In practice, communication from the training teacher occurs more with the distance tutors and of those with classroom tutors, i.e. the communication of the training teacher with the classroom tutors is often indirect. This can cause delays in detecting and solving problems, especially in the case of poor performance of some distance tutors. Thus, vigilance is needed so that there is direct communication between these, so that the classroom tutors can also collaborate on decisions and necessary modifications during the course, in the shared leadership process.

> […] *When I was evaluated I did not contact the classroom tutors … I did not know I was supposed to contact them.* […] *But from that moment on my practice changed completely. Today there are very few things I do not contact the classroom tutor.*
> (*Distance tutor*)

Again, it stands out as a means of communication the virtual team coordination room, through specific forums of the subject matters. Through these the classroom tutors can always be aware of what is happening and can interact whenever they find it necessary.

We can see for example, from the statements presented below, obtained in the subject forum "Distance Education and Virtual Learning Environments" on the Coordination Room (Team), the interaction between the training teacher of the subject, PROFA, and classroom tutors and distance tutors, so that the presented situations by some of the students could be accompanied with greater proximity (Fig. 6).

At times, teachers can also hold web conferences with the classroom tutors to pass guidelines, for example, to carry out assessments or classroom activities. It is also made extensive use of Moodle messages and email. The phone is less utilized, since the classroom tutors are in cities from the countryside and the cost of long distance calls is still high.

Fig. 6 Experience exchange forum in the team coordination room. *Source*: http://cead.ifes.edu.br

4.7 Student Interaction with Other Parties

Students of the course communicate with the classroom tutors in physical meetings at the support hubs, where they can answer their questions and be informed about the proposed practical tasks, and have the opportunity to meet other students, whether from their course or other courses and even from other universities. This, as quoted by Mattar (2009) "[…] characterized what is called collaborative and cooperative learning, which involves the social aspect of education […]".

In the presential moments methodologies will be used to promote discussion and reflection on the student's path, as well as for implementing actions through laboratories equipped with computers using specific software as needed, besides the application of mandatory presential tests, regulated by distance education legislation that requires that more than 50 % of the grade given to students must be made in presential evaluation activities. The hub support, in addition to an academic environment, is an integration environment between students and reinforces the sense of belonging to an educational institution. To Mattar (2009), that interpersonal interaction "[…] generates motivation and attention, while students await feedback from peers, and reduces the feeling of isolation from distance learning […]".

Students communicate asynchronously through messaging tools and existing virtual forum on the subject rooms, with peers from their class, distance tutors, the classroom tutors and specialist teachers. Although not encouraged, they use e-mail as a means of communication. Moore and Kearsley (2008) state that "[…] students generally consider the interaction with their peers stimulating and motivating […]" and usually "discussions between students are extremely valuable as a way to help them to reflect on the content that was presented […]".

They have also synchronous moments scheduled to be conducted through the chat tool of the virtual classroom, web conferencing by RNP and Skype, with distance tutors, classroom tutors and specialist teachers. These moments are used to answer questions on the content being studied, the resolution of tasks and even more detailed explanations, which could not be carried out only with the distance resources. To Mattar (2009), "the interaction, synchronous or asynchronous, provides motivation and feedback to students, assisting their learning."

In the course coordination room, for the students' communication with the team, you can deal with issues relevant to the course, but not to the subjects that should be addressed in virtual classrooms of their respective subject. In it, he can interact with the coordinator, pedagogue, specialist teachers, of all disciplines, and with classroom and distance tutors. They can express their opinions, make suggestions and many more inquiries In it they also get information about ancillary study materials as well as information about events in their area. Moore and Kearsley (2008) state that the interaction of the students with the teams who carry out the administration of the courses and particularly with instructors is important.

5 Conclusions

One of the great difficulties of an institution to start working in Distance Education is to establish efficient ways of communication between all involved, using appropriate technological resources. Often these matrices of interaction emerge slowly, but, until they have a mature model, several problems will have arisen.

From the various forms of communication and the use of technology in the promotion of them, we have that the communication dimension of education stands out as an integrating and transforming action. Freire (1996) states that it is essential that, for the communicative act to be efficient there is agreement between the communicating subjects, so that the language one uses is perceived within a common framework significant to the other.

In addition to the communication, in order to establish a rich and creative dialogue between subjects, we excel through a shared leadership in order to seek this integrating and transforming action referred by Freire. A shared, collective and committed task, which is discussed by all in order to cope with the dynamism necessary for monitoring educational practice.

It is worth noting that although it is a distance learning courses that uses the most diverse technological resources for communication, such as web conferencing, chats, forums, collaboration tools, email, rooms in the virtual learning environment, among others, the physical meetings are indispensable. In some cases they will take place more sporadically, especially those involving people living in remote locations, such as the classroom tutors, but in others they should be more frequent, as the weekly meetings of the coordination team and the meetings between content teachers and instructional designer.

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E-moderation and Interaction in a Course Promoted by the Distance Education Project of the University of Coimbra

Celeste Vieira, Teresa Pessoa, and João Filipe Matos

Abstract This article focuses on the study of e-moderation strategies adopted in the *Violence and Conflict Management in Schools* course promoted by the Distance Education Project of the University of Coimbra. This course resulted from a partnership between the Faculty of Psychology and Educational Sciences (University of Coimbra) and the Portuguese Ministry of Education.

The purpose of the study was to characterise the procedures involved in e-moderating a course and to compare them with the assumptions of the theoretical contributions of Salmon and González, (2002, *La función y formación del e-moderator. Clave del êxito en los nuevos entornos de aprendizaje*. United Kingdom: The Open University) e-moderating models and Garrison's et al. (2000) Community of Inquiry model. In order to achieve it, the following dimensions were analysed: (1) the e-moderator's profile regarding training, experience, and associated skills; (2) the e-moderation strategies concerning routines, practices, precautions and communication tools used; (3) the improvement proposals made by the e-moderators, based on difficulties experienced, aiming to systematise aspects that may enhance the quality of e-moderation procedures.

The study followed a qualitative methodological approach, embedded in the interpretive research paradigm; the case study and the convenience sample methods were chosen and the data were collected through interviews and discussion forums analysis. The data were processed through a content analysis of the e-moderators' interviews and a sociometric analysis of the discussion forums.

This study is part of a Master thesis in Education, Information, Technologies and Communication and Education, from the Institute of Education, University of Lisbon.

The choice of theme is related to the interest developed by the researcher in the importance of human and educational components in e-learning, as a result of professional experience in recent years.

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It was concluded that the various dimensions are interconnected and that their interpretation in the light of e-moderation theoretical models can contribute positively to the improvement process of teaching strategies in a b-learning course with an online tutoring system.

Keywords E-moderation • Distance learning • Learning communities • Models of e-moderation • Interaction

1 Theoretical Framework

1.1 Distance Education

In the last few years, the evolution of ICT has changed the society and these changes have been creating an irreversible impact on education (Gonçalves and Pedro 2012). Today, we recognize the concept of global village (McLuhan 1964) in the various activity sectors and the challenges of learning throughout life.

The possibility to learn at our own pace with no need to be in a certain place at a certain time (anytime/anywhere) is in line with the training needs brought by the globalization of information (Pedrosa et al. 2004), creating the emergence of distance education in response to the demands of adaptation and continuous updating.

Over time, the development of Learning Management Systems (LMS) allowed the optimization of a set of tasks the trainer should undertake in distance education contexts, such as managing trainees, offering content and creating communication mechanisms between participants in the learning process (Moreira et al. 2009).

Behind the technological potential of a learning management system, it is important to use it pedagogically well. As pointed out by Silva (1998, p. 134), 'technology is a tool, but the tool alone does nothing', the most basic requirement being, therefore, an articulation between technology and pedagogy, and the e-moderator role as a facilitator of learning in a virtual environment.

1.2 Learning Community and E-moderation

The term learning community—used for the first time in the context of Evergreen State College in 1984 (Tinto 2003)—is related to a new idea of organizing training, which requires the students to work together and participate actively and responsibly in the learning process. "Learning together is a complex achievement that weaves communal and individual engagement, aspirations and identities" (Wenger et al. 2009, p. 58).

The way virtual learning communities relate to each other derives mainly from the e-moderation models involved (Gonçalves 2008). Considering the importance of the e-moderator in the success of the learning processes, there are several skills

must be present: the ability to know how to create a useful, relevant online learning community (Salmon and González 2002); to deal with technical issues concerning the access and use of the virtual learning environment (Dias 2008); the confidence in being courteous, polite, and respectful in an online (written) communication (Salmon and González 2002); to reveal leadership abilities enabling shared guidance with the group, that can help the learning community develop autonomy and strength (Lisboa and Coutinho 2010).

Finally, the e-moderator should be an organizer and facilitator of the trainees by promoting, encouraging, guiding and supporting the interactions in order to ensure the learning process (Rodrigues 2004).

1.3 E-moderation Models

1.3.1 Gilly Salmon's E-moderation Model (2000)

This model of e-moderation consists in five stages or levels that provides the guidance to the e-moderator to work in supporting the trainees in the construction of learning.

In the first stage—*Access and Motivation*—the e-moderator supports the trainees in the moment when their first contact with the electronic environment, their colleagues and the pedagogical team occurs (Salmon, 2004).

Online Socialization is the second stage of Salmon's Model focused on the importance of creating a group identity, as a result of the interaction between the members of the learning community.

The third level is called *Information Exchange* and it requires that the e-moderator should induce and encourage trainees to participate in activities, to enhance interaction and communication.

At the fourth stage—*Knowledge Construction*—the trainees are expected to express control over their own learning, and to develop the skills for debate and collaborative knowledge construction.

In the final stage—*Development*—the trainees are capable of working more autonomously, critically and thoughtfully, assuming the accountability for their own learning in order to accomplish all the aims initially set.

1.3.2 Community of Inquiry Model (2000)

Community of Inquiry (CoI) is a conceptual model composed of three interdependent elements—social, cognitive and pedagogical—which refers to a significant learning experience (collaborative constructivist) (Garrison and Anderson 2005). Those elements feed each other and change along the way, and can manifest in both synchronous and asynchronous communications (Santuiste 2012).

2 The Study

This article discusses an analysis of e-moderation strategies adopted in an online learning environment taking into account the quality of the training tasks. Three dimensions were analyzed: (1) the **e-moderator's profile**—training, experience, and associated skills; (2) the **e-moderation strategies**—routines, practices, precautions and communication tools used; (3) **proposals for improvement** by the e-moderators—based on difficulties experienced and aiming to systematise aspects that may enhance the quality of e-moderation procedures.

Some questions raised in this research were: "What is the profile of the e-moderator of this course?"; "What tools are most used in e-moderating this course?"; "What are the practices/routines of e-moderating this course?"; "How can the strategies for the e-moderators be improved in future editions of the course?"

2.1 The Violence and Conflict Management in Schools Course Promoted by the Distance Education Project of the University of Coimbra

The University of Coimbra endorsed a Distance Education Project (UC_D)—created in 2010—which aimed to develop actions by distance, promoting continuous training and lifelong learning. UC_D developed eight editions of the course between October 2010 and June 2012. For the purposes of this study, we chose to examine the 6th edition of the course (November, 18th 2011 and March 16th, 2012).

The *Violence and Conflict Management in Schools* course promoted by the Distance Education Project of the University of Coimbra (UC_D), resulted from a partnership between that institution and the Ministry of Education (ME). This was a pilot project for teacher training that focused on the development of technical and pedagogical interpersonal competences, allowing teachers at different levels of education to act at the classroom and school level in a preventive and interactive way concerning aggressiveness and violent or criminal behaviours.

This course presented a modular structure consisting of three modules, each of them divided into sub-modules. Held in the b-learning mode, this course had a total duration of 100 h (6 h face to face + 94 h online) and estimated an average of 1 h daily work by the trainees. The interface that supported the learning was the Moodle LMS, which provides tools for communication and coordination that enabled the management of trainees' learning through asynchronous discussion formats (general and learning forums), files submissions, messages, evaluation, etc.

3 Method

The purpose of this research was to understand the strategies of e-moderating in a b-learning course. For that reason an integrated qualitative methodology in the interpretative paradigm was chosen. The research was centralized in a case study which allows a deeper analysis in the natural environment (Bogdan and Biklen 1994).

The participants in this research were all the trainees (15) and the e-moderators (6) of the course VGCE # 06.

In this article, the title of e-moderators applies to all the members of the pedagogical team, such as the *coordinator* (C), *teachers* (D1, D2, D3) and *tutors* of the course (T1, T2, T3). These agents have academic training in pedagogical issues, being the coordinator and the teachers being PhDs in Educational Sciences and the tutors either Graduates or Masters in Education.

Data collection in this research was processed through (a) semi-directive interviews and (b) analysis of discussion forums. An interview guide was drafted in order to facilitate the process, which included three groups of questions: Group A: the e-moderator's profile; Group B: the e-moderation strategies; Group C: proposals for improvement.

In this study, six interviews were carried out (45 min each). The processing of data from the interviews was conducted through content analysis. Matrices based on the dimensions discussed in the interview script were produced.

The data processing of the discussion forums consisted of a sociometric analysis supported by indirect observation and document analysis. UNICET/Netdraw software was used to analyse the course interactions in order to explore the centrality measures such as "degree of network connectivity, number of interactions, intermediation and the proximity between individuals" (Velázquez and Aguillar 2005).

In this research, there was the concern to validate inferences and to ensure that the study was/would be recognized and valued. A triangulation of the investigator's inferences with other sources of information was established (data from other studies in the area). Also, informally, some of the study participants provided feedback on the results, which served to confirm the direction of the research.

4 Results

To facilitate results systematization, the data are presented in two parts: Analysis of the interviews with the e-moderators; Analysis of the discussion forums.

4.1 Interviews

The results of content analysis of the interviews with the e-moderators are set out in three groups, each one corresponding to a matrix analysis (categories, subcategories, indicators and recording units).

4.1.1 Group A: E-moderators Profile

The e-moderator was seen as an agent who has knowledge in the scientific-pedagogical area and has mastered the technological tools available in the online learning environment. In this group, a matrix was constructed composed of two categories and five subcategories.

Experience in distance education—Of the sample, three subjects have had experience in distance education, having previously used LMS in support of face to face classrooms. All those surveyed expressed some experience in instructional design, since they participated in the design of Violence and Conflict Management in Schools course. However, only one of the subjects had experienced the e-moderator's role before.

E-moderator's role—Those interviewed showed support for the access to the platform and the motivation of trainees, such as D2 who said: "welcome graduates and help them, first to feel good and familiar with the platform". The e-moderators mentioned aid in the socialization process by encouraging participation in the forums in order to raise a sense of community between the students, such as D1 who said: "encourage participation, motivating, don't forgetting the concern related to learning, help to build such a group that will work together for some time". The interviewed also commented on the organization of communication that provided the rules and guidelines for the platform tools (forums) and the importance of the systematization of topics to avoid loss of information, thus promoting the trainees' learning. Other issues raised included support to build knowledge, encourage reading, and research after the course, providing regular feedback, connected with pedagogical team work (the team composed of the coordinator, teachers and tutors of the course) were other issues stated.

4.1.2 Group B: E-moderation Strategies

In the *Violence and Conflict Management in Schools* course, communication was carried out mainly through the tools available in the virtual learning environment. In this group, a matrix composed of three categories and five subcategories was constructed.

Communication—The e-moderators considered that it is important to stimulate communication routines in order to promote a learning community, like the one that occurs in a neighborhood, such as T3 who said: "the platform is our environment; it functions as a neighborhood and it is the way we use to share and communicate". In the *Violence and Conflict Management in Schools* course, there was asynchronous communication through the Moodle tools: messages and forums. (1) the messages are asynchronous communications tools that allow the exchange of text one to one and, therefore, are intended more particularly for individual contact. In this course the messages were used as a delay in submission situations and for solving

individual problems. (2) the general forum was selected by all those surveyed as the privileged communication space in this course. It is considered a tool often used by all community members to allow sharing, clarifications and learning of non-formal and spontaneous type.

Strategies—It is important to create routines to access the learning environment and the regular observation of the trainee's participation reports. E-moderation requires the availability (access daily and sometimes several times a day) and the organization of communication to ensure that the training group is involved. D1 said: "we must create routines, behaviors. It is necessary to create presences. At the first week of the course, I access the platform very often … it is important that trainees feel that I'm there …" The possibility of being always available for communication increases the expectation of communication. In the same way, the lack of tardiness in the response can lead to a feeling of emptiness and detachment (Rotta and Ranieri 2005).

Moderation activities—the interviewed reported that the stimulation of activities was carried out in three phases: (1) introduction of the activity—the e-moderator advises trainees about the beginning of the activity, mentioning the objectives and deadlines; (2) monitoring the activity—the e-moderator answers queries about task performance and stimulates trainees to achieve the goals; (3) end of the activity—the e-moderator alerts for the deadline, confirms receipt and sends messages to the trainees who are late in submitting their task.

4.1.3 Group C: Difficulties and The Improvement Proposals

A content analysis of the interviews enabled the e-moderators of this course to identify some difficulties related to the number of trainees and their level of technological competence. In this group, a matrix was established composed of two categories and four subcategories.

Difficulties—The high number of trainees may affect the quality and quantity of the e-moderator's feedback. The subjects gave examples of situations where the trainees presented technical problems and e-moderators had to present creative responses, like print screen and tutorials. Other difficulties mentioned were due to time, the accessibility of the e-moderators and a lack of face contact.

Improvement proposals—From the point of view of those questioned, the assessment process should be more individualized in order to produce a more complete feedback, such as providing a batch file. Another improvement could be a survey of the trainees' technological competences before the course so that the e-moderation strategies could be adjusted, such as T3 said: "To figure out the computer skills of the trainees through a diagnostic questionnaire." Other issues focused on the increase of collaborative work and interactivity (e.g. wiki) and the creation of synchronous sessions.

4.2 Forums Analysis

In the Violence and Conflict Management in Schools course there were two kinds of discussions forums: general forum and learning forums.

General forum was an asynchronous informal communication space which aimed to answer questions and address general issues; and to promote a sense of presence and sharing between trainees and the e-moderator's team. The analysis show the moments of highest participation, such as: (1) beginning of the course—welcome messages and technological issues; (2) beginning of each module—presentation of the e-moderation team and task objectives; (3) first module—period of time that coincides with the trainees adaptation to the course; (4) end of the course—project's final issues and messages of thanks and satisfaction.

First, the titles of the themes raised in General Forum were read to get an overview of the communication space. When the titles of the topics were not sufficiently clear, the reading would proceed to the entry in each issue for a better understanding of the content. Thus, we opted for a retrospective categorization, using as the unit of analysis the registration (themes) and numbering (time points). General forum had 312 posts, more than half (173) being e-moderators messages, which indicates that this is a communication tool that was often used.

Learning Forums were used as a formal tool for learning and for evaluation activities in each module of the course. We conducted a brief analysis of all the participants' posts to identify the amount and nature of the interactions. The identifying criterion for an interaction was when a participant said the name of another person, as in: "F1 > F3 addressed the issue…" Santuiste says (2012, p. 109) "la utilización de los vocativos es un indicador de la cohesión del grupo. Se utilizan dirigiendose a los participantes por su nombre".

Subsequently, a sociometric matrix was constructed using software UNICET/Netdraw software which provided outcomes relevant to this research. We analyzed one learning forum for each module and presented the graphic representation of the network's interactions.

Sociometric analysis#01: *A Letter from a Father* Forum (Fig. 1).

In this graph, we can see the different links established between the participants in the network. **Unidirectional ties** (T2, D1, C, F1, F8, F12, F6, F3), **bidirectional ties** (F9, F4, F13, F7, F2, F5, F14, F10, F15) **and free nodes** (T1 and F11) were identified.

Sociometric analysis#02: *A positive school climate* Forum (Fig. 2).

We can see that this forum is an inclusive network. All the participants made or received some interaction, which leads to the conclusion that there is a strong sense of community.

Sociometric analysis#03: *Coexistence Forum* (Fig. 3).

In this case, 4 participants did not interact with the group. The vast majority of participants made or received some interaction in this forum. However, compared with the two previous forums, this communication network was less inclusive.

The structure of a network can be analyzed through different points of view, depending on the aims of the research. Therefore we also studied the centrality measures of each module network, using Unicet Software (Table 1).

From the sociometric analysis it was concluded that the community has a high degree of inclusivity in the three learning forums analyzed, although reciprocation is lower. It is considered therefore that the intervention of e-moderators in these spaces should be higher in order to increase interaction and reciprocity in the debates.

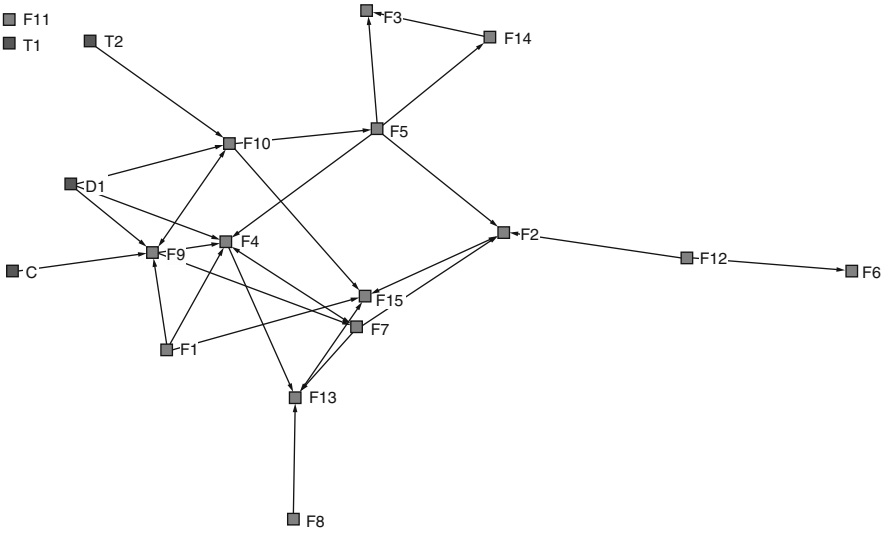

Fig. 1 Module 1—Network graph

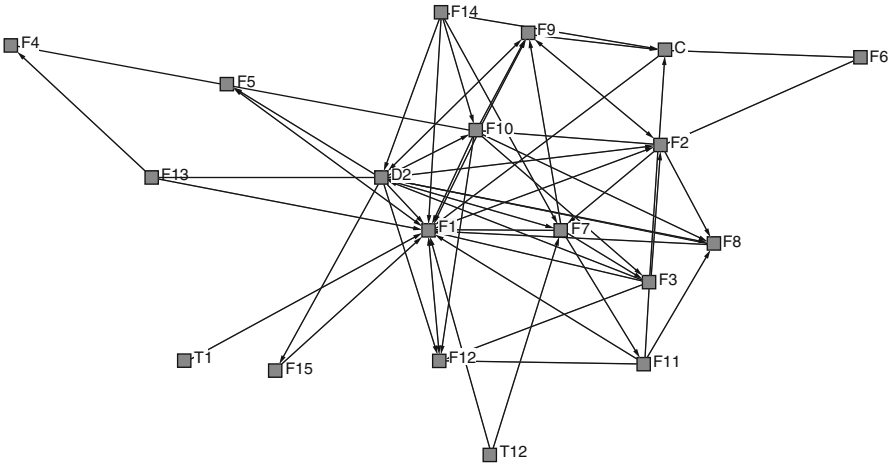

Fig. 2 Module 2—Network graph

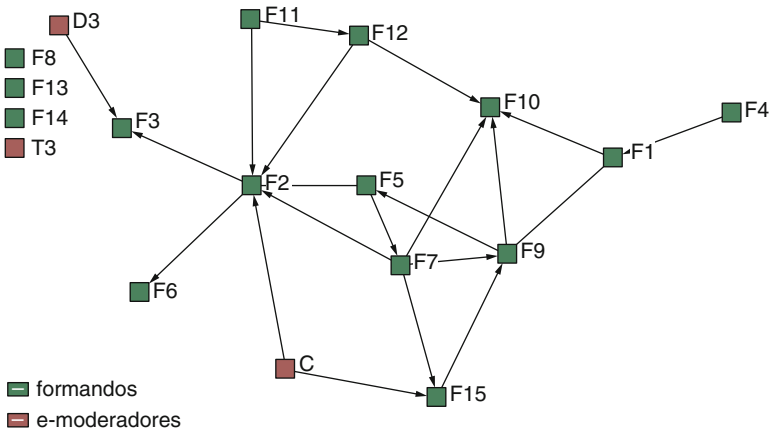

Fig. 3 Module 3—Network graph

Table 1 Results of the sociometric analysis of training forums

	Forum 1	Forum 2	Forum 3
Total posts number	61	51	48
Density	8.7 %	16.8 %	6.86 %
Inclusivity	89.5 %	100 %	78 %
Reciprocity	1.75 %	1.17 %	0 %

5 Conclusions

This study focused on the e-moderator profile of competencies and definition of functions. The e-moderators were very involved and motivated in the process of designing and monitoring the training action, and underlined the importance of teamwork in the project's success.

In respect of the e-moderators' skills, it was found that the most important features are: to master the scientific subject matter, the type of tools available in the virtual learning environment, availability and the sense of opportunity and objectivity throughout all communication.

In this course, the e-moderators were responsible for access support, for trainee motivation, and for encouraging participation and socialization in the community. Communication planning and organization in the community, providing feedback and an evaluation of the trainees in order to accomplish active participation in the knowledge-building process were also identified as tasks of these agents.

Overall, the e-moderators used the general forum to write messages for all the trainees, creating global communication. To solve particular problems, the pedagogical team preferred to use the 'messages board', displaying a concern to protect the trainees from situations of unwanted exposure.

Regarding the routines practiced by e-moderators, we highlight the concern in regularly accessing the virtual learning environments to ensure that students receive the necessary follow-up. In this context, those interviewed showed particular care with the activities and they used the general forum as a support tool, as well as answering questions and encouraging messages and motivation for the pursuit of goals.

In the proposals for the improvement of e-moderation strategies we emphasize the importance of an e-moderator's more active presence in the learning forums. In short, the results from this research are important to the description of the practices and strategies of e-moderation of the *Violence and Conflict Management in Schools* course. A convergence was identified between the strategies used in this particular course and the assumptions of G. Salmon's model (Salmon and González 2002). The level that require a more active role by the e-moderator is the first community development level.

In this case, one of the research limitations was the subjectivity associated with the researcher's point of view. Actually, the conclusions cannot be conclusive or generalized because this is a case study. However we believe that the results will provide the impetus for reflection on the practices of e-moderation in other situations.

Future developments in this area could go deeper in the study of all the communication tools (e.g. questionnaire to students about the used e-moderation strategies).

Future developments in this area of research could go deeper into verifying the way communication tools are used, in particular checking the historical analysis of messages conveyed between the students and the group of e-moderators and by applying a questionnaire to students about the strategies used.

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Design and Evaluation of OptimEx, an Experimentation System for Optimization Algorithms

J. Ángel Velázquez-Iturbide

Abstract We hardly find educational systems that allow computer science students to experiment with optimization algorithms with respect to the optimality property. We may highlight the GreedEx system, but it has the limitation of only being usable with a small set of predefined problems. In this chapter, we present a system similar to GreedEx but generic, called OptimEx. The contributions of the chapter are threefold. Firstly, we introduce the main features of the OptimEx system. Secondly, we describe different issues regarding its educational use: usage in educational scenarios, usage with different algorithm design techniques, and how it can inform us about students' errors. Thirdly, we present the results of a usability evaluation conducted with students. As a result, students consider the system highly usable but they also report on a number of issues that should be addressed to enhance it.

Keywords Optimization algorithms • Experimentation • Benchmarking • Usability

1 Introduction

Algorithms are a part of the core of computer science, as can be seen in the main curricula recommendations (ACM and IEEE Computer Society 2013). Mastering algorithms involves theoretical and practical aspects (Denning et al. 1989). In particular, it is important for the student to experiment (Reed et al. 2000) with the diverse properties of algorithms (Velázquez-Iturbide et al. 2012): correctness, efficiency and optimality.

Correctness is the main property to be satisfied by an algorithm. We may experiment with it by means of tests. The main systems designed for this task are automatic assessment systems (Ala-Mutka 2005; Douce et al. 2005; Ihantola et al. 2010). Its use has fostered a novel way of addressing the learning of programming, known as test-driven development (Edwards 2003).

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Experimenting with efficiency has been accomplished in a wider range of ways, from *ad hoc* experiments (Baldwin 1992) to experiments conducted with the support of specific software (Chen et al. 2006) to automatic assessment systems (Ala-Mutka 2005).

The optimality property only makes sense for optimization problems, therefore has received less attention than the previous properties. A review (Velázquez-Iturbide et al. 2015) found a number of didactic methods or tools that indirectly address optimization algorithms. For instance, some tools are aimed at supporting the learning of graph algorithms. Similarly, didactic methods usually support a specific optimization algorithm or a class of optimization algorithms. However, none was specifically aimed at supporting the learning of optimization algorithms.

One of the few didactic methods found, proposed by ourselves (Velázquez-Iturbide 2013), is aimed at learning the foundations of greedy algorithms. In brief, the student is given an optimization problem to be solved by means of greedy algorithms, as well as a number of selection functions that can be used as the basis to design a greedy algorithm for such a problem. The student must experiment with these selection functions to compare their results and deduce whether any of them are optimal. Experimentation can be supported by an interactive system called GreedEx (Velázquez-Iturbide et al. 2013). It is a friendly and powerful system, but it has the limitation of being limited to a finite (but extensible) set of optimization problems. In this chapter we present a similar but generic system, called OptimEx, which can be used to experiment with any kind of optimization algorithms.

The structure of the chapter is as follows. In the second and third sections we present the systems GreedEx and OptimEx, respectively. In the fourth section we analyze the didactic use of OptimEx. The fifth section presents a usability evaluation that has been conducted. Finally, we present our conclusions and future work.

2 An Antecedent: The GreedEx System

As explained in the introduction, the GreedEx system (Velázquez-Iturbide et al. 2013) was designed for the active learning of greedy algorithms. Given an optimization problem, GreedEx offers the student a number of predefined selection functions, and she must experiment (by simulation) with different input data and decide which selection functions are optimal, if any. GreedEx currently supports six problems (though it can be easily extended): the activity selection problem (Cormen et al. 2009; Kleinberg and Tardos 2006), the knapsack problem (Cormen et al. 2009; Brassard and Bratley 1996), the 0/1 knapsack problem (Kleinberg and Tardos 2006; Brassard and Bratley 1996; Sahni 2005) and three additional knapsack problems (where the target function is to maximize the number of objects introduced, the weight introduced and the weight introduced in two knapsacks, respectively). The problems cited in the first, second and forth places can be optimally solved with greedy algorithms, but the remaining problems require the use of other algorithm design techniques, e.g. dynamic programming or branch-and-bound.

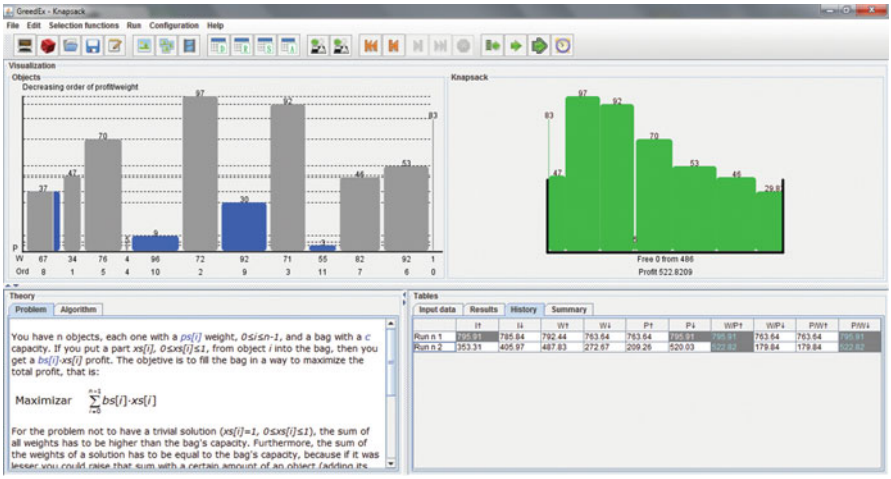

Fig. 1 Screen capture of GreedEx in an experiment with the knapsack problem

Figure 1 shows a screen capture of GreedEx in an experimental session with the knapsack problem. The figure shows that the user interface of GreedEx consists of three panels. The top area corresponds to the visualization panel, where data are displayed in a graphical format. The most common visualization layout displays input data at the left (in this problem, the objects) and the result at the right (here, the knapsack with the objects introduced). Initially, all the objects had a bluish color, but those introduced in the knapsack have been colored in gray. The visualization shows the final state after executing the selection function P/W↓ (explained below) with the second input data set used (see the second row in the history table).

The left bottom area in the screen is the theory panel, consisting of two tabs: the problem tab, that holds the problem statement (visible in the figure), and the algorithm tab, that holds a greedy algorithm that solves it, coded in Java-like pseudocode.

Finally, the right bottom area is the table panel, with four tabs that hold the input data table, the result table, the history table (visible in the figure), and the summary table. In the figure, the history table shows the result of executing the algorithm for two input data sets (one per row) and the ten selection functions available for the knapsack problem. Visual analysis is eased by highlighting in gray the cells of the selection functions that have yielded an optimal value for the corresponding input data. Notice in the figure that, after experimenting with two input data sets, two selection functions have all the cells of their columns in gray: decreasing order of profit per unit of weight (Cormen et al. 2009; Brassard and Bratley 1996, represented P/W↓), and its equivalent reverse, increasing order of weight per unit of profit ((Velázquez-Iturbide and Debdi 2011), represented W/P↑). If we experimented with

more input data, we could check that they always provide an optimal profit. (Notice, however, that a formal proof is necessary to have complete certainty.)

When the student launches GreedEx, she must select a problem. Then, the theory panel becomes active so that the student may read the problem statement and its greedy solution. Afterwards, the student may generate a test case (i.e. input data) from any of the following sources: typing in the keyboard, randomly generating or reading from a file. A test case may also be obtained by interactively modifying another available test case.

Data generated are displayed in the input data table and in the visualization panel, and the student may then select and execute any of the selection functions proposed by GreedEx. Four execution/animation controls are available: one step forward, forward to the end, one step backward, and rewind. The visualization is updated as the user presses animation controls. A detailed examination of each execution may enhance the student's understanding and analysis of each selection function. When the execution of a selection function finishes, the results are stored in a row of the results table and in a cell of the history table. The summary table also updates the percentage of optimal results obtained by each selection function in the executions launched.

GreedEx provides some functions for faster experimentation: execute all the selection functions of the selected problem with the current test case, execute a subset of them, or execute all the selection functions with a very large number of test cases randomly generated. A set of test cases may be generated by specifying their number or the length of time to be spent in their generation.

We want to highlight that GreedEx was designed to teach the foundations of greedy algorithms, including the fact that some optimization problems cannot be optimally solved using the greedy technique. For instance, Fig. 2 shows that, after ten runs, no selection function always yields an optimal value for the 0/1 knapsack problem. Notice that no column has all its cells in gray.

Finally, GreedEx includes some mundane, but very useful functions with educational aims: exporting tables and selecting the user's language (it currently supports English and Spanish).

	I↑	I↓	W↑	W↓	P↑	P↓	W/P↑	W/P↓	P/W↑	P/W↓
Run n 1	499	Run n 12	587	366	507	560	587	425	425	587
Run n 2	455	452	521	493	452	524	521	455	455	521
Run n 3	436	425	436	392	314	515	527	224	224	527
Run n 4	347	324	430	326	385	446	489	232	232	489
Run n 5	50	116	126	50	34	196	196	34	34	196
Run n 6	206	159	334	114	18	359	359	18	18	359
Run n 7	87	193	204	154	120	154	234	87	87	234
Run n 8	141	135	137	56	66	225	225	66	66	225
Run n 9	116	143	143	89	86	153	143	86	86	143
Run n 10	389	251	384	322	245	417	417	251	251	417
Run n 11	90	92	90	76	10	92	90	10	10	90
Run n 12	491	642	586	397	488	675	675	361	361	675

Fig. 2 History table obtained in an experimentation with the 0/1knapsack problem

3 The OptimEx System

OptimEx is inspired in the same didactic method as GreedEx, consisting in comparing the results of different algorithms for the same optimization problem (Velázquez-Iturbide 2013). Two design decisions allowed us to achieve genericity in OptimEx:

– Remove the elements of GreedEx that are problem-dependent (the visualization panel, animation controls, and the theory panel).
– Allow the user to provide her own algorithms. The resulting system does not simulate the execution of predefined algorithms but rather supports the actual execution of any algorithm.

In the following subsections, we present the main features of OptimEx by highlighting their difference with respect to GreedEx.

3.1 User Interface

Figure 3 shows a screen capture of OptimEx. Notice that it has two panels: the code panel and the table panel. The code panel hosts an editor that allows loading, editing and storing the Java code of algorithms. In the figure, a file has been loaded that contains four algorithms to solve the 0/1 knapsack problem: a greedy algorithm based on the P/W↓ selection function, an approximation algorithm (Brassard and

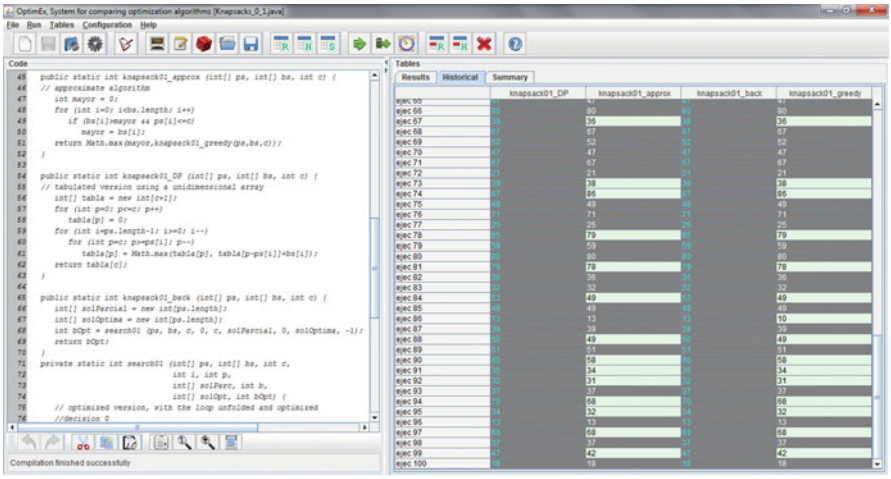

Fig. 3 Screen capture of OptimEx in an experiment with four algorithms for the 0/1 knapsack problem using 1000 test cases

Bratley 1996), a dynamic programming algorithm, and a backtracking algorithm. The tables are analogous to those in GreedEx, and allow storing and comparing the results of the algorithms executed. Notice in the figure that the greedy and the approximation algorithms are not optimal, but the other two algorithms are (all their cells are in gray).

3.2 Conducting an Experiment

OptimEx allows experimenting with any algorithm coded in Java, provided it is contained in a single class, its heading only contains predefined data types and it returns a comparable value (e.g. a numeric value). Even if the experiment is carefully planned, it is common to proceed in several iterations. However, for this introduction to OptimEx, we may assume that the user will ideally proceed according to the following sequence of steps:

1. Load and compilation of a Java class. The user may create a new Java class or load it from a file, as well as edit, compile and store it. For the sake of the user's convenience, the operation to load a file compiles it simultaneously.
2. Selection of the problem to solve. The user must select the problem that the algorithms to compare are intended to solve. OptimEx enforces a restriction on the algorithms to compare: given that they solve the same problem, the signature (data types of the parameters and the result) of the main method of each algorithm must be the same.

   The dialog to select a problem gathers two pieces of information: its signature (selected from the signatures available in the current class), and whether the target function of the problem is maximizing (a profit) or minimizing (a cost). For example, the signatures of the four algorithms shown in Fig. 3 are equal and adequate to the 0/1 knapsack problem: an array of weights of the objects (of type `int[]`), an array of their profits (of the same type), the knapsack capacity (of type `int`), and the profit obtained (the result, of type integer). In addition, it is a maximization problem.
3. Generation of input data. Test cases may be typed with the keyboard, randomly generated, read from a file or obtained by editing previously existing data. Random generation allows specifying a valid range of values to generate and, in the case of arrays, a valid range of its size.

   The user not only may handle a test case for a single run but also a set of test cases for multiple runs. The user may store in a file all the data used in a session and retrieve them in a future session. Alternatively, she may generate in a single action multiple test cases by specifying either their number or the lapse of time devoted to generate them. Test cases are available to the user for the whole session, unless they are cleared.
4. Execution of the algorithms. The simplest execution operation allows the user to run a specific method over a specific test case. However, faster experimentation can be obtained by running a group of methods over one or several test cases.

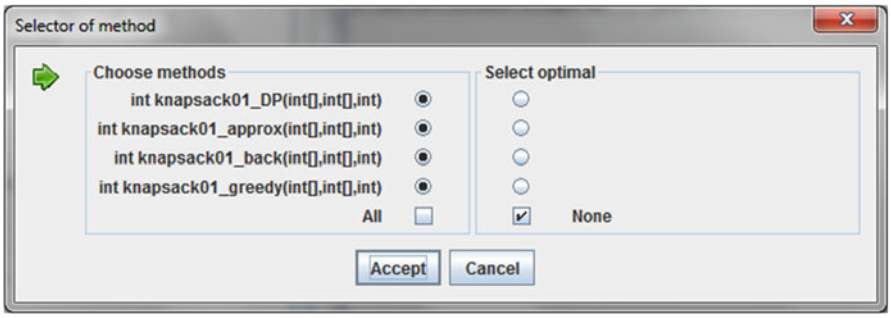

Fig. 4 Dialog for selecting the methods to execute and compare

Tables

Results | Historical | Summary

Measure	knapsack01_DP	knapsack01_approx	knapsack01_back	knapsack01_greedy
Num. executions	100	100	100	100
% suboptimal	0,00 %	36,00 %	0,00 %	37,00 %
% optimal	100,00 %	64,00 %	100,00 %	63,00 %
% superoptimal	0,00 %	0,00 %	0,00 %	0,00 %
% mean deviation	0,00 %	5,13 %	0,00 %	5,62 %
% maximum deviation superoptimal	0,00 %	0,00 %	0,00 %	0,00 %
% maximum deviation suboptimal	0,00 %	19,51 %	0,00 %	23,08 %

Fig. 5 Summary table after experimenting with four algorithms for the 0/1 knapsack problem using 100 test cases

Execution of multiple methods proceeds in two steps. First, the user is prompted to specify the methods to run, as Fig. 4 shows. OptimEx shows the methods available in the current class that match the signature selected by the user. The user may select the methods she wants to compare; by default, all of them are selected. Furthermore, she also may specify whether any of them is an optimal algorithm; by default, none is selected. If no method is marked as optimal, their outcomes are simply compared. However, if one method is marked, its results are considered optimal and the outcomes of the remaining methods are classified as optimal or suboptimal under this assumption.

In a second step, the user is prompted to specify the test cases. They can be either generated on-the-fly or a subset of the test cases generated during the session.

5. Display of the results. The results are shown in three tables, i.e. the result, history and summary tables. The first one displays the result of running the algorithms with the active test case. The history table (see Fig. 3) shows the results obtained by all algorithms for all test cases. Finally, the summary table provides several descriptive statistical measures that summarize the results of each algorithm.

   In GreedEx, the summary table showed the percentage of optimal runs obtained by each algorithm. This table has been enriched in OptimEx to gather more comprehensive and meaningful measures on algorithm optimality. Figure 5 shows the summary table corresponding to the execution (partially) displayed in Fig. 3.

Each column corresponds to a different algorithm. We give the definition of rows for maximization problems; for minimization problems, they have the inverse definition. The seven rows contain the following information for each algorithm:

(a) Number of executions of each algorithm.
(b) Percentage of suboptimal solutions. It is the percentage of algorithm outcomes that are lower than the outcomes computed by any other algorithm for the same test cases.
(c) Percentage of optimal solutions. It is the percentage of algorithm outcomes that are higher or equal than the outcomes computed by any other algorithm for the same test cases. It should be 100 % for optimal algorithms, independently of whether the user marked them as being optimal.
(d) Percentage of "superoptimal" solutions. This bizarre terminology names a measure similar to the percentage of suboptimal solutions, but referring to cases that should not occur: outcomes greater than the outcomes computed by an algorithm marked by the user as being optimal.
(e) Mean percentage of deviation. It shows the mean deviation of the algorithm with respect to an optimal algorithm in the cases the former computes a suboptimal outcome.
(f) Maximum percentages of suboptimal and "superoptimal" deviation. They are important measures for approximation algorithms (Brassard and Bratley 1996). They show, as percentages, the maximum deviation detected for the algorithm as a lower or a higher outcome, respectively, than an optimal one. Again, the latter case should not occur.

Problematic situations are analyzed in more detail in Sect. 4.3.

6. Elaboration of a report on the experiment. A typical experimentation assignment in an algorithms course will require students to elaborate a report including the experiment conditions and results. To facilitate report elaboration, OptimEx allows exporting tables into files.

4 Educational Use of OptimEx

In this section, we present the educational use of OptimEx in a course on algorithms from several perspectives. Firstly, we present educational activities, then we discuss its use with different algorithm design techniques and, finally, we show different cases of bad use of OptimEx by students.

4.1 Educational Activities

GreedEx was designed to learn the foundations of greedy algorithms by means of experimentation. Given an optimization problem, its associated experimental method (Velázquez-Iturbide 2013) consists in running different selection functions

with different test cases, compare their outcomes and infer which ones are optimal, if any. GreedEx does not force the user to code, because it simulates the behavior of the supported selection functions. Therefore, it is adequate for two educational activities:

– Demonstrations in the classroom by the instructor to illustrate, with the problems supported, the structure of greedy algorithms and the optimality or suboptimality of different selection functions for these problems.
– Assignments for learning by discovery and for problem-based learning using any of the problems supported by GreedEx.

OptimEx is a generic tool. As a consequence, it demands greater effort to the user, because she must develop the algorithms to compare.

In summary, GreedEx and OptimEx support similar activities, the former being a basic system and the latter being a more advanced one. Therefore, it is natural to combine their use so that GreedEx is used in the first place with the problems it supports and OptimEx is later used with other problems. GreedEx gives the novice student scaffolding to understand and analyze the behavior of greedy algorithms. Such a scaffolding is removed in OptimEx, which is transformed into a general experimentation tool. The transition between both systems is eased by providing a user interface as equal as possible.

We must be careful in designing activities based on OptimEx, because the mere comparison of outcomes is not always an interesting activity. Therefore, instructor's demonstrations must restrict to some comparisons, especially illustrative or interesting. Furthermore, constructing several algorithms to solve a given problem demands an effort that the students should perceive as useful. Therefore, a small number of assignments based on learning by discovery should be proposed.

A natural use of OptimEx can be to develop Java classes throughout the course as follows. Initially, one or several algorithms (probably, greedy algorithms) will be designed to solve a given problem. As the course progresses, the student develops algorithms to solve the same problem, but based on different design techniques. New algorithms are incorporated into the class. Every time an algorithm is incorporated, the previously existing algorithms serve as a reference to compare with the outcomes of the new one. The instructor may use this kind of classes for demonstrations in the classroom, while the student may similarly extend her classes with her new developments in the assignments. Notice that Java classes constructed in this incremental way play a role similar to "portfolios".

4.2 Use with Different Algorithm Design Techniques

In this section, we first discuss possible scenarios of use of OptimEx with greedy and approximate algorithms. Given that they are (mostly) non-exact algorithms, they provide more opportunities for open experimentation. We then discuss the use of OptimEx with techniques for designing exact algorithms.

4.2.1 Greedy Algorithms

Obviously, OptimEx may be used in the same way as GreedEx with respect to the greedy technique, that is, to compare different selection functions for a given problem. This is an easy task for many problems for which intuitive, reasonable selection functions exist (for many problems, even our daily experience suggests the optimal selection function). Some examples follow:

- The variant of the knapsack problem where the target is to maximize the number of objects introduced.
- The problem of coin change (Brassard and Bratley 1996).
- The problem of the minimum cost spanning tree (Cormen et al. 2009; Kleinberg and Tardos 2006; Brassard and Bratley 1996; Sahni 2005).

However, the optimal selection function is not as easy to discover for other problems or, at least, its statement must be nuanced in a non-trivial way:

- The knapsack problem (Cormen et al. 2009; Brassard and Bratley 1996). We identified above the non-evident optimal selection functions P/W↓ and its reverse W/P↑ (Velázquez-Iturbide and Debdi 2011).
- The problem of scheduling with fixed deadlines (Brassard and Bratley 1996). The optimal selection function chooses the tasks in increasing order of deadline, but we may wonder whether selection in decreasing order of profit is optimal too.
- The single-source shortest-paths problem (Cormen et al. 2009; Kleinberg and Tardos 2006; Brassard and Bratley 1996; Sahni 2005). It is more intuitive to select candidates in increasing order of arc length than in increasing order of path length (Dijkstra's algorithm).

4.2.2 Approximate Algorithms

For some problems, optimal selection functions do not exist. However, some selection functions may serve as approximate solutions if the outcome difference between them and the optimal solution is bounded. Furthermore, they may yield an optimal solution in a high percentage of cases. For instance:

- The 0/1 knapsack problem (Kleinberg and Tardos 2006; Brassard and Bratley 1996; Sahni 2005). The selection function P/W↓, which is optimal for the knapsack problem, is not optimal for this variant. However, we have checked experimentally that it is optimal in about 80 % of the cases. More interesting is the finding that the selection function that chooses objects in decreasing order of benefit is optimal in about 87 % of the cases.
- Variant of the knapsack problem to maximize the weight of the objects introduced. Interestingly, the selection of objects in decreasing order of weight yields an optimal solution in about 78 % of the cases.
- Variant of the knapsack problem to maximize the number of objects introduced into two knapsacks of the same capacity. The selection function that introduces objects in increasing order of weight in the more packed knapsack gives an optimal solution in about 91 % of the cases.

– Some problems have optimal selection functions, but it is interesting to find nearly-optimal selection functions as well. For instance:
– The activity selection problem (Cormen et al. 2009; Kleinberg and Tardos 2006). It is optimal to select activities in either increasing order of end time (Cormen et al. 2009; Kleinberg and Tardos 2006) or its reverse, namely decreasing order of start time (Velázquez-Iturbide and Debdi 2011). Another selection function, namely increasing order of duration, yields an optimal solution in about 98 % of the cases.

4.2.3 Other Algorithm Design Techniques

OptimEx can be used with optimization algorithms constructed according to the principles of other design techniques, such as dynamic programming, backtracking or branch and bound. It may also illustrate the need of using any of these techniques: it may be used to assess several selection functions for a given problem and conclude that none is optimal. Some textbooks do this analysis for some problems (Kleinberg and Tardos 2006), which is very recommendable, because students have a great tendency to propose greedy algorithms (Ginat 2003).

This use is particularly interesting with variants of problems that can be optimally solved with greedy algorithms, such as:

– The 0/1 knapsack problem, cited above.
– The coin change problem (Brassard and Bratley 1996). The greedy algorithm computes an optimal solution only if the monetary units satisfy certain conditions, but not in the general case.
– The single-source shortest-paths problem with some arcs of negative length (Ford-Fulkerson's algorithm) (Cormen et al. 2009; Kleinberg and Tardos 2006; Sahni 2005). Dijkstra's algorithm only works optimally with graphs whose arcs always have positive lengths.

4.3 Unexpected Results in Experiments

In general, an experiment must be carefully prepared; otherwise, unexpected results may result. Experimentation with optimization algorithms is not an exception. It may seem trivial, but some conditions must be checked before performing an experiment: to use data satisfying the precondition of the problem statement, to identify the correct signature, or to mark the adequate target goal to optimize.

The most difficult to guarantee condition is to use correct algorithms. It is not uncommon to have algorithms that fail to yield an optimal result in some cases or that may even have running errors for some test cases. If any strange situation is detected, the algorithms must be revised and debugged to remove the wrong behavior.

Figure 6 illustrates this situation. In this case, the approximate algorithm has been marked optimal (notice the 100 % of optimal outcomes). However, it is not

Tables

Results | Historical | Summary

Measure	knapsack01_DP	knapsack01_approx	knapsack01_back	knapsack01_greedy
Num. executions	100	100	100	100
% suboptimal	0,00 %	0,00 %	0,00 %	1,00 %
% optimal	64,00 %	100,00 %	64,00 %	99,00 %
% superoptimal	36,00 %	0,00 %	36,00 %	0,00 %
% mean deviation	5,62 %	0,00 %	5,62 %	23,08 %
% maximum deviation superoptimal	24,24 %	0,00 %	24,24 %	0,00 %
% maximum deviation suboptimal	0,00 %	0,00 %	0,00 %	23,08 %

Fig. 6 Summary table after experimenting with four algorithms for the 0/1 knapsack problem using 100 test cases and having marked the approximate, suboptimal algorithm as optimal

optimal, therefore exact algorithms (i.e. the dynamic programming and the backtracking algorithms) yield greater outcomes on some cases.

Let us review the most common problematic situations (we assume that it is a maximization problem; for minimization, the situation typically is the inverse one):

- Some cells of the history table contain running errors. There are two possible reasons: the algorithm contains logical errors or the test data used do not satisfy the precondition of the problem statement. In the first case, the algorithm must be debugged; in the second, the test cases must be discarded or fixed.
- "Superoptimal" values are obtained. This bizarre terminology means that a value computed by an algorithm is greater than the value computed by an optimal algorithm. Of course, this situation only occurs when at least one algorithm has been marked as optimal. There are two possible explanations of these results:
  - A suboptimal algorithm has been marked as optimal (e.g. see Fig. 6 above). The experiment must be replicated without marking any algorithm or marking an exact algorithm.
  - An optimal algorithm has been marked as optimal. The algorithms under experimentation must be revised because at least one of them contains errors: either the exact algorithm yields values that are lower than expected or the "superoptimal" algorithm computes too high (and wrong) outcomes.
- No algorithm obtains 100 % of optimal outcomes. This situation only occurs when no algorithm has been marked as optimal. It is correct if no algorithm is optimal. Otherwise, exact algorithms must be revised to assure that they always yield optimal values, and approximate algorithms must be revised to assure that they do not yield higher values than expected.

5 Usability Evaluation

OptimEx was subject to expert evaluations of usability (Dix et al. 2004) during its development. This kind of evaluation allows identifying opportunities of improvement and inconsistencies from the early stages of development. However, the

experts' perception of a tool is not generalizable to any user, thus it is recommended to conduct evaluations with end users. This combination of techniques has proved useful in the development of educational tools (Velázquez-Iturbide et al. 2013).

In this section we first describe the treatment and protocol used for the evaluation, we then show the results obtained and we finally summarize and discuss these results. The evaluation is described in full detail in a technical report (Velázquez-Iturbide 2014a).

5.1 Treatment

The evaluation was conducted during the first semester of the academic course 2013–2014. It was held in the elective course "Advanced Algorithms", offered in the fourth year of the Degree on Computer Science at the Universidad Rey Juan Carlos. Several algorithm design techniques were studied to solve optimization problems: greedy technique, backtracking, branch and bound, dynamic programming, and approximate algorithms.

The students enrolled in the course had solved four assignments involving these algorithm design techniques. The first assignment dealt with the activity selection problem (Cormen et al. 2009; Kleinberg and Tardos 2006) and assignments 2 and 4 dealt with the related but more complex problem of weighted activity selection (Kleinberg and Tardos 2006).

The fifth assignment also dealt with the weighted activity selection problem. Students had to compare the optimality of at least three algorithms. They were given a greedy algorithm and had to choose the other algorithms from their assignments 1, 2 or 4. Algorithms from assignment 1 should be adapted to the new specification.

The fifth assignment had two goals. On the one hand, students had to deal (i.e. experiment) with exact and approximate algorithms. On the other hand, the assignment was intended to serve as a review of the course syllabus.

5.2 Protocol

Students could voluntarily attend a session of 2 h in the laboratory. They could start the assignment during the session and dispel doubts, but they had 1 week to finish the assignment and deliver a report. During the session, students could download from the virtual campus several materials: the assignment statement, a Java class with the given greedy algorithm, a file with 100 test cases, the OptimEx system, and a brief user guide of OptimEx. The test cases were provided to the students due to the limited capabilities of OptimEx to randomly generate data with constraints: this problem requires that the end instants of the activities must be greater than their corresponding start instants.

At the end of the session, a usability questionnaire was given to students. Filling it was optional, but, in the affirmative case, they had to fill it before leaving the laboratory.

The usability questionnaire consisted of three parts:

- Multiple-choice questions on general issues. It comprises five general assessments of OptimEx.
- Multiple-choice questions on specific elements. It assesses ten elements of the tool.
- Open questions on general issues. It comprises five open questions about positive and negative features.

Answers to multiple-choice questions were in a Likert scale ranged from 1 (very bad) to 5 (very good). The number of questionnaires gathered was 32.

5.3 Results of Multiple-Choice Questions

We asked students to give their opinion in five multiple-choice questions, directly related to ease of use, effectiveness and satisfaction. Table 1 shows the questions and the mean and standard deviation of their scores. (The median is a most adequate measure for ordinal values, but we show the mean for a more intuitive perception of students' opinions.)

Students were also asked about the quality of specific elements of the system. The results are show in Table 2, in decreasing order of mean.

5.4 Results of Open Questions

The questionnaire contained five questions that asked students to give their opinion, in free format, about five issues: positive features of GreedEx, negative features, features difficult to use, useless features, and features that GreedEx did not have but it should.

Table 1 Numeric scores on general issues

Question	Mean	Std. deviation
Is the system easy to use?	4.09	0.78
Is the system useful to analyze the percentage of optimal results of suboptimal algorithms?	4.38	0.87
Is the system useful to reinforce the confidence in the correctness of optimal algorithms?	4.09	0.89
General quality	3.81	0.86
Overall, did you like the system?	4.00	0.91
Total of answers	4.08	0.87

Table 2 Numeric scores on specific elements

Element	Mean	Std. deviation
Summary table tab	4.38	0.83
History table tab	4.31	0.86
Exporting tables	3.97	0.90
Result table tab	3.91	1.15
Organization of the main menu	3.84	0.88
Functions for algorithm execution	3.75	0.88
Icons	3.63	1.01
Functions to handle Java classes	3.59	0.87
Functions to handle input data	3.47	1.05
Selection of signature and methods	3.44	0.95
Total of answers	3.83	0.98

Table 3 Numeric scores on general issues

Question	# Students	# Simple answers
Positive features	30	46
Useless features	4	4
Features to improve	32	85

Many of the answers gathered did not contain constructive information, for instance "I think that everything is useful" as an answer to the question to identify useless parts. Moreover, some answers contained several pieces of information. Therefore, we decomposed answers into "simple answers" and we recataloged them into three categories, namely positive features, useless features, and features to improve.

Table 3 shows the number of simple answers classified into these categories. We include both the number of students who contributed with at least one answer and the number of simple answers within each category.

Let us review the answers. Answers on positive features were clustered into six categories. The two first categories represent generic judgements of the system while the remaining four categories are more specific:

- Ease of use (14 simple answers).
- Usefulness to compare optimization algorithms (12 answers).
- Handling of data, including their generation and exportation (7 answers).
- User interface issues (6 answers).
- Issues regarding comparison of outcomes (6 answers).
- Compilation issues (2 answers).

We only gathered four answers identifying different elements of OptimEx that students would remove.

Finally, we gathered 85 simple answers suggesting improvements. It is a very rich source of information for enhancing existing features of OptimEx. We may classify them into 11 categories, highlighting those features identified by at least five students:

- Support to Java execution (24 answers). The most relevant issue (20 answers) is regarding students' difficulties to bind the system with a working Java virtual machine.
- Presentation of results (12 answers). The most common suggestion (6 answers) is to display data of the summary table in a graphical format.
- Editor (11 answers). They give different suggestions on how to enhance the editor.
- Input data (9 answers). The most common suggestions (6 answers) are about the confusing way of proceeding to select test cases from the input data loaded.
- Configuration and preparation of the execution (6 answers).
- Exporting results (6 answers). Some students (5 answers) suggest supporting the exportation of tables into graphical files.
- Compilation issues (4 answers).
- Information about the progress of the executions (4 answers).
- System documentation (4 answers).
- User interface (3 answers).
- Other issues (2 answers).

5.5 Discussion

We may summarize the findings of the usability evaluation as follows:

- Students score very high the usefulness of OptimEx to experiment, and score high that they like it and find it easy to use. The quality of the system obtains a (relatively) lower score.
- Tables are the elements with higher acceptance, then the user interface and, finally, functions to handle data and executions obtain the lowest sores.
- Students find many positive features and make many suggestions of improvement, and find very few elements to remove.
- Positive features of OptimEx can be classified into two classes, namely generic statements about OptimEx (facility of use and usefulness), and specific elements (handling of data, user interface, and support to compare and compile).
- Students identify a high number of elements to enhance. We may remark the following ones:
  - To enhance Java support to execution (stability and configuration).
  - To incorporate graphical representations of statistics.
  - To enhance the editor functionality.
  - To enhance the processes of data loading and preparation of execution.
  - To incorporate exportation into graphical files.
  - To revise compilation and execution functions.

A few suggestions are worthwhile to consider, but they are not easy to attend and require a deeper analysis (e.g. improving random data generators).

6 Conclusions

We have presented OptimEx, a generic system to experiment with the optimality of optimization algorithms. The contributions of the chapter were threefold. Firstly, we introduced the main features of the OptimEx system. Secondly, we described different issues of its educational use: educational scenarios where it can be used, its usage with different algorithm design techniques, and how it can inform us about errors in the experiment materials or conditions. Thirdly, we presented the results of a conducted usability evaluation. Students considered the system highly usable, but they also reported on a number of issues that could be enhanced.

We foresee conducting several related works. The most obvious would be to enhance OptimEx using the results of the usability evaluation here presented. A second one is more ambitious. We have been using OptimEx for two academic years in a course on advanced algorithms, including several design techniques for optimization problems. We have analyzed students' contributions to detect their difficulties and attitudes (see the results of the first academic year in (Velázquez-Iturbide 2014b)). We hope to refine the instructional use of OptimEx in actual instruction, and to obtain a deeper understanding of students' difficulties and misunderstandings regarding optimality.

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What Do Portuguese Students Play on Mobile Devices: Inputs for the Development of Educational Games

Ana Amélia Carvalho and Inês Araújo

Abstract The use of mobile devices by students is growing every day. Students are connected all the time and can use them anywhere. To link the advantages of mobile learning (learn at any time and any place) with the fascinating features that attract students to play games, is one of the goals of the project "From Games to Interactive Activities for Mobile-Learning". The project aims to analyze students' game preferences and the games most played, based on data collected from students, in order to provide inputs for the development of educational games adjusted to this target group.

This chapter presents findings based on data collected through a national survey carried out to students from grade 7 to 9 (n = 555). The survey provided information on the games most played by students and findings were analyzed in the light of Paul Gee's learning principles. Inputs for the development of educational games will be presented and discussed.

Keywords Mobile devices • Mobile learning • GBL • Games • Learning principles • Educational games • Game design

1 Introduction

Technology is indispensable to make day-to-day tasks easier, to maintain updated information, record data, transfer data, monitor conditions, etc. Education and schools have always tried to keep up with technological developments. However, it still needs more time to adapt to these. This becomes a complicated task with the quick evolution of available technologies.

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For example the e-school program facilitated the purchase of Laptop computers with Internet connection by students from the second cycle of basic education up to secondary school at an affordable price. However, students quickly gave up to take them to school because they were heavy and because of the fear of being damaged or stolen (Moura and Carvalho 2008; Certal and Carvalho 2011). They prefer mobile devices such as mobile phones, MP3/MP4 players, PSP or Nintendo DS (Moura and Carvalho 2008; Trotter 2009).

The activities available for these students in school are, in general, less challenging than the technologies which they have and also less interactive than their social network.

Games are increasingly used in the lives of young people, being accessible from any device. "Games are used for training, advertising, and sales in business, the government, and K-12 education and the Serious Games industry is projected to be about $50 million annually" (Squire 2005, p. 10). Student engagement in learning can be encouraged by linking technologies to students' day to day activities and also with the use of mobile devices at school.

This paper aims to analyze grade 7 to grade 9 student's game habits in order to identify their game preferences and motivations to play. These findings will provide inputs for the design of educational games.

2 Mobile Devices and Education

The NMC Horizon Report 2013 presents the Tablets as the technology which in 2014 would rise as the top technology for learning (Johnson et al. 2013). At the same time, UNESCO (2013) recommended to its countries member that policy-makers should examine the potentials of mobile technology and avoid blanket prohibitions on the use of mobile devices in the School. The main benefits identified for education were: Expand the reach and equity of education (p. 10); Facilitate personalized learning (p. 12); Provide immediate feedback and assessment (p. 13); Enable anytime, anywhere learning (p. 14); Ensure the productive use of time spent in classroom (p. 16); Build new communities of learners (p. 17); Support situated learning (p. 18); Enhance seamless learning (p. 20); Formal and informal learning bridge (p. 21); Minimize educational disruption in conflict and disaster areas (p. 22); Assist learners with disabilities (p. 23); Improve communication and administration (p. 24), and Maximize cost-efficiency (UNESCO 2013, p. 26).

The recognition that mobile devices have great potential for education allowed to overcome some barriers to its use in the educational context, as these devices are in most cases already used for their entertainment features (SMS's, MMS's, sharing photos, comments, access to social networks and games).

Some studies have been carried out in order to analyze the benefits of using mobile devices in the learning context. In a study carried out in Portugal with secondary school students, it is reported that "students accepted the use of their mobile phone to support their study because they included them in their school learning

practices on a daily basis. When students used a mobile phone in classroom activities, they felt it asses some school benefits (convenience, utility, facility, motivation), and so they recognized this device as a learning tool" (Moura and Carvalho 2013, pp. 67–68). It was found that students with recent mobile devices were more involved in the proposed activities and considered that it was more advantageous for their learning the fact that they could use an equipment which they are familiar with (idem).

"Most mobile devices are now capable of processing information in the same way desktop computers." (Khaddage and Lattemann 2013, p. 119). Apps for mobile devices have grown exponentially, giving access to features that facilitate the day-to-day tasks (ibidem).

These technologies enable access to learning content by following the three "Ss": (1) Speed "are designed to be fast and efficient", (2) Security "are designed to keep users safe and more secure" and (3) Simplicity "apps can be streamlined, clean and simple, efficient, and easy to use" (Khaddage and Lattemann 2013, p. 121). Also Quinn (2011) highlights the achievements of mobile learning through the 4 C's: Content—"accessing content in the form of media" (p. 98), Capture "of information" (pp. 98–99), Compute—"the ability to compute a response" (p. 99), and Communicate—"to communicate people with each other" (idem).

Students are part of the thumb generation (Rheingold 2002), the game generation or screenagers (Alves 2004), the Mobile Generation (Moura 2008, 2009). They are often online, participate in social networks, are used to having immediate feedback, they spend a lot of time playing games individually or with others. They are inseparable from their mobile phone, in which they quickly and often send SMS or MMS, being always in touch with friends (Carvalho 2014).

With the benefits of mobility and diversity of mobile devices, the following expression is imposed "Bring Your Own Technology" (BYOD). "It Refers to the practice of people bringing their own laptops, tablets, smartphones, or other mobile devices with them to the learning or work environment" (Johnson et al. 2014b, p. 35). According to the NMC Horizon Report 2014—K12, the possibility of integrating the "BYOD has profound implications for primary and secondary education because it creates the conditions for student-centered learning to take place." (ibidem).

These technologies "are increasingly cloud-based" (Moura 2012). This means that users will have access to applications, services, or resources through the Internet, and therefore it is no longer necessary to have a device with a specific software installed, you can access them from any device with Internet access, anywhere in the world.

Linking the benefits of the cloud-based trend which allows different apps to work on different devices, keeping content updated, its potential in an educational context is very big (Khaddage and Lattemann 2013).

A study held in 2011 with German, Australian and Japanese students in higher education argued that "mobile phone can contribute to learning [in fields like]: collaboration and communication among students (perceived as useful by 50 % of students); quizzes (perceived as useful by 21 % of the students); and up–downloading of content (perceived as useful by 30 % of the students)" (idem, p. 126).

A report published under the Tomorrow Project, which is based on a survey of more than 400,000 respondents from numerous schools in the USA, concludes that 58 % of the students from grade 9 to 12 use their own device at school, stating that about 60 % of those who use it do it for taking online tests, accessing the Internet, creating presentations and using the school portal. Also 69 % of school principals (n = 3207) found that offering online learning options keeps the students engaged in school (Project Tomorrow 2015).

From the Creative Lab Classrooms project, coordinated by European Schoolnet with ten partners from eight European countries ran from 2013 to 2015, the conclusions are that "Tablets support collaborative ways of learning such as peer learning, mobile group-work, and project work, and can be used to: (1) collect evidence and capture progress; (2) exchange: with peers, teachers, experts and others; (3) share ideas/collaborate online and (4) gather feedback from the teacher or others"(p. 5). These possibilities facilitate the flipped classroom approach, enable students to create content and share it, and can be a support for personalized learning (European Schoolnet 2015).

However, a recent study raises the debate once again on the effects of the distraction caused by the use of mobile devices for personal use, concluding that it can have negative effects on low-achieving students. This is, when comparing schools that forbid the use of mobile phones with those that allow, the authors concluded that "Banning mobile phones improves outcomes for the low-achieving students (14.23 % of a standard deviation) the most and has no significant impact on high achievers" (Beland and Murphy 2015, p. 17). However, they do not question the benefits of devices for a structured learning process (idem). So "The most important and complex are the teaching strategies and methods created with and for the technology" (Moura and Carvalho 2013, p. 68).

3 Games and Mobile Learning

Students need interactive activities for their mobile devices that are challenging and involve them in learning, such as what happens in the games that they usually play on the computer, on the cellphone or on other mobile devices (Douch et al. 2010; Gee 2007; Prensky 2006; Squire 2008).

Games for mobile devices have gained popularity, with particular emphasis on those that are available for smartphones and tablets by downloading them at the respective online stores. Players play when they want and where they want. The game establishes a set of rules, obstacles and choices that the player needs to learn to be successful (Gee 2007). Players explore space, learn through successes and failures, receive feedback that helps to develop the task (Klopfer 2008). They make decisions and analyze its consequences, solve problems, are aware of various aspects simultaneously, take risks and experience failures, learn to manipulate and control complex environments and in some games also collaborate with other players (Douch et al. 2010; Prensky 2006; Williamson 2009). Gee (2003), after having

played numerous games, concluded that good games incorporate good principles of learning, motivating students to learn.

According to Raph Koster (2005) the pleasure of play is in the very act of learning from the game, this is, learning is coded in our brains as essential for survival. Only by learning can we overcome obstacles that put us at risk and for this reason, new learning leads to the discharge of chemical indicators of pleasure (dopamine). When we complete a task in a game it is because we learn something that led us to achieve this result. "As the buzz around games and learning continues to grow, one particular subset—Massive [Multiplayer] Online (MMO) games—is catching the attention of educators as a particularly interesting way to encourage students to collaborate, problem solve, create and think for themselves within a game" (Schwartz 2013).

Starting from the interest that games like World of Warcraft (Blizzard Entertainment) had by the young Americans, an MIT Education Arcade[1] team developed an educational game, The Radix Endeavor. This game has all the features of an MMO and allows the study of Biology and Mathematics contents, being already available for use in educational context. Making educational games look similar to entertaining games is a demand to increase student motivation. This is an important idea that means a new concept of educational games that will be more similar to the entertaining games, and therefore allow greater motivation for students. In this way, it is possible to overcome the idea, often associated with educational games, that these are boring (Squire 2011).

For this similarity to happen, it is necessary to learn from games themselves. According to Gee (2003), education benefits a lot from the experience of the game development industry, who, throughout 30 years, has been testing and developing strategies that involve and motivate players to engage themselves in the tasks and reach the goals. The author highlights the existence of a specific literacy that it is necessary to master so that you can be successful and achieve the goals of the game. In the game there is always the possibility to start over, each player can advance at his own pace feeling rewarded for that. The interaction with other enables the player to be an apprentice against the most experienced ones and be a master for those who are starting. Feedback is always stimulating and positive, which develops the sense of achievement and progress by the player, even when you lose and it is necessary to restart. It is also important to define what games are. There is no clear definition shared by authors as the most correct. However, "all games share four defining traits: a goal, rules, a feedback system and voluntary participation" (McGonigal 2011, p. 21).

The game industry has created a way to categorize the game genre in games based on the type of gameplay that each one presents. The gameplay is defined by the type of game mechanics used and which is the basis of the rules that underpin the entire game environment. These game Mechanics can be of five types: physics (defines all the changes that take place in the games, the position that objects occupy and their direction), internal economy (game elements that are collectible,

[1] Project url: http://education.mit.edu/projects/radix-endeavor

consumed or exchanged in the game, for example coins, medals, energy, equipment, lives), progression mechanisms (goals to achieve and progress in the game), tactical maneuvering (frequent mechanic in simulation and role-playing games which determines what advantages can be obtained and how they are achieved) and social interaction (this is a new mechanic associated with the development of Internet through which enables real-time interaction synchronously and/or asynchronously between players) (Adams and Dormans 2012).

Other issues should be taken into account when analyzing the complex system which games belong to. In addition to the mechanics, games are also composed by the Story (sequence of events in the game), Aesthetics (is how the game looks, sounds, smells, tastes, and feels) and Technology (any materials and interactions that make the game possible) (Schell 2008). These characteristics involve the players and motivate them to apply their time in an effort that it is not necessary for his/her survival and that is often criticized by adults.

With the technological advances in terms of hardware, games that previously were only available for PC or video game consoles today have mobile versions that can run on Tablets or Smartphones. Mobile games have increased exponentially. The easy access to the development and publication of contents online has contributed so that every day new applications are available for download. Games for mobile devices are presented as short games, where the games or tasks to be done take only few minutes and are often associated with social networking. They are a way of quick entertainment for times that the user needs to occupy. These games follow players anywhere, since they can be played on different platforms keeping the player's progress logged in.

Educational games, in order to be engaging and motivating, need to meet these demands. Otherwise, students will reject them (Squire 2011). It is therefore important to analyze the features of the most played games in order to identify common issues that may support the development of more engaging and motivating educational games for students.

4 Project: "From Games to Interactive Activities for Mobile-Learning"

The Project "From Games to Interactive Activities for Mobile-Learning" was designed based on the ideas of mobile learning, the use of mobile devices in classrooms (BYOD: Bring Your Own Device) and the growing interest of games for leisure and also for learning purposes. The project aims to develop and evaluate interactive activities and games for mobile devices, which students possess, based on student's game preferences. The project is in progress at the Faculty of Psychology and Education Sciences at the University of Coimbra.

The overall goal of this project is to identify students' game preferences in regard to mobile devices, afterwards, analyze those games based on the learning principles

of Gee (2003) and then create interactive activities for mobile devices to be used in formal educational contexts.

The project is currently in its final phase. The project began with the implementation of a survey aimed to identify students' game preferences at different education levels, as well as to characterize Portuguese students' game habits.

The project includes students from the age of 10 years old, from grades 5 to 9, secondary school (grade 10–12) and University students (Bachelor and Master Degree students). This paper will focus only on data collected from students enrolled in grades 7–9, this is, with ages from 12 to 15 years old, who belong to the normal Portuguese Education System.

4.1 Survey "Playing in Mobile Devices"

4.1.1 Description of the Survey

The survey aimed to characterize the participants' game habits, their preferences as players, as well as the mobile devices used to play. It is organized in four parts: (1) student profile (gender, age, location, education level); (2) characterization of game habits (devices used to play and time spent); (3) game preferences (identification of favorite game and why; general preferences in terms of game elements, playing alone or with others, and opinion about the use of games in the context of a classroom); (4) ideal game (open question at the end, optional, where students can describe key features of a game they would like to play).

In total, the survey included 18 items, mainly multiple choice questions, three open ended questions and one item with several options such as a Likert scale. The survey was validated by specialists in the field.

4.1.2 Methodology and Application Procedures

After the validation process was concluded, the survey was made available online, using the tool "Forms" from Google Drive. The survey was submitted to the National Board of Education for approval. After this, the link was available for national schools and teachers. The survey (Babbie 1997) collected data at a national level, from the months of May to October 2013.

4.1.3 Sample Characterization

The survey was answered online by 767 students. The participants include 400 female and 367 male students. In this study, 148 (37.0 %) female students and 64 (17.4 %) male students stated that they did not play games. Based on all the respondents answers, 72.4 % of the participants referred that they played videogames and,

therefore, will constitute the sample of this study (n = 555). Most of the players are male students (54.6 %).

A study carried out with Dutch students (Simons et al. 2012) also refers that 96 % of all male are players and 81 % of all female, which reveals the tendency of most of the players to be male students.

The age of students ranges from 12 to 14 years old, corresponding to 81.2 % of the sample. With 15 years old there are 12.8 % and the rest, 6.0 %, with a higher age. In regard to the education level, the sample is mainly based on students in grade 7 (38.2 %) and grade 8 (37.5 %). Students from grade 9 represent 24.3 % of the sample. In terms of location, students are mainly from the North region of Portugal (47.9 %) and the Centre (41.3 %), regions where the team members of the project are from. The other locations include: Alentejo (4.9 %), Lisbon (4.3 %), Madeira (1.3 %), Azores (0.4 %) and no answer from Algarve. Although the project dissemination was carried out in several schools located in the national territory, one of the first difficulties faced was to get the collaboration of the board of schools to disseminate the survey. This difficulty was overcome by asking the Teachers Associations to collaborate and disseminate the survey amongst their members.

5 Discussion of Results

5.1 Characterization of Game Habits

5.1.1 The Use of Mobile Devices to Play

Students were asked to identify the games they played most in each of the mobile devices: Mobile phone, Smartphone, Tablet, PSP, Nintendo 3DS and Laptop Computer. Results show that 82.2 % of students who play use the Laptop Computer, but other devices are also used by more than 50 % of the sample: Cellphone 61.4 %, 51.4 % PSP. With less than 50 %, students refer the use of the Tablet with 42.9 %, the Smartphone with 29.9 % and Nintendo 3DS with 21.4 %. The average use is three devices per student.

When comparing results in terms of gender, there are some differences worth mentioning. The Laptop Computer (71.8 %) and Cellphone (69.8 %) are the devices most commonly used by female students, followed by Tablet with only 44.0 % of respondents. While in the case of male students the Laptop Computer is the most used (90.8 %) followed by the PSP (62.4 %) and Cellphone (54.5 %). It should also be noted that Nintendo 3DS is used more by girls (23.8 %) than by boys (19.5 %). Results based on the level of education show that there is a decrease from grade 7 to grade 9 in the use of the Cellphone (65.1–57.0 %) to play which is offset with the increase in use of the smartphone (27.4–34.8 %) and tablet (40.2–52.6 %). But the use of the Nintendo 3DS remains stable between grade 7 (23.1 %) and grade 8 (23.6 %), decreasing in grade 9 (15.6 %). The PSP and Laptop Computer have greater use in grade 8 (54.8 % and 85.1 %, respectively), and less in grades 7 and 9.

Based on these findings, it appears that the vast majority of these students use mobile devices to play, with the most recent devices (Smartphone and Tablet) being used mostly by older students.

5.1.2 Time Spent Playing

We asked students how much time do they play, in average, per week. The analysis shows that the average time corresponds to 6 h per week,[2] equivalent to 3.5 % of their weekly time. If classes occupy about 15 % of the students time during a week, we concluded that the time used to play is quite considerable and therefore it is important to analyze what motivates students to spend such time playing games in order to adjust educational activities and resources to students' interests.

When comparing data between genders, it is possible to verify that male students are the ones who spend more time per week playing: 1–5 h (38.9 %), 6–10 h (18.5 %), 11–20 h (14.9 %) and over 20 h (14.9 %), that is 48.3 % play more than 6 h a week. In regard to female students, 50.8 % refer to play less than 1 h a week, followed by the period between 1 and 5 h (31.0 %).In average, male students play 8.1 h per week while female students play 3.5 h per week. This is understandable since the games, in cultural terms, are considered a "boy's domain" (Lucas and Sherry 2004). Several studies report that the boys spend more time playing games than girls. According to Carvalho and Araújo (2014), the average time used to play by male students in different education levels is always greater than the time spent by girls. This varies between 5.5 h in grade 7 to grade 9 and 8.9 h in secondary education in case of the male students, while female students vary between 2.8 h in grade 6 and grade 7 and 3.5 h per week in grade 7 to grade 9. These results are similar to a study carried out by Wang (2011), with Norwegian teenagers, who reports that the average time for girls was 1 h and boys ranged between 5 and 10 h per week spent on games. Simons et al. (2012) also states that "the Netherlands,(…); boys an average of 9.8 h a week and girls 3.9 h a week "(p. 2). In regard to the differences between each level of education, it is possible to highlight that it is in grade 8 where higher percentage of students play over 20 h per week (13.9 %). However, in all education levels (from grade 7 to 9), most of the students play less than 5 h per week: 67.0 % in grade 7, 61.0 % in grade 8 and 68.8 % in grade 9.

5.1.3 Preferences in Terms of Game Features

Students were asked to classify, using a Likert scale, the level of importance of each game feature in order to continue to play it. Data were organized by the following categories: "Important", "Slightly Important" and "Don't know". The students were

[2] To determine the time, the average of answers was calculated by giving each item the following values: less than 1 h = 1 h; from 1 to 5 h = 3 h; from 6 to 10 h = 8 h; from 11 to 20 h = 15 h; more than 20 h = 20 h

asked about gameplay, the scenarios, the sounds, the music, the history, the characters, being a long game (takes some days to get to the end of the game), being a game with different levels, being a game that allows to improve scores, allows you to play cooperatively, multiplayer online and the fact that friends play the same game. In general, participants consider these components important (see Table 1) and it was possible to identify three different clusters, according to the ratings achieved.

The first cluster, with percentages above 80 %, includes the graphic effects, the scenarios, the Gameplay, being a game with many levels and the characters.

The graphic effects and animation appear at the top of the choices being mentioned by 86.7 % as important. It is for the male gender that this feature gets the highest percentage (93.7 %). In terms of education level, the percentage increases from 83.5 % in grade 7 to 91.1 % in grade 9.

Also related to this item comes "The scenarios" ranked with 83.4 % of importance given by players. For male students, this element has higher percentage (92.4 %) than for female students (72.6 %). Between grade 7 and grade 9 these values increase from 80.2 % to 87.4 %.

Being a game with many levels was noted as important by 82.7 % of individuals. In what concerns gender, male students present the highest percentage (85.8 %). In regard to education levels, the importance gradually increases from grade 7 to 9.

As for the game characters, they were ranked as important by 81.8 % of students, where the highest percentage belongs to the male students (88.1 %). In terms of differences between education levels, there was an increase of 78.8 % to 85.2 % between grade 7 and grade 9.

For the second cluster, with percentages above 70 %, the following items were identified: allows to improve the score (78.6 %), being a long game (77.1 %), possibility to play cooperatively (74.1 %), the history (70.8 %) and the possibility to play online multiplayer (70.3 %). Also in these items, the male players show the highest percentage and reveal an increase from grade 7 to grade 9.

When comparing the items "Being a game with many levels" and "allows to improve the score" and "be a long game", it should be noted that the order of interests, by gender, is different. While for male students it is important for the games to have multiple levels (85.8 %), followed by being a long game (85.1 %) and allowing to improve scores (79.9 %), for the female students, the importance, despite being lower than that mentioned for males, presents by order of preference having multiple levels (79.0 %), followed by allowing to improve score (77.0 %) and being a long game which presents the lowest value (67.5 %).

Comparing the items "being able to play cooperatively" and "multiplayer online", it turns out that the cooperative mode is ranked as more important (74.1 %) than multiplayer online (70.3 %). It is the male students who give more importance to these two items with 84.2 % and 85.1 %. In regard to education levels, an increase between grade 7 and 9 is found.

Finally, we have identified a set of items that are above 60 %, namely: my friends play the same game (68.8 %), the sounds (65.0 %) and the music (60.4 %). The male students remain always with higher percentage, as well as an increase in the percentage between grade 7 and 9. Except for the Music, where it decreases from 59.4 % in grade 7 to 58.2 % in grade 8 and 65.2 % in grade 9.

Table 1 Importance given to different game features—by total, by gender and by education level (%)

Items	Level of importance	Total	Male	Female	Education level		
					Grade 7	Grade 8	Grade 9
Graphic effects and animation	Important	86.7	93.7	78.2	83.5	87.0	91.1
	Slightly Important	10.5	5.0	17.1	5.7	1.4	0.7
	Don't know	2.9	1.3	4.8	10.8	11.5	8.1
The scenarios	Important	83.4	92.4	72.6	80.2	84.1	87.4
	Slightly important	13.2	6.3	21.4	5.2	1.9	3.0
	Don't know	3.4	1.3	6.0	14.6	13.9	9.6
Gameplay	Important	83.1	92.4	71.8	80.2	84.1	85.9
	Slightly important	9.2	5.3	13.9	8.5	7.2	7.4
	Don't know	7.7	2.3	14.3	11.3	8.7	6.7
Game with several levels	Important	82.7	85.8	79.0	79.7	85.1	83.7
	Slightly important	13.9	12.2	15.9	5.7	2.9	0.7
	Don't know	3.4	2.0	5.2	14.6	12.0	15.6
The characters	Important	81.8	88.1	74.2	78.8	82.7	85.2
	Slightly important	15.0	11.2	19.4	4.7	2.9	1.5
	Don't know	3.2	0.7	6.3	16.5	14.4	13.3
Game that allows to improve the score	Important	78.6	79.9	77.0	76.4	78.8	81.5
	Slightly important	17.8	18.2	17.5	5.7	1.9	3.0
	Don't know	3.6	2.0	5.6	17.9	19.2	15.6
Long game	Important	77.1	85.1	67.5	73.6	75.5	85.2
	Slightly important	17.3	11.9	23.8	8.5	5.3	1.5
	Don't know	5.6	3.0	8.7	17.9	19.2	13.3
Play cooperatively	Important	74.1	84.2	61.9	69.3	77.4	76.3
	Slightly important	18.2	11.2	26.6	11.3	5.8	5.2
	Don't know	7.7	4.6	11.5	19.3	16.8	18.5
The history	Important	70.8	78.2	61.9	69.8	69.2	74.8
	Slightly important	26.3	21.1	32.5	5.7	1.4	0.7
	Don't know	2.9	0.7	5.6	24.5	29.3	24.4
Multiplayer online	Important	70.3	85.1	52.4	67.0	69.7	76.3
	Slightly important	22.7	11.2	36.5	9.0	6.3	5.2
	Don't know	7.0	3.6	11.1	24.1	24.0	18.5

(continued)

Table 1 (continued)

Items	Level of importance	Total	Male	Female	Education level		
					Grade 7	Grade 8	Grade 9
My friends also play the same game	Important	68.8	77.9	57.9	64.2	72.1	71.1
	Slightly important	24.3	17.8	32.1	10.8	4.3	4.4
	Don't know	6.8	4.3	9.9	25.0	23.6	24.4
The sounds	Important	65.0	76.6	51.2	61.3	63.0	74.1
	Slightly important	32.8	22.8	44.8	3.8	1.4	0.7
	Don't know	2.2	0.7	4.0	34.9	35.6	25.2
The music	Important	60.4	64.7	55.2	59.4	58.2	65.2
	Slightly important	38.2	34.3	42.9	3.3	0.5	0.0
	Don't know	1.4	1.0	2.0	37.3	41.3	34.8

These findings show that all game features and characteristics mentioned are important for these participants, and that the sounds and music are the least important features. It appears that it is the male students who give particular importance to these items. In terms of differences between education levels, data shows only that the level of importance increases from grade 7 to grade 9.

5.1.4 Playing Alone or with Others Online

Students were asked whether they prefer to play alone or with others online. The opinions vary, although the majority prefer to play alone (53.0 %), followed by playing with others (47.0 %). When analyzing the differences in terms of gender, the preferences are opposite. While the female students prefer to play alone (73.3 %), male students prefer to play with others online (54.4 %).

In terms of education level there are some differences, while in the 7th grade students prefer to play alone (61.8 %) from the 8th grade onwards the preference switches to play with others online, featuring 50.5 % and increasing to 55.6 % in grade 9. These findings are in accordance with those in the previous section regarding the importance of the items concerning social interaction through games, which achieve greater importance with the advance of the education level.

Compared to previous findings published (Carvalho et al. 2014), playing with others online is a preference that grows between the grade 5 to grade 12. However, comparing gender issues, female students always prefer to play alone, while the boys prefer to play with others except in the context of Higher Education.

Those who prefer to play with others online were asked about who these others were. Most students referred that they were friends/acquaintances (82.5 %), followed by colleagues (66.7 %), family members (47.9 %) and finally unknown people (42.9 %).

When analyzing gender issues, findings show some differences. In case of male students, their preference lies with friends/acquaintances (85.2 %), followed by colleagues (69.9 %), strangers (50.0 %) and finally family members (43.9 %). For the female students, data shows that they prefer to play with friends/acquaintances (73.8 %), followed by family members (60.0 %) and colleagues (56.9 %). To be noticed that only 21.5 % indicate that they play with strangers. The major difference seen in playing games with unknown people can be understood by analyzing the games that are most played, which will be discussed further in this paper. Male students prefer games involving online competition with people that they do not know, while female students prefer games that involve only the exchange of items between elements of their personal relationships through social networks. In terms of differences between education levels, results vary. However, when there is an increase or decrease between grade 7 and 8, the opposite happens for the case of grade 8 and 9, in regard to all options. The option "friends/ acquaintances" increases from 76.5 % in grade 7 to 86.7 % in grade 8, reducing to 82.7 % in grade 9. The highest increase can be found in the option "strangers", where it increases from 28.4 % in grade 7 to 49.5 % in grade 8, reducing a little in grade 9 to 49.3 %.

In the case of the options "colleagues" and "family members", the situation switches. In grade 7, the option colleagues shifts from 70.4 % to 61.9 % in grade 8, increasing to 69.3 % in grade 9. Also in the case of "family members", which goes from 54.3 % in grade 7 to 43.8 % in grade 8 and increases slightly in grade 9 to 46.7 %. These findings reveal, however, that colleagues and family will be replaced in the preferences by unknown persons throughout the school trajectory.

Students were also asked about their preferences when they play in multiplayer. The preference is for the competition "In teams" (68.6 %), with options such as one to one and one to all below 50 %. When analyzing data by gender, the male students show the highest preference for competition "In Teams" (76.5 %) compared to female students (44.6 %). It should also be noted that this preference increases with the education level, ranging from 66.7 % in grade 7 to 72.0 % in grade 9.

5.2 Use of Games in the Educational Context

Most students (82.2 %) agree with the use of games to support learning in educational contexts. The percentage of accordance by gender is very close: 82.5 % for girls and 81.8 % for boys.

In terms of distribution by education level, it appears that there is a decrease from grade 7 (89.2 %) to grade 9 (74.8 %). This is in accordance with data presented previously, where the percentage of players decreases compared to the total of respondents throughout the education levels. This may lead to the conclusion that in the same way that the interest in playing decreases, also the interest in using games to learn may also decrease.

The respondents who agreed with the use of games in the educational context (n = 456) were asked to indicate what types of games they considered most

appropriate. About 70 % indicated Action and Adventure games, followed by Sport (52.4 %) and Strategy (49.3 %) games, with the remaining types presenting less than 36 %.

When we analyze the same information, but regarding gender issues, there are differences in the order of preference. While boys prefer Action games (77.0 %), followed by Adventure (64.1 %) and Sport (64.1 %) games, girls prefer Adventure games (78.8 %), followed then by Action games (62.5 %) and Strategy games (50.0 %).

As for the distribution by education level, there are differences. While adventure games are suitable for about 73.5 % of 7th graders, Action and Sport games are preferred by 9th graders (70.3 % and 64.4 %, respectively). However Action games are those who maintain a similar preference among the three school years (68.8 %, 72.3 % and 70.3 %, respectively), the remaining differ widely.

6 Most Played Games

6.1 Games by Mobile Devices

Before we indicate which were the most played games identified by the participants in the survey, it is important to refer the amount of games referred for each device: 87 for laptop computer, 22 for Nintendo 3DS, 50 for PSP and Tablet, 45 for Smartphone and Cellphone. These numbers reflect very well the diversity of games available, which also results in a different interests for games by students.

Table 2 presents the most played games by mobile device. Two types of devices are identified. On one hand, there is the Cellphone, Smartphone and Tablet, which allow to play shorter games typical for this kind of devices. And on the other hand, there is the PSP, Nintendo and Laptop computer, with longer games and more sophisticated graphic designs. These equipments are very different in terms of their capacity, and, therefore, justify the reason for such distinctions in the types of games.

Another interesting finding relates to the fact that there are games that are repeated in different devices in each group. The games Pou, Subway Surfers, and Angry Birds are repeated in the Cellphone, Smartphone and Tablet. It is possible to highlight the game Subway Surfers, used by 77 of the students, which presents the highest score for the types of games played. In regard to the PSP and the Laptop computer, the games GTA and The Sims are also repeated. The Nintendo games are different from others, since they are developed for this type of device.

Concerning the Laptop computer, students mention playing online in platforms of minigames (n = 30). The players can find several minigames divided in different themes, which allows students to choose the game they like best and also change games if they wish to.

Although there is a variety of games available, there is a set of games which are preferred by students to play. These include: Subway Surfers, mentioned 129 times in the different mobile devices, Pou with 74, GTA with 56, The Sims with 54, and PES with 53 times referred by students.

Table 2 Most played games by mobile device

Ranking	Cellphone	Smartphone	Tablet	PSP	Nintendo	Computer
1st	*Pou* (Paul Salameh e Zakeh) (n = 34)	*Subway Surfers* (Kiloo Games and Sybo Games) (n = 35)	*Subway Surfers* (n = 77)	*Pro Evolution Soccer* (PES; Konami) (n = 53)	*Super Mário* (Nintendo) (n = 45)	Web (n = 33)
2nd	*Snake* (n = 31)	*Pou* (n = 20)	*Pou* (n = 20)	*FIFA* (EA Sports) (n = 37)	*Pokemon* (Nintendo) (n = 14)	*Grand Theft Auto* (GTA, Rockstar Games) (n = 30)
3rd	*Diamond Rush* (Bankey) (n = 18)	*Hill Climb Racing* (Fingersoft) (n = 17)	*Angry Birds* (Rovio Entertainment) (n = 12)	*GTA* (n = 26)	*Nintendo Dogs* (Nintendo) (n = 11)	*Minecraft* (Mojang) (n = 28)
4th	*The Sims* (Electronic Arts) and *Subway Surfers* (n = 17)	*Angry Birds* (n = 5)	*Fruit Ninja* (*Halfbrick Studios*) (n = 9)	*Need for Speed* (Electronic Arts) (n = 14)	*Mario Kart* (Nintendo) (n = 6)	*Counter Strike* (Valve Software) and *The Sims* (n = 24)
5th	*Angry Birds* (n = 14)	*Benji Bananas* (Fingersoft) and *Palavraz* (Fugo) (n = 4)	*Jetpack Joyride* (Halfbrick Studios) (n = 7)	*The Sims* (n = 13)	*Inazuma Eleven* (Level 5) (n = 2)	*League of Legends* (LoL, Riot Games) (n = 22)

6.2 Statistical Description

From our sample, 94 games were identified. From these, 57 games were mentioned only by a single respondent, corresponding to 10.3 % of the sample. In a first analysis, we identified the type of game from the list of most played games. The predominant game type found was the game Platform (13.3 %) and Sport (13.0 %), followed by FPS (First Person Shooter, 11.7 %) and Simulation (11.7 %), but these are unique choices of each gender (Table 3). The female students prefer the games of Platform (23.0 %) and Simulation (22.6 %), while the male students prefer Sport (22 %) and FPS (20.5 %). However, in both, the remaining types of games present a percentage lower than 10 % each.

Based on Table 4, it is possible to see that the most played games are: Subway Surfers, The Sims, Grand Theft Auto (GTA), Minecraft, Pro Evolution Soccer (PES) and Call of Duty. The first two are games mostly played by female students

Table 3 Types of games most played by students

Total (%)		Female students (%)		Male students (%)	
Plataform	13.2	Plataform	23.0	Sport	22.1
Sport	13.0	Simulation	22.6	FPS	20.5
FPS (First Person Shooter)	11.7	Unkown	7.9	Action	9.6
Simulation	11.7	Puzzle	7.5	Sandbox	8.9
Action	8.1	Action	6.3	MOBA	6.9
Unkown	5.8	Web	6.0	Run	5.9
Run	5.4	Run	4.8	Plataform	5.0
Sandbox	5.0	Cards	4.0	Unkown	4.0
Puzzle	4.5	Adventure	3.2	RPG	3.3
MOBA (Multiplayer Online Battler Arena)	4.0	Management	2.8	Simulation	2.6

Table 4 Most played games in total, by gender and by education level

Ranking	Total	By gender		Education level		
		Female	Male	Grade 7	Grade 8	Grade 9
1st	*Subway Surfers* (Kiloo Games and Sybo Games) (n = 34)	*The Sims* (Electronic Arts) (n = 33)	*Minecraft* (Mojang) (n = 26)	*Grand Theft Auto* (GTA, Rockstar Games) and *Subway Surfers* (n = 12)	*The Sims* (n = 17)	*Pro Evolution Soccer* (PES; Konami) (n = 12)
2nd	*The Sims* (n = 33)	*Subway Surfers* (n = 27)	*Call of Duty* (Activision) (n = 25)	*Minecraft* and *The Sims* (n = 11)	*Minecraft* (n = 13)	*Subway Surfers* (n = 10)
3rd	*GTA* and *Minecraft* (n = 27)	*Pou* (Paul Salameh e Zakeh) (n = 18)	*PES* (n = 24)	*Call of Duty* (n = 10)	*GTA* and *Subway Surfers* (n = 12)	*Pou* and *Football Management* (SEGA) (n = 9)
4th	*PES* (n = 26)	*Super Mario* (Nintendo) (n = 10)	*League of Legends* (LoL, Riot Games) and FIFA (n = 21)	*Criminal Case* (Pretty Simple) (n = 9)	*FIFA* (EA Sports) (n = 11)	*LoL* and *Counter Strike* (Valve Software) (n = 6)
5th	*Call of Duty* (n = 25)	*Candy Crush* (King) (n = 9)	*Counter Strike* (n = 16)	*PES* (n = 8)	*Call of Duty* and *Lol* (n = 10)	*The Sims*; *FIFA*; *Call of Duty* and *Need for Speed* (Electronic Arts) (n = 5)

while the remaining by male students, showing here a clear difference in terms of gender preferences.

Female students, on one hand, prefer games where they can deal with the lives of people (Sims) or animals (Pou), customize an avatar (The Sims, Subway Surfers and Pou) and where the matches are fast (Subway Surfers, Pou, Super Mario and Candy Crush). Male students, on the other hand, prefer sports games (PES, FIFA), violence and war (Call of Duty, Counter Strike), fight (LoL) or crime (GTA), and Sandbox (Minecraft).

This preference seems to somehow reflect gender stereotypes stimulated in childhood (Blakemore et al. 2008; Vieira 2013). Boys choose sports, in particular football and fighting, while girls prefer to take care of people, manage day-to-day tasks, dress the avatar, in short, a kind of playing with dolls, as also shown by the results of Cherney and London (2006).

Of important notice is the fact this difference is found within data collected under this project (Carvalho and Araújo 2014) from grade 5 to Higher Education. Another interesting fact is that girls play games that are characterized by being short, this is, matches held between 30 seconds and 5 minutes. This preference was also observed in the study carried out by Winn and Heeter (2009). These authors concluded that girls have less free time and spread over short moments, so they prefer to choose short games. By opposite, boys prefer games with long matches that can last 60 minutes or more.

Another difference, which is consistent with what was mentioned about the preferences to play alone or with others, is that girls prefer single player games, even though some allow exchanges between players through SMS or social networks (Subway Surfers, Pou, Candy Crash) and boys prefer multiplayer games.

The most played games are distributed by education levels, but there are some relevant aspects to mention:

1. The game Subway Surfers remains in the first places, ranging from the 1st, 3rd and 2nd place throughout the education levels;
2. Also the game The Sims comes in the first place for the 7th and 8th grade students, then passes to the 5th place in grade 9;
3. The game Minecraft is more played by students from the 7th and 8th grade, being in the 2nd place in the table.
4. Games like GTA and Call of Duty, which had new versions released during the time of application of this survey, appear with greater importance in the 7th grade (1st and 3rd, respectively), decreasing in the next years;
5. On the contrary, the game PES gets a top position in grade 9 (1st place), while games like LoL, FIFA and Counter Strike are ranked in the fourth and fifth place for grade 8 and 9.

These findings show that the games most played by girls remain constant over the three levels of education, while the most played games by boys show variations between the different years.

In total, the games most played by students are representative of the different interests of the students from grades 7 to 9, and include both the preferences of boys

and girls, and also their interests by education level. These also represent the most referred in regard to the different mobile devices (see previous section), except for Pou which, although it is mentioned 74 times in different devices, it appears only in the 9th place, being chosen as the most played game only by 21 students.

7 Analysis of the Games

After presenting the results, it is important to analyze, in a deeper way, the games most played by students from grade 7 to grade 9, in order to identify the common characteristics of the preferred games by students and draw inputs for the development of an educational game, based on these findings.

The analysis will focus on the most played games by students, as these represent the students' preferences by gender and also by school level, as discussed in the previous section. Thus, the analysis will focus on the following games:

- *Subway Surfers* (Kiloo Games and Sybo Games);
- *The Sims* (Electronic Arts);
- *Grand Theft Auto* (GTA, Rockstar Games);
- *Minecraft* (Mojang);
- *Pro Evolution Soccer* (PES; Konami);
- *Call of Duty* (Activision).

One of the first ideas to analyze is the fact that there are several differences, namely, the themes and types of games are very different. However, for the purpose of this study, it is important to analyze the common assets. To meet this goal, we will focus on the Learning Principles presented by Gee (2003) to guide our analysis. According to Gee (2003), the videogames are developed based on a set of learning principles which have been improved by the videogame industry and that schools should try to implement in their teaching practices, in order to improve student learning and engagement. This author identified 36 learning principles. However, for the scope of this paper, we will only consider 14 of those principles, which can somehow be found in the features of the most played games identified by students. These principles are:

(a) 6. "Psychosocial Moratorium" Principle: "Learners can take risks in a space where real-world consequences are lowered" (Gee 2003, p. 67);
(b) 7. Committed Learning Principle: "Learners participate in an extended engagement (lots of effort and practice) as extensions of their real-world identities in relation to a virtual identity to which they feel some commitment and a virtual world that they find compelling" (idem, p. 67);
(c) 8. Identity Principle "Learning involves taking on and playing with identities in such a way that the learner has real choices (in developing the virtual identity) and ample opportunity to meditate on the relationship between new identities and old ones. There is a tripartite play of identities as learners relate, and

reflect on, their multiple real-world identities, a virtual identity, and a projective identity" (ibidem);

(d) 9. Self-Knowledge Principle: "The virtual world is constructed in such a way that learners learn not only about the domain but about themselves and their current and potential capacities" (ibidem);

(e) 10. Amplification of Input Principle "For a little input, learners get a lot of output" (ibidem);

(f) 11. Achievement Principle: "For learners of all levels of skill there are intrinsic rewards from the beginning, customized to each learner's level, effort, and growing mastery and signaling the learner's ongoing achievements" (ibidem);

(g) 12. Practice Principle: "Learners get lots and lots of practice in a context where the practice is not boring (i.e., in a virtual world that is compelling to learners on their own terms and where the learners experience ongoing success). They spend lots of time on task" (idem, p. 71);

(h) 15. Probing Principle: "Learning is a cycle of probing the world (doing something); reflecting in and on this action and, on this basis, forming a hypothesis; reprobing the world to test this hypothesis; and then accepting or rethinking the hypothesis" (idem, p. 107);

(i) 16. Multiple Routes Principle: "There are multiple ways to make progress or move ahead. This allows learners to make choices, rely on their own strengths and styles of learning and problem solving, while also exploring alternative styles" (idem, p. 108);

(j) 17. Situated Meaning Principle: "The meanings of signs (words, actions, objects, artifacts, symbols, texts, etc.) are situated in embodied experience. Meanings are not general or decontextualized. Whatever generality meanings come to have is discovered bottom up via embodied experiences" (ibidem);

(k) 20. Multimodal Principle: "Meaning and knowledge are built up through various modalities (images, texts, symbols, interactions, abstract design, sound, etc.), not just words" (idem, p. 111);

(l) 24. Incremental Principle: "Learning situations are ordered in the early stages so that earlier cases lead to generalizations that are fruitful for later cases. When learners face more complex cases later, the learning space (the number and type of guesses the learner can make) is constrained by the sorts of fruitful patterns or generalizations the learner has found earlier" (idem, p. 137);

(m) 25. Concentrated Sample Principle: "The learner sees, especially early on, many more instances of fundamental signs and actions than would be the case in a less controlled sample. Fundamental signs and actions are concentrated in the early stages so that learners get to practice them often and learn them well" (ibidem);

(n) 35. Affinity Group Principle: "Learners constitute an "affinity group," that is, a group that is bonded primarily through shared endeavors, goals, and practices and not shared race, gender, nation, ethnicity, or culture" (idem, p. 197).

On all games, the principle (a) "*Psychosocial Moratorium*" was found, as there is risk in playing, whether it may mean the death of the avatar (GTA; Call of Duty,

The Sims), or an accident with the avatar (Subway Surfers), the loss of a championship (PES), or the attack of the avatar by wild animals (Minecraft). But these are risks that occur in the game environment, not having any consequence for the real life of who plays it. Besides this, it also does not have strong consequences for the game itself, as it allows to always go back to the starting point and repeat the match. This allows the game player to make decisions, although he knows he is taking a risk, so that he can analyze the different steps and learn which is the best way to proceed.

These are also the games which include avatars that represent the player in the game scenario (The Sims, GTA, Minecraft, Call of Duty) or those who the players gives orders in order to attain his/her goals for the game (Subway Surfers, PES). These assets are related to the following learning principles: (b) Committed Learning Principle; (c) Identity Principle; (d) Self-Knowledge Principle.

The *Committed Learning Principle* can be found in all the games, as effort and practice is demanded by the game character in order to attain the goals, establishing a commitment between the player and his virtual identity in the World, making an effort to meet what is expected.

It is within this context that the game player develops his/her virtual identity, deciding the *character customization*, which reflects the identity that he/she wishes to create, but at the same time is also related to his/her own real life expectations and previous experiences (*Identity Principle*). But to achieve the intended goals, the player learns where he can get more or less advantages, influencing the decisions during the game, as well as when buying equipment or features for the character customization, in order to attain the best results (*Self-knowledge Principle*).

(e) On all the games, it is also possible to find the *Amplification of Input Principle* as the tasks are always organized in order to facilitate the action in the game compared to similar tasks in real life, avoiding routine tasks or unnecessary waiting times, which can be unmotivating. For example, a PES match can take about 4–12 minutes, not being necessary 90 minutes long matches as happens in real life, focusing its action on the football passes which will quickly get the ball to score.

(f) It is also possible to find the *Achievement Principle*, where all players feel an intrinsic reward in doing the tasks, independent of their performance. This happens because feedback is already structured in order to allow that, regardless the ability of the player, he could always proceed and feel the reward related to this advance.

(g) The tasks requested in the different games are repetitive (either a football match in PES, or take care of a Sim in The Sims, a race in Subway Surfers, a chase on GTA, build a hut on Minecraft or fight enemies in Call of Duty) which may increase its difficulty, but they are always very similar and repetitive. These conditions are the basis of the *Practice Principle*, where repetition and practice lead to the improvement of the player's performance on the tasks that are proposed.

(h) The games we mentioned allow to perform the *Probing Principle*, where the player can test his/her hypothesis and learn from these in future issues that may

arise in the game. While experiencing a combination of different materials in Minecraft, the player will unlock different tools that may be useful in the tasks ahead.

(i) The same feature that allows you to test different hypotheses also enables the *Multiple Routes Principle*, since the player has the choice to play and may have different results depending on the decisions he/she makes. In the GTA, for example, you can go all over the map as desired, may carry out assaults to different buildings or persons, other than as part of the mission, but where the player can find equipment that can assist him in doing the task.

(j) In most of these games there is a specific language, which is related to the surroundings of the game itself which enables the development of the *Situated Meaning Principle*. For example, in The Sims, there is a language between avatars (Sims), and these present symbols that identify their mood and needs throughout the game. This implies the presence of the (k) *Multimodal Principle*, which means that it is through various forms of communication that knowledge and its meaning are transmitted to the player. Therefore, the Sims have speech balloons with symbols, but also through representative colors it is possible to know the state of mind of the Sim at every moment.

(l) These games also allow the development of the principles *Incremental Principle* and (m) *Concentrated Sample Principle*. On one hand, in the early stages of the game the main features are presented, helping the player to become familiar with the game—*Concentrated Sample Principle*, on the other hand, it allows, whenever a new feature appears, the player will have space to adapt to this and get prepared for the new challenges throughout the game—*Incremental Principle*.

(n) The last principle that has been identified as common was the *Affinity Group Principle*, because regardless of whether the games are single player or multiplayer, they allow the contact with other players, either by exchanges of support through SMS's and social networks (Subway Surfers, The Sims), either by creating teams to compete in real time against other teams (Call of Duty) or by interacting with others online (GTA, PES and Minecraft) that can be in the game or in discussion forums.

It is also important to mention some game features that we find in common, namely:

- Internal economy: in these games there is a reward which is represented through coins that can be used within the game to purchase equipment that can improve the Avatar performance (Call of Duty, GTA, Subway Surfers, The Sims), to acquire new avatars (The Sims, PES and Subway Surfers) or customize the avatars or the environment (Subway Surfers and The Sims).
- Feedback: its role is to strengthen the player's performance, by giving points or coins, whether by animation and/or sound effects. Punishment is also used in these games, but in a moderate way. This is, the avatar may die during a mission in GTA, but returns to the starting point of the level he is at, allowing the player to repeat and improve his/her performance. Punishment only means that it is required greater effort in carrying out the matches.

- Aesthetics: Games usually feature scenes and animations that simulate real situations (football, war, city, people's life), only Minecraft is different from others since it is based on graphic cubes, but the design fits the tasks and surroundings of the game.
- Difficulty levels: All imply a gradual increase in difficulty allowing players to improve their skills through practice whenever something new is included.
- Missions: In most games the player is given specific missions he/she has to complete to continue the game (complete a word in Subway Surfers, steal in GTA, defeat enemies in Call of Duty). However the player can also design his/her own route by outlining goals that he/she will try to achieve (e.g., build something specific in Minecraft, have a home and family with specific features in The Sims).

Based on this analysis it is possible to understand and identify Portuguese students' preferences and interests, which can, at this point, provide important inputs for the development of educational games that may foster student's motivation and engagement in learning.

8 Inputs for Educational Games

Squire (2011) calls attention to the difficulty in attending the interests of all target group when implementing a game in the educational context, whether it is commercial or educational. Therefore, it is important to note that what is sometimes thought as ideal may not please everyone or its effect may not be equal among all students. Based on the data collected, clear differences were found in regard to gender issues and education level. However, there are games that are played by the majority of students such as the Subway Surfers, which was mentioned 129 times amongst the various devices. This means that there are common preferences amongst students and these are seen in the set of the most played games identified by students. It is for this reason that, based on the results of this project, we suggest a set of guidelines for the development of educational games that can motivate and engage grade 7 to 9 students.

In Education, funding is not always available for great investments, which sometimes leads to the neglecting of the **aesthetic** component in favor of the educational component. But it is the aesthetic component that is the most valued characteristic by these students, as they consider graphic effects, animation and also the gameplay as the most important features in games. Therefore, it is essential that the pedagogical teams work together with the game design teams, suggestion also proposed by Squire (2011). In regard to sounds and music, respondents gave them minor importance, which is understandable since the sound is often turned off not to bother people around them. However, there must be a sound component, appropriate to the context and to the existing graphics.

It is also important to create a context—**situated meaning**, which involves all the aesthetic of the game, allowing the communication of what is expected from the game at each time. A specific language must be developed (images, symbols, sounds, words) or by using terms and symbols that in the context have a very specific meaning. This means, on one hand, that the player needs to get acquainted with these meanings, but these meanings, since they are situated or contextualized during the course of the action, are easily developed and facilitate the game interaction. This context must be linked to the most important concepts to be worked on, which will then facilitate their learning.

Creating avatars, with whom the player can identify himself with, can also support the engagement of participants in the game, enabling the sense of commitment with the goals set.

A common feature of the games mentioned is the fact that they are highly **repetitive**, this is, there is a set of actions that the player will have to perform to meet a diversity of challenges. For example, in Minecraft, the action is to break cubes to collect material, then combine them and create new cubes with specific characteristics or equipment to support the player. With these repetitive actions it was possible, for example, to create a replica of a country, such as happened in Denmark, which was then recreated by the Danish Agency of Geographic Data. This map is available[3] and aims to encourage young Danish students to know their country and to analyze the urban planning and its effects.

The fact that these tasks are repetitive facilitates the handling of the devices in terms of motor skills, focusing the mind of the player in the missions to complete. This encourages players to **test** their skills and outlined strategies, giving them the certainty that there is no higher consequence in taking the risk. This is a characteristic of great potential in terms of educational issues, allowing students to test their assumptions, assess the consequences and reorganize their ideas, all in a safe environment without effects on the students themselves. Therefore, it is important to create the necessary conditions for students to be able to choose from **multiple options** or routes the best option that meets his/her goal. Only like this can he/she test his/her own hypothesis.

But there is also something important to consider here—feedback. Provided at each moment the feedback must be positive and recognizes each **achievement**, even if the player looses, he must feel that he made an advance and that he learned something. Students must stay with the feeling that things will go better the next time. This means that each attempt, even if failed, allows players to learn and improve their skills.

Although repetitive, several conditions in the game make it more and more complex, with the **difficulty level** gradually increasing. This can happen due to demanding tasks (GTA, Call of Duty, PES, Subway Surfers), new objects with different effects (Minecraft, GTA, The Sims), the game map with more unpredictable characteristics (Call of Duty) or new equipments (GTA, Call of Duty). But for the student

[3] The project is available for download in the following link: http://eng.gst.dk/maps-topography/denmark-in-minecraft/#.VWuXpdJVg9o

to get acquainted to each new element, it is necessary to give him/her time so that he/she can develop the new skills needed. This is possible through **practice** in new conditions.

Finally, another aspect to keep in mind is the **interaction with peers** (Affinity Group). For these students, it is important to compete in teams, play with others online (especially for boys) and carry out the exchange of items or sharing achievements among players through social networks (especially for girls).

It is by sharing experiences among peers that have the same affinity that they can experience being learners and masters simultaneously, sharing achievements and being recognized for that. At the same time, students are aware of achievements made by others and find pathways that can lead to the improvement of their performance. Therefore, it is also important to create ways that support the interaction between the different players, whether in-game or through social networking, or through forums dedicated to this.

These are important considerations to take into account when designing educational games for grade 7 to 9. It is true that they are not a magic formula for educational games. However, they can sure help to guide the design of a game.

9 Conclusion

"In the last few years, games have converged with natural user interfaces to create an experience for players that more closely mimics real life. (…) these game-like environments transform assignments into exciting challenges, reward students for dedication and efficiency, and offer a space for leaders to naturally emerge" (Johnson et al. 2014a, p. 42).

There is no doubt that mobile devices have become essential tools. Combining their use to something that brings pleasure to students while they are learning is an idea that can allow schools to be thought in a more positive and engaging way.

Students already feel predisposed to use their own mobile devices and to learn using games. However, it is necessary to invest in creating games that are simultaneously educational and engaging, so that they are not easily rejected by students. It is necessary to bear in mind that in order for a game to provide pleasure to those who play it requires a voluntary act of the player (McGonigal 2011), this is, the student voluntarily puts an effort to play a game which he/she believes will be rewarding for him/her in terms of fun, but which he/she does not need.

Although students have different preferences, there are general principles that are common. Findings from this study provided a basis for the identification of a set of guidelines to support the development of educational games for grade 7 to 9 students.

It is therefore important to consider the aesthetic of the game and its gameplay, create an environment that provides meaning to the transmitted information, use avatars so that students can identify themselves with, design the game based on repetitive actions that allow to test hypothesis and progress with each achievement,

use positive feedback to strengthen the player's confidence, stimulate practice through the development of new challenges and enhance the interaction with others, by the sharing of knowledge and achievements.

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Use of ICT in School Context: Pupil's, Parents' and Teachers' Perceptions

C. Brigas, C. Ravasco, C. Fonseca, J. Mateus, and U. Bolota

Abstract We have been witnessing the rise of a different model in education, starting in primary school. On one hand, teaching is very student-centred, on the other, technology is spreading and taking room in the school environment. Consequently the roles of the teacher/pupil/parents and the interaction itself have changed. In Portugal, there have been some programs sponsored by the Ministry of Education, since the 1980s. We highlight three major programs: *Minerva*, *Programa Internet na Escola* (Internet at school Program) and *Plano Tecnológico na Educação* (Technological Plan in Education). One of the goals of this last program aimed the increase of the use of ICT in at least 25 % of the classes. Another goal was to achieve the ratio of two pupils for a computer provided with Internet access. In order to achieve the goals, a new computer was created, specially designed for children: the *Magalhães*, which was supplied by the Ministry at a very reasonable price according to the families' income all over the country.

The project Interactive Approaches in Education was carried out by researchers from the Research Unit for Inland Development (UDI), from the Polytechnic Institute of Guarda. The main objective is to assess the influence of the use of these programs in elementary schools, in Guarda's county. This project tried to assess the use of ICT in all primary schools by teachers, pupils and parents. Issues such as the integration and use of Information and Communication Technology (ICT) in the overall context of elementary schools, the perception of the digital literacy of the pupils, teachers and parents and ICT's influence in the construction of knowledge from a multidisciplinary point of view were addressed in an encompassing manner.

The study was carried out from April 2012 to June 2012. In a first phase, the study implied the development of a questionnaire and its validation. The methodology used is empirical and descriptive. This methodology allows describing the

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characteristics of a population. The questionnaire was the tool used to collect the data for our study. Thus, the target market of our research has involved all the pupils, teachers and parents from the public primary schools in Guarda's county. We are presenting the final results of the study, currently crossing data from the perceptions of parents, pupils and teachers from primary schools in Guarda's county, their habits in using computers and their sensitivity towards the *Magalhães* computer.

From the results obtained, we can conclude that almost all pupils/teachers have a permanent contact with technologies and that parents value this sort of practice. It can also be observed that the practice is held in different contexts and for different finalities.

Keywords Primary school • ICT programs • Educational tools • ICT in education

1 Introduction

In Portugal, since the 1980s, there have been some ICT programs sponsored by the Ministry of Education. Within a worldwide growing conscience of the importance of the computer and its capacities, several European countries have started a steady investment in ICT in educational curricula. In Portugal, this period of investment corresponds to the very same period prior to the Portuguese entry into the European Community. Consequently, that represented a motivation in the investment in the area of education and ICT. According to many scholars, Portugal has indeed succeeded in this first technological updating (Cardoso et al. 2007).

In the 1980s, the project *Minerva* (*Meios Informáticos no Ensino—Racionalização*, *Valorização*, *Atualização*) was brought to light, lasting from 1985 to 1994. Its main concern was the diffusion of the use of computers among the population which represented the basis of the restructuring of an educational reform felt as needed in order to improve the quality of the educational system and also as a tool for the international cooperation. In the primary school cycle there were, however, same obstacles to be surpassed, such as the instability of the teaching staff and the disinvestment suffered in these particular schooling years, namely, revealed in the out-of-date hardware and software of the schools. Nonetheless, the legal system states the existence of one single teacher responsible for the teaching of all the curricula in one class and this situation enabled the use of one single computer in a single classroom. The same computer was fully used as an educational resource extended to all the areas taught in the primary school context. *Minerva* project did not solve all the problems concerning ICT. However, primary teachers became more confident and valued appreciated regarding other school levels' peers. For all these reasons, *Minerva* program can be considered to be the foundation of the ICT programs.

Later, in October 1996, the Ministry of Education launched the *Nónio-Século XXI*, which was active up to the end of 2002. Simultaneously, from 1997 to 2003, the Ministry of Science and Technology, created the Program Internet in Schools, whose main objective was to install at least one multimedia computer in the library

or media library in all school levels, from primary school to high school, guaranteeing the Internet access through the net of the Ministry (*Rede Ciência*, *Tecnologia e Sociedade* (RCTS)). To support this last program, a unit of support—the *Unidade de Apoio à Rede Telemática Educativa—uARTE*—was created aiming the promotion and cooperation between the different educational agents and the production of scientific and technological content available online to all.

Some other programs were launched in the following years; it can be said that one program was replaced by another one, all with basically very similar aims. Thus in 2002 there was the *Programa Internet@EB1* that was restored in 2005/2006 by the program "*Competências Básicas em TIC nas EB1*"—CBTIC@EB1. The former sought after the use of computers and the Internet in primary schools for pedagogical purposes. The Ministry of Education, Universities and Polytechnic Institutes were involved in the partnership.

Despite the many programs created and designed and their positive results, there were, still, some issues to be addressed. The document printed by the Ministry Council number 137/2007 still acknowledged several problems, specifically in the area of Technology, Contents and Teacher Training. This is the reason why the Technological Plan of Education (Plano Tecnológico da Educação (PTE) from 2007 to 2010) was created. The goals were quite ambitious: a ratio of two pupils per computer, the full connection to the Internet in high speed of 48 Mbps up to 2010 and the use of ICT in, at least, 25 % of the classes.

In 2008, the Government initiated the program *e-escolinha*, intending the acquisition of a low cost computer for children—*Magalhães*—with Internet access. This program expected to increase the access to the Internet and the use of computers in order to abridge the access to the society of information and to endorse info inclusion and the equality of opportunities. Children from primary schools had the right to purchase a computer costing up to 50 €, according to their parents' income, including free access to the Internet by using Portuguese operators. A year after the beginning of the program, 412,700 computers had already been sold and distributed.

In this context, it is important to assess the practical effect of all these measures and this requires going to the context in which they must take effect and question the actors on the use of computers, more particularly as far as the Magalhães is concerned, and ICT, at home and in the classroom, and seek their views on the subject. The aim of this study is to describe the situation in a particular inland county of Portugal, Guarda, identifying gaps based on data collected from pupils, parents or carers and teachers. Thus, the results obtained will enable the development of intervention strategies to promote the use of computers and ICT in the teaching-learning process.

2 The Project Interactive Approaches in Education

ICT is definitely altering our society. ICT is "everywhere, at all times, in all places" (Jonassen 2007). In the last decades, ICT has changed the places where we live in, the way we connect with other, the relations in a society, the way we work and how we access information (Cardoso et al. 2007; Chapman 2003; McDonough and

Clarke 2002). The use of ICT in the school context is a topic that has been the subject of attention from the scientific community (Ferreira et al. 2013; Jones 2003; Mota and Coutinho 2011; Santos and Jorge 2013; Yuan and Lee 2012) and is regarded as an important element in the context of innovation in education (Lagarto 2013). ICT are educational tools with a huge potential. It is undeniable its use in daily school life, no matter the age or the school level of the students (Wu and Lee 2004). It can be used in the improvement of the learning and the teaching process and it can also facilitate the introduction of some innovative approaches (Fonseca and Mateus 2014).

Over the past few years, the Internet has had a profound effect on the private and professional life of European citizens, offering them a bare-increasing number and variety of opportunities to access information, to acquire and exchange knowledge and to achieve personal learning objectives. On average 51 % of Europeans (EU27) aged between 16 and 74 years use the Internet to find information about goods and services. The use of the Internet for learning purposes is also reflected in the Eurostat data. In 2009, an average of 31 % of the population EU27 (16–74) used Internet to find information for learning purposes, which corresponds to an increase of 8 % since 2007 (Redecker et al. 2010).

According to Davidson and Goldberg (2009) the most important feature of the Internet is its ability to allow the existence of a world community with a multitude of communities' subsets where you can learn and share knowledge in a way previously unavailable. The authors argue further that the future of educational institutions requires a deep epistemological appreciation of the possibilities that the Internet offers to humanity in terms of teaching models.

From a pedagogical perspective, participatory learning includes the many ways in which students (of any age) use new technologies to participate in virtual communities where they share ideas, comment on projects, and plan, design, implement, anticipate, or simply discuss the su-practices, goals and ideas together (Davidson and Goldberg 2009).

Besides, its use in the school context should be promoted for social reasons, once students must be prepared to face a technological society.

The educational and pedagogical paradigm has been changing. The roles and the models are now very different from what they used to be. This change has also affected/influenced the primary school process. Teaching is currently student-centred, autonomy in learning is a competence to be developed. The use of technology enables pupils' autonomy. ICT is a tool that is present in the school environment and has to be pedagogically dealt with. As a consequence of all those, the roles of the teacher/pupil/parents and the interaction itself have changed.

The project Interactive Approaches in Education was born out of the need to study the effects and the behaviour towards ICT in the school context. The project is being carried out by a team of researchers from the Research Unit for the Inland Development from the Polytechnic Institute of Guarda. The purpose of the project is to assess the use of ICT in education, especially as far as the computer is concerned and more particularly as far as the *Magalhães* is concerned, in the case of the primary schools from Guarda's county. Besides the analysis of the integration and use of ICT in primary schools in its total dimension, it is also intended to study the

development of ICT competences and the digital literacy of the pupils, parents and teachers connected to Guarda's primary schools.

Furthermore, we intend to consider ICT's inclusion in knowledge construction from a multidisciplinary point of view. A critical reflexion on the outlook of the integration of ICT has become relevant as the technological development and the general access to the Internet have changed social behaviour and might have changed educational practices in the school context. Professional and socializing activities demand ICT competences from most citizens. Therefore, schools should prepare children to be able to respond to these expectations. According to the effort undertaken in the scope of the several programs mentioned previously, the existence of technology in the school environment can be considered real. A priori schools are well equipped. However, this may not correspond to the use of technology in learning and teaching (Pedro 2012; Wu and Lee 2004).

3 Methodology

The methodology adopted for this study was empirical and descriptive, because it allows to describe the characteristics of a population (Carmo and Ferreira 2008). The universe was made of all the pupils, teachers and parents or carers of the public primary schools in Guarda county.

To begin with, the researcher had to develop the questionnaires. Subsequently, their contents were validated. The process of data collection was structured in different phases. Afterwards, a special authorization to a particular office from the Ministry of Education (*Direcção-Geral de Inovação* e de *Desenvolvimento Curricular* and *Gabinete de Estatística e Planeamento da Educação*) had to be asked for. After that authorization was communicated to the school clusters' directors the visits to the schools were scheduled. These visits included the physical presence of some of the researchers of the study involved.

Data collection was done with three different surveys by questionnaire, aiming children, teachers and parents from public primary schools of Guarda's council. The study took place from April 2012 to June 2012.

As a way to reach the goals it was proposed, in a systematic way, surveys by questionnaire to pupils, parents and teachers. It is generally consensual (Silva and Menezes 2001) that objective questions are more easily answered when compared to subjective questions. Objective questions tend to minimize ambiguity and therefore demand less effort in comprehending them. This sort of tool also makes the analysis of information easier, more reliable and less time consuming.

When the questionnaires were made, a goal was to maximize the number of valid answers by using a simple survey, whether in clarity and objectivity. Another goal was avoiding dissuasive approaches in order to obtain the maximum answers.

Three different questionnaires were used with the following goals:

1. Questionnaires directed to the pupils, aiming to assess the way they use ICT, the tools they are able to operate, in what context and if they require any support for that;

2. Questionnaires directed to the teachers, with the objective of finding out they perspectives towards the integration of ICT in classes;
3. Questionnaires directed to parents or carers to check their own ICT competences, if they promote the use of ICT in schoolwork and if they supervise their children's activities.

The three questionnaires are organized in two main parts, one with questions that allowed the socio-demographic characterization of individuals and the other with specific issues related to the use of ICT in the classroom and at home, as well as personal opinions about computers in general. The process of data collection took 2 months to be carried out and had the active participation of parents, researchers, educators and pupils. The questionnaires of the pupils were answered in class, in the presence of the primary teacher and a researcher. The questionnaires for the teachers were left at the school for a week, as well as the parents' questionnaires. Subsequently, the researchers went back to the schools to collect these two questionnaires.

4 Results

The results of the study come from the questionnaires to parents or carers, teachers and pupils from the 24 public schools in Guarda's county. The analysis is based on 1064, 1080 and 80 survey questionnaires answered by, respectively, parents or carers, pupils and teachers.

As far as age is concerned, regular pupils attending primary schools in Portugal are largely aged between 6 and 10 years old. More specifically, in the 24 schools studied, there are 15 % of the children with 6 years old, 24 % with 7; 27 % with 8 years old, 22 % with 9 years and finally 10 % with 10 and 2 % with more than 10 years. Although it was meant to have a 100 % coverage of the parents' answers, the fact is that not all of them accepted to answer the questionnaire. According to the results, most of the parents or carers are from 30 to 39 years old (48 %), 39 % of them are aged between 40 and 49, whereas 11 % are less than 30 years old. A minority of 2 % are more than 50 years old.

Eighty surveys were received from the primary school teachers working in public schools in Guarda's council. As far as characterization of teachers is concerned, it is noticed that they are mostly women (91 %) and aged 50 or more.

4.1 Pupils Perception on the Use of Computers in Primary Schools

The questionnaires analysis show that 92 % of the pupils have got a computer and 8 % do not have. When asked whether they could use a computer, 94 % of the pupils answered positively, only 5 % of the pupils answered negatively and 1 % did not answer.

Table 1 Results to the question: "Where do you use your computer?"

	Frequency	Percent (n = 1080)
In the classroom	452	42
In the school library	73	7
In extracurricular classes	200	19
At home	995	92
In ATL (free time activity)	218	20
Other places	182	17

As far as the use of the computer is concerned, there are 93 % of children's positive answers to the question "Do you use the computer?" In the questionnaire, pupils were asked to identify the weekdays in which they use the computer. From the results, it is seen that Friday, Saturday and Sunday are the days referred to, by a larger number of pupils, as their favourite to use the computer.

Questioned about the place where they use the computer, 92 % of the pupils showed they use the computer at home and only 42 % of the pupils said they also use it in the classroom (Table 1).

When questioned "How have you learnt to use the computer?", only 8 % of the sample refers having been taught how to use a computer by a teacher, whereas 40 % of the pupils says they have learnt with their parents. 24 % points out they have learnt to use the computer autonomously. The remaining 20 % learned with brothers/sisters or other unidentified person and 8 % did not answer.

Considering the nature of activities performed at school using the computer ("At school you use the computer for…"), data show that there is a wide range of activities. Among the 1080 pupils the answers are distributed by: Research on the Internet: 46 %; Playing: 36 %; Writing texts: 56 %; Studying Maths: 44 %; Drawing: 39 %; Studying Portuguese Language: 47 %; Chatting with friends: 7 %; Studying Sciences: 44 %; Listening to music: 42 %; Studying English Language: 13 %; Watching movies: 37 %; Studying Expressions: 14 %.

Similar scattered results appear in the issue "Out of school you use the computer for…." Outside school context, pupils refer the following uses: Research on the Internet: 60 %; Playing: 86 %; Writing texts: 53 %; Studying Maths: 40 %; Drawing: 61 %; Studying Portuguese Language: 40 %; Chatting with friends: 28 %; Studying Sciences: 38 %; Listening to music: 70 %; Studying English Language: 20 %; Watching movies: 59 %; Studying Expressions: 17 %. Comparing the results of the use in the school context and outside it, the answers show that although in school context pupils refer "Writing texts" as a major task, outside school "gaming/playing" is the activity they prefer.

Questioned if they have a *Magalhães* computer the results showed that the majority of the pupils have got a *Magalhães* computer (76 %). When they are questioned where they use it, 73 % answered "at home" and 37 % pointed that they use it "at school." A possible reason for the lower percentage of use at school may have to do with the fact that not all pupils say they have got the *Magalhães*, which, certainly, may interfere with the teacher's decision about using it in class. About the activities

Table 2 Results to the question: "How does the Magalhães computer work?"

		Frequency	Percent	Valid percent
Valid	It does not work	85	8	10
	It works bad	81	8	9
	It works well	296	27	35
	It works very well	389	36	46
	Total	851	79	100
Missing	System	229	21	
Total		1080	100	

carried out with the *Magalhães* computer, 64 % of the pupils referred they use it to do the homework. In addition, 63 % of the pupils also said they use it for entertaining activities. It is quite expectable that pupils indulge in a social, entertaining use of the computer, if we bear in mind the widespread use of technology in so many socializing actions.

Regarding the pupils' perception about how the *Magalhães* computer works, the majority say that it works well (27 %) or very well (36 %), 8 % refers that it works bad and another 8 % have the perception that it does not work (Table 2).

When questioned "Do you use the Internet?" a percentage of 69 % of the pupils says that they use the Internet against 23 % of the pupils who do not. The remaining (8 %) did not answer the question.

4.2 Discussion

From the general results obtained, we emphasize the overall characterization of pupils' perceptions attending Guarda's primary schools and we can pick out their habits when using computers, particularly *Magalhães* computer (Ravasco et al. 2014). Results demonstrate that almost all pupils have a regular contact with computers and ICT, this contact is made in different contexts and serves multiple purposes.

4.3 Parents or Carers Perception on the Use of Computers in Primary Schools

Although it was meant to have a 100 % coverage of the parents or carers' feedback, the fact is that not all of them have accepted to answer the questionnaires. However, it was possible to obtain cooperation from 1064 parents or carers.

The majority of parents or carers are female (77 % against 22 % male) and aged between 30 and 39 (48 %) and between 40 and 49 years old (39 %). The representation of lower and higher ages can be considered negligible, with 10 % aged under

30 and 2 % older than or equal to 50 years old, the remainder 1 % did not respond. In the questionnaires analysis we realized that most of the parents or carers considers his competence to work with computers enough (36 %) good (37 %) or very good (17 %), only 9 % considers it poor and 1 % did not answer. Likewise, 61 % of parents or carers think that computers are important, 24 % very important, 12 % unimportant in schoolwork and only 2 % considers it is not important, the remaining 1 % did not answer.

In terms of the regularity of computer use at home, the majority indicates that children use it 2 or 3 times a week (41 %), and, in second place, those who use the computer once a week (30 %), followed by more than 3 times a week with 24 %, with 5 % non-responders. It is noticeable that parents tend to favour the weekends for computer use (75 %) against working days (17 %), the remaining 8 % did not answer.

Although 647 parents or carers consider technology a major tool for schoolwork (61 %), 796 tend to favour its use during weekends (75 % as mentioned in the previous paragraph), what seems to be an inconsistency in the opinion of the surveyed parents.

The majority of the parents or carers (621: 58 %) have the opinion that *Magalhães* works well and 104 (10 %) say it works very well, but for 124 (12 %) it works badly and 84 (8 %) think it does not work, with 12 % non-responders.

4.4 Discussion

With this descriptive approach we were able to typify the parents or carers in Guarda's council, as far as computers and technology are concerned. It can be concluded that they self-asses their informatics competence as enough or good, meaning that they are able to run basic operations with computers (Ravasco et al. 2014).

Most of the families have joined the *Magalhães* program and are satisfied with the way these computers work, possibly because they believe computers are important in their children's school life. In fact, they perceive computers are major tools at school, though they do not allow children to use them all the time.

4.5 Teachers' Perception on the Use of Computers in Primary School

In the data collection process, we have received 80 surveys from the primary school teachers working in public schools in Guarda's council.

As far as the characterization of teachers is concerned, we notice that they are mostly women (91 %) aged 50 or more (68 %). It is noted that 26 % are aged between 40 and 49 and only 5 % are aged between 30 and 39 years old, with 1 % non-responders.

The use of computers demands, among many other competences, some knowledge and ability. This is why it is appropriate to understand if teachers have attended any course in the area of computers and what exactly are the tools/expertise that they want to achieve. It is also important to realize the self-assessment teachers make of their own general competence to work with computers.

Thus, it was observed that 71 teachers (89 %) have already attended some course in the field of computers. From these 71, nearly half (35 teachers) has attended that course in the last 5 years, whereas the remaining have attended a course more than 5 years ago. Indeed the vast majority (84 %, 67 teachers) has shown some interest in attending a course in the area of informatics. This remark is valid for both genders and different ages.

It is considered extremely important that a teacher, during his/her career, makes his/her self-assessment as a way to identify weaknesses and strengths. This habit will allow him/her to guide his/her teaching and learning strategies and define his/her training needs. In this sense we have asked teachers to classify their competence in using computers and some tools as common users. The scale ranged from unsatisfying, satisfying, good, very good. In this self-assessment the majority, equivalent to 50 teachers (64 %), considers their competence satisfying. This is common to different ages in our sample. There is the same number of teachers (5: 6 %) that qualifies their competence with unsatisfying or very good; these two groups belong to older age groups.

As mentioned before, there has been a great economic and political commitment in order to provide schools and teachers with computer equipment. This is why it was intended to observe the practical result of these policies on the ground. So, as far as using the computer equipment is concerned, the results confirm that from the 80 teachers that have answered the surveys, only one refers not using any of the presented equipment's: *Magalhães*, Personal Computers, school computer. The distribution of the answers in the use of the different equipments show that *Magalhães* is used by 17 %, whereas Personal Computers are used by 45 % of the teachers, 39 % prefer, for different reasons, the school computer.

It must be said that 24 teachers (30 %) declare that they use the three types of equipment.

From the answers provided, and bearing in mind the rural and urban areas of the county, there is not a remarkable difference in the use of computer equipment among teachers working in rural areas and urban ones.

As for using the computer tools with the pupils, most teachers say they do it (68 teachers: 92 %).

The use of computers is connected to an enormous investment of time, effort and willingness to change, which is not available to everyone (Beauchamp 2004).

More important than just using the computers in schoolwork with children, we regard as significant to examine the frequency of that use. Likewise, the majority of the teachers use computers equipment once a week (27: 44 %), followed by a similar number of teachers who use this equipment two or three times a week (22: 36 %). However, only 12 teachers (20 %) use it four or more times a week. In conclusion, it could be stated that in most of the cases there is no such thing as a daily or even

regular use of computers in schoolwork. Once more, there was no evident difference between the schools from rural areas and the urban ones.

Teachers were required to select the main areas where they use computers with children: research work, project work, online contact, presentations of contents or another area. The activity preferred was research work (22 in rural area—42 %, 37 in urban area 34 %).

Another area with high preference was project work (16 in rural area—31 %, 27 in urban area—25 %), in presentations of contents (8 in rural area—15 %, 32 in urban area—29 %). A few number of teachers select activities like online contact or other activities.

These results are close to those presented by Mumtaz (2001), whose research was developed in UK primary schools. In his work, the author concluded that, at the school, children use computer mainly to word processing.

When t answers are analysed in terms of sections, we can see that research is the section in which there is more work developed, both in rural and urban places. In urban areas, the second section of work is the presentation of the contents of the syllabus, from the point of view of the teacher. However, in rural areas, the second one is project work. When the age and genre are considered, there are no particular differences to account for.

With the aim of identifying possible reasons why teachers do not use computers with children, it was made a specific question. Hence, only four female teachers answered the question "why don't you use computers with children?" One teacher said that she does not like using the computer, whereas the other three answered other reasons ("I do not have access to the computer" or "the computer does not have suitable materials or contents").

From the four teachers who have answered this question, three are more than 50 years and one is aged between 40 and 49.

Three of this group of teachers are from the urban area, and one from the rural area. This piece of information does not provide a noteworthy difference.

In a previous question, there was only one teacher who said he does not use any computer equipment (in a general perspective), but that number increased up to four teachers in this last question, where it was clearly evidenced that the use of computers with children is quite limited.

From the total number of the surveyed teachers, the majority, i.e. 56 (76 %), considers the use of computers in schoolwork important and 17 teachers (23 %) consider it very important. It should be noted that there is no single teacher who says that the use of computers is not important at all and only one considers it of minor importance. So, it can be deduced that almost all the teachers who answered the question (73: 99 %) are convinced of the importance of this use in schoolwork.

One of the questions in our survey intends to count the number of children who have joined the program *e-escolinha*, in particular by buying the *Magalhães* computer. In this case, it can be noticed that in most of the classes (49: 73 %) more that 75 % have joined the program. There was only one class in which only less than 25 % have joined it. The remaining six classes had between 25 and 75 % of children joining the program. This program has been under postponement since 2011. This is why 11 of the classes (16 %) could not join it.

As far as the teachers' opinions on how well the computer *Magalhães* operates 46 consider that this piece of equipment works well (66 %) or very well (3 %). The remaining 18 consider that *Magalhães* does not work well (27 %) or simply does not work at all (4 %).

About children competence to use the computer, 13 (18 %) teachers think that children do not have enough competence to work with computers, 47 teachers (66 %) consider that children have a satisfactory level of competence and 10 (14 %) think they have a good level of competence, or even very good, according to one teacher (2 %).

About family support to children in order to help them operating with computers, 37 teachers (52 %) regard as a few, the number of children that have family support, 32 (45 %) think that almost all children have support and only 2 teachers (3 %) consider that all children have it.

It can be observed that children make more use of the computer at home than at school (Mumtaz 2001), which turns out to be important to know more about family support.

4.6 Discussion

It can be concluded that teachers do use some ICT tools in the teaching and learning process, although there is not a daily or even regular use of computers in schoolwork (Ravasco et al. 2013).

Teachers wish for some entrepreneurship in using the computers at school, but there is an evident need of training and technical support (Costa et al. 2009). This issue goes back to universities and education schools during the process of teacher training periods. Entrepreneurship and competence are paths that have to be toddled when preparing teachers for new roles in education, both in terms of technical and pedagogical competence (Beauchamp 2004).

Teachers cannot yet show a remarkable competence in using information and communication technology, but this is undoubtedly an on-going trend. Teachers will progress eventually, but it may happen in a different pace and only if there is a supportive environment.

Nonetheless, teachers must be entrepreneurs if they wish to succeed with their students, because, on one hand, due to all the economic problems we are dealing with, they should expect less material resources in schools and, on the other hand, the pupils' ability in ICT is growing.

4.7 Crossing Data from the Perceptions of Parents, Pupils and Teachers

Based on the three different surveys and in the collected data the three perceptions of ICT tools use were analysed in different ways. However, the goal is crossing information from parents, pupils and teachers as far as it is possible.

From pupils' answers, we get to know that 994 (92 %, n = 1080) have a computer and 1018 (94 %) say that they can use it. This shows that there are pupils who do not

have a computer, but that have or had contact with such equipment. This may be related with high computer use in Free Time Activities Centres, as mentioned by 995 (47 %) pupils. The school is the place where 452 (21 %) pupils say they use the computer.

The teachers' opinion about pupils' competence allows us to conclude that the majority (59 %, n = 80) of the teachers classify the performance of their pupils as satisfying. This result can be considered in accordance with the self-assessment of the pupils.

It is important that each person, in particular a teacher or a parent/carer, is able to identify his/her weakness and strengths. In their role of teachers and educators, they must evaluate their performance and, when necessary, pursuit strategies to improve their practices: Sometimes this update involves attending specific courses. Thus, teachers and parents or carers were asked to classify their competence in using ICT tools. There is a higher percentage of parents or carers than teachers that qualifies their competence with good or very good. On the other hand, the majority of teachers (63 %, n = 80) consider that their competence is satisfying. The classification of unsatisfying was selected by 97 parents or carers (9 %, n = 1064) and by 5 teachers (6 %, n = 80).

The family support, in the different situations, is an important dimension of children's lives and it is fundamental in their physical and intellectual growth process. In this context, teachers expressed their perception of family support given to pupils. The majority of their answers are divided between almost all pupils (40 %, n = 80) and few pupils (46 %, n = 80) have family support with ICT tools. Since the highest percentage of teachers says that few pupils have family support and only 3 % (n = 80) say that all pupils have family support, doubts could be raised in the answers given by parents or carers about their ability to work with ICT tools. Furthermore, it was observed that 40 % (n = 1080) of the pupils had learnt to use computer with their parents and 15 % with brothers. However, 24 % of the pupils say that they have learnt alone. This is possible, because children have a great capacity for learning and can learn by simply observing older people or peers.

In the current technological context, the computer is a crucial tool, as it is present in everyday activities of the general population and, as such, in pupils' routine. Hence, because school is an important part of society, the computer is present in the school life, even when it is not used in the teaching/learning process. In addition, if there is the intention of increasing the digital competence of the population, this will necessarily involve schools. Despite its widespread use, particularly by children and young people, this does not mean that their level of digital literacy, in this item, is high. Thus, it seems essential that the teacher integrates the use of computers in the teaching/learning process, whenever it is an appropriate a well planned strategy that promotes meaningful learning. Hence, we inquired parents or carers and teachers about the importance they confer to computer use for schoolwork.

The majority of the parents or carers (61 %, n = 1064) and teachers (70 %, n = 80) consider that using computer in schoolwork is important and none of the teachers and just 2 % of the parents or carers classifies it as not important at all (Fig. 1).

So, in this particular point, both sides seem to agree. Thereby, pupils were inquired about the use they gave to the computer at school and at home.

From the results it can be seen (Fig. 2) that pupils use the computer in the school as a support in the study of different subject matters and to develop other knowledge/

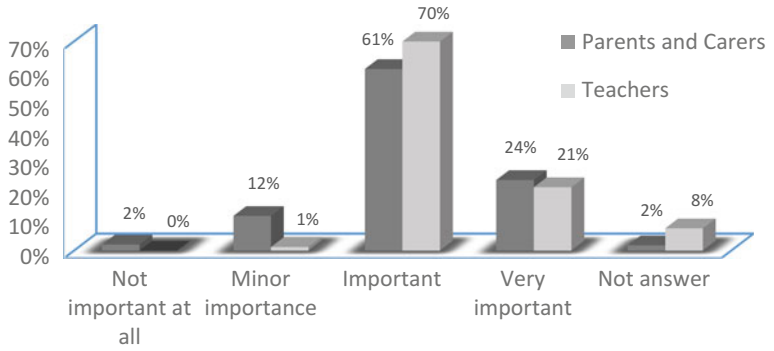

Fig. 1 Distribution of parents' or carers' and teachers' opinion about computer use for schoolwork

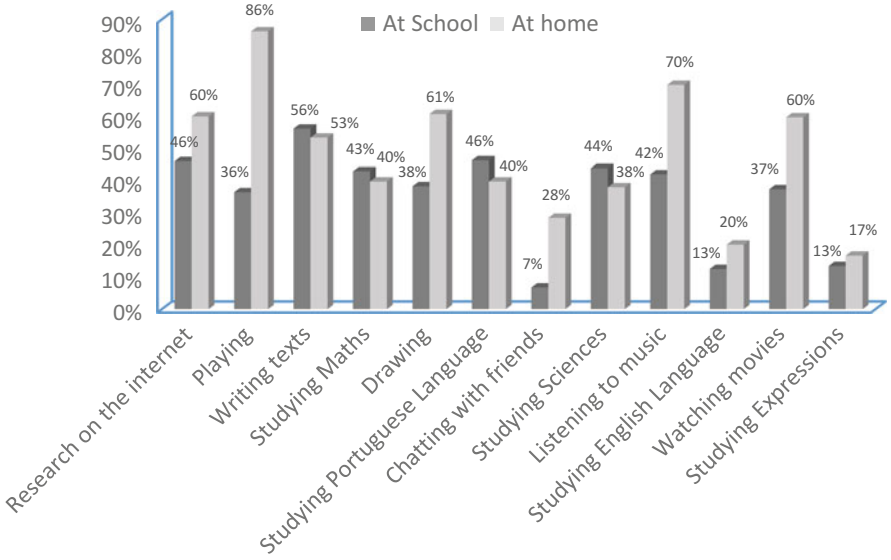

Fig. 2 What use pupils give to the computer at school and at home

skills, but the majority of the pupils do not mention these. We highlight that, at home, pupils say their main use is to play (86 %, n = 1080).

In this context, teachers also presented their choices for computer in schoolwork and the majority (74 %, n = 80) use computer for research, followed by project work (54 %, n = 80). By the students' answers, it can be said that, at school, the research on the Internet (46 %, n = 1080), writing texts (56 %, n = 1080) and studying Portuguese language (46 %) are the activities that stand out. These results meet the teachers' results.

The community of people, whose professional area involves working with children or young people of school age, has been alerting about the time that children and young people spend on the computer. It was intended to analyse the weekly distribution of computer usage time so pupils were asked about this.

Results show that the highest use of computer is at the weekend, Saturday with 81 % and Sunday with 72 %. In addition, parents or carers and teachers were asked about the number of days that their children use the computer (outside or in school, respectively). It is possible to conclude that the percentage of teachers who did not answer (24 %, n = 80) is high, but the majority use the computer more than once a week. The answers given by parents or carers are in accordance with the answers given by pupils, the highest percentage is 41 % for 2 or 3 times a week.

The Technological Plan of Education, mentioned before, has had a central role in the educational policies in Portugal, especially with the appearance of the *Magalhães*. It was intended to know the number of families that bought *Magalhães*. Teachers were asked to describe what it was like in their classroom. By the results obtained, it can be said there was a high access, because 61 % (n = 80) of the teachers declared that more than 76 % of their pupils had acquired a computer *Magalhães*.

The next step was to ask pupils if they had a *Magalhães* and if they used it to work/study or to play. From the 825 (76 %, n = 1080) pupils who had acquired it, 557 said they used it in activities, 127 just for school work and 133 just to play. The majority of pupils use it at home (73 %, n = 1080).

The *Magalhães* was contentious in the educational community, namely its operability. For this reason we inquired parents or carers, teachers and pupils about that. After analysing the results the conclusion is that the majority of the parents'/carers' (58 %, n = 1064) and teachers' (55 %, n = 80) opinion is that it works well. Further, a high percentage of the pupils said it works very well (36 %, n = 1080). So, it can be said that, in general, the inquired people have a positive view of the computer operability.

Based on the data collected, the existence of association between different variables in each questionnaire was analysed, based on the statistical Pearson's chi-square. There is no unexpected association, apart from parents' age and the competence to use the computer or know how to use it (Ravasco et al. 2015).

5 Conclusions

From the general results obtained, it can be emphasized the overall characterization of the teachers', parents or carers' and pupils' perceptions describing a population living and attending Guarda's primary schools. It can be picked out their habits when using computers, particularly the *Magalhães* computer. Results demonstrate that almost all the pupils have a regular contact with computers and ICT, and this contact is made in different contexts and serves multiple purposes.

With this descriptive approach it was possible to typify the parents in Guarda's council as far as computers and technology are concerned. It can be said that they

self-assess their ICT competence as enough or good, meaning that they are able to run basic operations with computers.

Teachers wish for some entrepreneurship in using the computers at school, but there is an evident need of training and technical support. Teachers do not show high levels of competence in using ICT, however they are willing to learn and to practice. This issue goes back to universities and education schools during the process of teacher training periods. A supportive environment is required even in a life long term. Even so, there will always be different paces and rhythms. Entrepreneurship and competence are paths that have to be toddled when preparing teachers for new roles in education, both in terms of technical and pedagogical competence.

Nonetheless, teachers must be entrepreneurs if they wish to succeed with their student's. Times have changed and pupils have to be prepared to face a different society and professional market.

We can conclude by saying that teachers do use some ICT tools in teaching and learning, although there is not a daily or even regular use of computers in schoolwork.

Most of the families who have joined the *Magalhães* program are satisfied with the way these computers work. Families seem to believe computers are important in their children's school life. In fact, they see computers as major tools at school, though they do not allow children to use them all the time.

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Collective Storytelling with Children from 6/10 Years Old Using ICT Support

Maria Rosário Rodrigues, António Moreira, and João Grácio

Abstract This article emerges as part of a case study with ethnographic nature undergone during a school year in a classroom with children from 6 to 10 years old (Elementary School). The teacher involved in this study is a committed user of ICT with his students because he strongly believes that students learn better when they are able to work using a project based methodology associated with the use of ICT. One of the projects that were developed during the school year was a collective book with the participation of all students and where ICT played an important role across the working process. This article aims to reflect on this project, about how it was organized, how ICT was used and on the development of the students' skills.

Keywords Primary school • ICT • Native language • Learning

1 Introduction

The project e.escolinha allowed Primary Education students in Portugal to acquire, at a low cost, small laptop computers called Magalhães. However, this project was not a success, because it suffered strong criticism and it finished without an evaluation about its benefits. In this article we will try to describe and reflect upon an experience of collective book building that could not have occurred without the technological conditions provided by the Magalhães computer. We begin this article

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with a brief description of the context in which the project took place and then we talk about the theoretical approach, the methodology used in the research, the activities organization and how technologies were integrated in them and, finally, some thoughts about this subject matter are presented.

2 Context

The technological conditions in the classroom where the study took place can be considered good because the Internet had an acceptable range and speed. The classroom was also equipped with two computers and the students also had some laptops, which allowed work in small groups. Although we consider that the classroom was good, the number of computers in good conditions was not enough to work in pairs so the working groups had three or four students. The class had 20 students spanning over two school years (third and fourth year) and two autistic students. The majority of the students were aged between 9 and 10 years old, but there was also some younger and other older. The dispersion is too large for a class of students with these ages, which is justified with the overlapping of 2 years, but also because it had six students retained from previous school years.

Students did not have ICT use habits and, in the beginning of the year, computers were seen as playful instruments. The school is set in a newly built neighbourhood, but it is adjacent to another very old neighbourhood in very precarious conditions. So the students were from two different socioeconomic groups: an economic and culturally most favoured group and one with many economic and cultural difficulties. Students also showed many difficulties in Portuguese and Mathematics, diagnosed in some assessments made by the teacher early in the school year.

The teacher started working with this group in the school year of 2009/2010 in which the study took place and already had previous habits of technology use with the students, because he was convinced that one learns best when the work follows a project design methodology, and where the use of the computer can improve the diverse phases: data collection, organization and management, communication and presentation of results.

This characterization of the class is important because the study was carried out in a class with some special characteristics that made it difficult not only because of the cultural and social diversity of the students, but also due to the weak school exploitation of resources. In fact, what seems important and was the most relevant matter for this study was the teacher's working methods and the way he integrates technologies in some projects.

3 Theoretical Contextualization

According to constructionist approaches, reality is internal to the individual and s/he is the one that is capable of building his/her own knowledge. Constructivists believe that learning should focus on active creation of individual meaning for the

experience (Dede 2008). So, people acquire new knowledge and skills based on what they know and believe, according to socio-cultural development, previous experiences and the context. Learning should be provided through rich, unstructured experiences encouraging the construction of meaning, without imposing a fixed set of knowledge and skills (Dabbagh 2006). This approach assumes that teaching is not a process of transmitting knowledge but it aims to be a support to the construction of knowledge, where the teacher is a guide, responsible for suggesting authentic learning activities focused on students, encouraging them to reflect on experiences, seeking alternative points and testing the feasibility of those ideas (Schultz and Schultz 2005). The same authors point that students' motivation to achieve these goals is determined by factors such as challenge, curiosity, fantasy, choice and social recognition.

Authors who have developed these methodologies also point out the diversity of technological tools that can be used in constructivist methodologies. Piaget (1973) can be seen as the pioneer of this vision. Vygotsky (1978) developed Piaget's idea and set out Social Constructivism, which argues that the development of man changes according to the characteristics of the social environment where he lives in. This idea of social constructivism is later developed by Lave and Wenger (1991) and deepened by Wenger (1998) that envisages learning as social participation, viewing individuals as active social agents and participants in the various communities of practice, and social spaces, where they belong. The use of technologies in constructivist contexts begins with Papert (1980), which states the importance of social interaction to build the cognitive structure and adopting an approach whereby the students build their own knowledge through various means. Papert considers that the challenge of building artefacts is fundamental for students because this will improve their learning abilities and their own learning construction process.

However, the use of software in these constructivist environments is not the most important part but the wealth of contexts created by the teacher, the authenticity of activities and teamwork (Apple Classrooms of Tomorrow 2008). The project work methodology is based on these principles. Castro and Ricardo (1993) state that a project working method "is a method that requires the participation of each member according to their capabilities, in order to carry out some group work, decided, planned and organized by mutual agreement" (p. 9). The referred authors are not consensual on project work steps but they all state the importance of students' collaborative work in order to build a product (Cruz and Ferreira 2009).

Also according to these authors, projects must arise from students' interests and needs and they are materialized by a sequence of steps where students are the main actors and where the teacher's role is to manage consensus, to guide and discuss. Students, in a negotiated and consensual way, make decisions about what and how to learn, being responsible for the implementation and evaluation of planned activities, being active stakeholders in all project development phases. In this way, learning occurs by intentional discovery of the actors themselves and it consists on the acquisition of knowledge, attitudes and life values in a democratic society. Vasconcelos et al. (2012) state that the last phase of project work consists on the socialization of knowledge, making the apprenticeship useful to others. The same authors report that this sharing can be done within the classroom,

including kindergarten rooms, other school classes or even the surrounding community and can take shape in the form of an exhibition, a conversation, in a movie or in other media that the group considers appropriate to disclose their knowledge. The activities developed in a project work context must be authentic and developed in a rich and typical context of the knowledge society, using also real tools and design. Apple Classroom of Tomorrow has concluded that these working circumstances contribute effectively to improve student's results.

3.1 Methodology Adopted Throughout the Study

This research fits itself in a qualitative methodology, which focuses on the meaning conveyed by the participants in conjunction with their behaviour (Schensul 2008). As it relates to the research methods, we consider that the work has the characteristics of a case study, because we tried to study a phenomenon in depth—the use of ICT in the classroom. The case study is a research method widely used in social sciences when you want to know the "how" and "why?" of things (Yin, 2010), when the researcher has little control of the real events and when the research field focuses on a natural phenomenon within a context of real life. On the other hand, we also agree that ethnography is concerned with "the common and the usual trying to identify the culture of what appears to be the same or familiar to «us»" (Caria 2002, p. 5). These characteristics of the ethnographic method seem to adapt well to our study context. In fact we have plunged into a classroom where the parties concerned were strangers and where the whole dynamics was unknown, in order to understand how they worked, how they interacted with each other and with the technologies. Thus, the study includes the qualitative study paradigm and uses the case method with ethnographic characteristics.

The main technique used for data collection was observation—we stayed in classroom for 105 h. The researcher aimed to change as little as possible the observed environment, taking a non-participant attitude. However, this was not always possible, because, sometimes, there was a reflection on what was happening and the students recognized the researcher as a resource that they could use during the group work moments. Thus, we assume that there may have been some influence in the context of investigation, in particular as to the use of Web 2.0 instruments.

However, it seemed to us that all the information we could collect previously could help us understand the activities that we were following. So, we took acquaintance of the school's guiding documents and practices as well as information available on the school website. In order to understand the practices, we collected documentation that was being produced by various actors, whether in the form of handouts produced by the teacher, lesson plans or the work produced by the students. Throughout the observation process we talked with the teacher, using the elicitation technique described by Schensul (2008), in order to realize the meaning of some of the options taken.

Finally, at the beginning of the school year 2010/2011, after an organization and first reflection on the data collected, we interviewed the teacher in order to reflect on some of his methodological choices and the role that technologies played in such options. We also listened to the students to realize the technologies that they found useful and if they were still using ICT in educational processes. This auscultation also took place in the following school year, because it was expected that the students already had some detachment of the facts and that this would allow them a more dispassionate reflection of that school year. In order for students to feel more available to talk, we decided to do some collective interviews, distributed into two groups of hearings: a third grade and a fourth grade group. Thus, the data collection focused initially on the documentation that featured the reality under study, continued with the observation process and ended with some interviews with the teacher and the students, in a Focus Group mode.

The script to collect observation data was organized into four major themes: the session's development, the use of technology, the assessment activities and the available resources. As it relates to the development of the session the points that we considered most important were the relationship with the national curriculum, the curriculum of the class, the characterization of the suggested activities and the students' role.

As far as the use of technologies is concerned the script sought to reflect its integration into the lesson plan, the technologies used by the students and the way they were using them, the skills shown in that use, the technologies used by the teacher and their purpose and finally the relationship between the role of the teacher and that of the students. The inclusion of evaluation activities in this guide aimed to realize if technologies were related to evaluation and if the students were responsible for that evaluation. The last point of the grid was dedicated to the resources given to the students and intended to organize the criteria that the teacher adopted for this aspect.

The lessons observed were recorded on video and the interviews were audio recorded. Both types of recording were transcribed with the support of the Express Scribe program, complemented with some notes taken. We tried to do a transcript as close as possible of what was going on in the classroom so that we could have a fresh memory of the events and record, in writing, the details of the observation. This caution relates to the need to have a detailed description of the facts in order to analyse the data. We tried to record everything, even some details that seemed unrelated to our goal, and we analysed them later in order to make sense with other collected data.

The interpretive field research involves deep reflexivity and the perception and description of daily events in the field environment, in an attempt to identify the actions and their meaning in the events from different points of view of the actors themselves (Erickson, 1986). The data analysis done after the sessions allowed us to triangulate information that came from different instruments which, according to Yin (2010), allows us to consider a more diverse set of topic analysis and, at the same time, confirm the same phenomenon or detect isolated phenomena cases. The amount of data collected demanded that its treatment was performed with a

program dedicated to content analysis, the QSR N6.[1] We adopted the conclusions of Hewson et al. (2002) when they refer the growing use of technology in qualitative research. The authors also assume that the most significant impact is the use of technologies as tools of analysis, because they provide a set of data organization mechanisms by categories or interlocking criteria that facilitate analysis and writing of subsequent reflection.

According to Bardin (2004), the analysis performed can be considered thematic, because it was organized under a set of themes, and transversal, because the references to the themes will be analysed through several data sources and several observations. The progressive classification of documents allowed us to realize that some of the initial categories had similar meanings and so they were merged. On the other hand, the reality under study had special characteristics that according to the literature review did not seem relevant, but we felt a need to include them as categories not covered initially. The QSR N6 software features greatly facilitated this interactive process of construction of categories, because it allowed revisiting the data, analysing them in different stages, and join or separate classifications already made.

The authorization of the participants is coated, in our context, under several perspectives. On one hand, there is the teacher and his agreement. On the other hand the observation of the classroom requires collecting data and the students are very young so we anticipated the need of permission from their parents. The authorization expressed by their parents for data collection with the guaranteed anonymity raises some questions and requires extra care due to the children identification in some of the publications made on the class site. Over the process we tried that the reference to some of the students did not allow their identification and whenever it seemed necessary to mention some of them we adopted an alias name.

The confidentiality of the teacher is, from our point of view, impossible. We have developed some work with him that led to the publication of some documents that must be mentioned because they constitute the indicators of his previous work and clarify the options of this study. Santos (2000) discusses this issue and frames it under a perspective that seems to adapt well to this study. Rather than maintaining the confidentiality of those involved, it is important to ensure that they are aware of the extra work that this task may have. We ought to clarify or even talk to the people involved and negotiate the way the study will take place ensuring that there are no data collected without the consent of the stakeholders. On the other hand, it must be ensured that the produced and published text does not intervene in any way in the professional or personal lives of the actors. This aspect can be considered by the stakeholders' involvement in the study, their reflection, and if the stakeholders appreciated the text before it being released. This set of options seems to adapt well to the context in our study and we had them all into consideration.

[1] © QSR International.

4 The Project's Development

At the beginning of the year, students argued that reading was "boring." Books were unattractive and therefore they preferred to do other things. This was the starting point for the construction of a collective book. The teacher said: "So let's do a book that is not boring and that others enjoy." Thus, this project was rolled out throughout the school year and had as its main goal the production of a collective book where all elements of the class could participate. The story's subject was decided in group and they also opted for a writing methodology: each one of the students and the teacher had to write and illustrate a book chapter, which allowed twenty illustrated chapters, which were published on paper and on the website of the class.

Each one of the students had the responsibility to write and illustrate a chapter that would be discussed in the classroom, in order to detect writing problems, intrinsic problems of consistency and ensure the continuity features of the story. The criticism of some students during the class under discussion shows the consistency of the text failures, as can be seen in the following transcript:

> *They come into the police station to secure Zack and they are like humans. And they cannot be like that because we said that they would never appear in the form of humans so that no one knew who they were (student Francisco).*
>
> *That's right. It makes sense what they are saying. I have forgotten what we agreed (student Hélio).*

This concern with the story's consistency is also presented in the chapter written by the teacher, situated in the middle of the story, to allow adjustments that might be appropriate. This organization method of the students' work, sought to give prominence to each of them through their writing and creativity process in order to carry on with the story, but it was also a challenge they considered complex and therefore suitable to develop some skills, as Schultz and Schultz (2005) consider.

The final chapter was built in the class. The teacher suggested that, organized in small groups, they could build an end to the story. The groups wrote five different endings that were presented to the class (Fig. 1). The final decision was taken after much discussion, with moments of detection of inconsistencies in the texts that led to their exclusion by the large group. Throughout this discussion, the students' posture was very interesting, because they were more interested in having a good solution than supporting their own version. One of the students proposed that the story should initiate like her working group had suggested, ought to continue according to the suggestion of a second group and ended as proposed by a third group. This attitude that we have seen in other circumstances, reflects the ability to appreciate the work done by others, analysis of the ideas contained in the texts and reconstruction towards a final and truly collective text. In a certain stage of the process there were still three possible endings with different destinations for the villain of the story: be arrested, be admitted into a mental hospital or become a super wild animal. The choice for each one of them forced the teacher to make available to each group 1 min to defend their proposal, to convince the colleagues to opt for a solution in the election that followed. During argumentation it was noticeable the development of argumentation skills that some students had acquired.

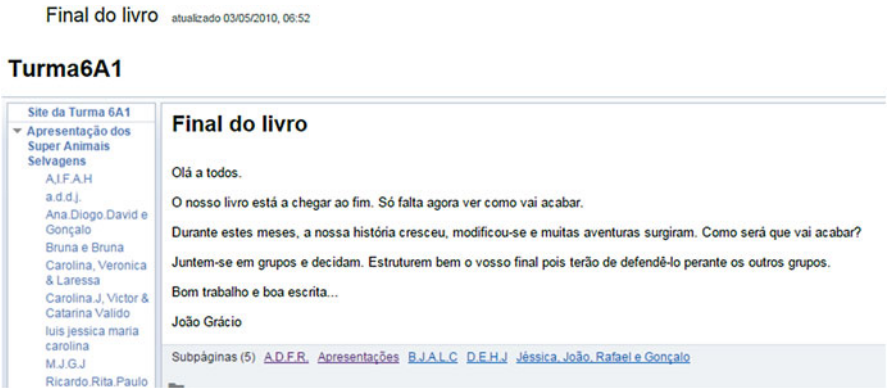

Fig. 1 The final chapter: teacher proposal available at https://sites.google.com/site/turma6a1/final-do-livro

He was already arrested and always escaped from prison (student Rui).
If Zack could turn into an animal, he could always choose a stronger animal than us and end up destroying us (student Hélio).
A person who hurts others without a cause is not a criminal, is crazy. So he should go to a madhouse. There, the doors don't have keys, there are walls around, and it has security and padded walls (student Francisco).

After the book building process, it was necessary to disclose it to the school to realize if the goal of producing a text that was "not boring" had been reached. This presentation was made in two ways: students built a production using PhotoStory to present the work to a pre-school students group and a dramatization, produced in group with another fourth grade class, which was presented at the school end of the year event. The presentation using PhotoStory was made based on the illustrations of each chapter, but as the story was long and preschool children are very small, the chapters had to be summarized. Thus, it was necessary to summarize each one of the chapters and prepare readings so it could be recorded. This presentation of the story was also shared with a fourth grade class, who prepared the dramatization, aiming to a more careful assessment of the story. Based on Google forms, the students produced a set of questions about the presentation that their colleagues had to answer. This led to data treatment through the production of some charts, producing very consistent multidisciplinary use of skills. The dramatization was another very rich activity that required the intervention of 40 children and two teachers, not only to test the entire dramatization, but also to build the scenarios.

It seems worth noting that the work methodology adopted by the teacher follows, in many aspects, the project design methodology. In fact, the projects arise in accordance with the interests and needs of the students and they are the main actors and stakeholders that were active in all phases of the project.

5 The Role of Technology

Technologies proved to be very important to favour the different stages of the project and allowed students to be, at the same time, developing technological skills. All students used email without difficulty. It was used daily to access the day plan. In the previous day, at night, the teacher sent to the mailbox the next day's plan and, in the morning, it was usual to observe the students before the teacher arrived, in small talks as they were turning on their small Magalhães. Once on the computer, sometimes they showed each other some facts they had discovered and it was common for them to start talking about what was going to happen in the room during the day.

In addition to the disclosure of the daily plan, the email was also used for other less frequent activities. Among them, we highlight sending messages with the attached work to the teacher so that it could be presented to the class group, which happened when students built an offline document. This same process of sending messages to the teacher was also used when a student wanted to print a document, since the teacher was the only one to have a printer installed on his computer. The email was also used to exchange less formal messages either between teacher and students or between the students themselves.

The word processor was also used on a daily basis. It was highly valued by students for two main reasons: the ability to change the text easily and the fact of having a dictionary. So the story chapters were written using a word processor, an instrument that also supported the operations of rewriting and formatting text and whose dictionary was used regularly to check the spelling of some words or even to look for synonyms.

In the first phase of the project, the student responsible for the chapter writing sent it to the email box of the class and the text was projected, read and discussed in the class. The result of this discussion often focused on spelling problems or grammatical construction, but also of intrinsic coherence of the story and continuity with the previous chapters. After this discussion, a new version of the chapter was built and the teacher published it on the website of the class. In a second phase, the teacher proposed the use of GoogleDocs for the chapters' production as it facilitated the sharing of documents among them. "The student responsible for the chapter opened a new document and shared it with all colleagues so that everyone could cooperate" (Grácio). It was interesting to see students' reaction when they realized that they had lost their writing dictionary support (at the time, the browser that they were using did not support it). Several solutions to this problem were found: some of them chose another browser (Google Chrome had a dictionary) and others wrote the text on the word processor and then copied it to GoogleDocs. When questioned about the value attributed to the dictionary, they mentioned that the dictionary pointed out unknown words and that they could understand if there was an error or not. The students had the notion that not all the marked words corresponded to errors and that it was necessary to use another program, for example an online dictionary to see if the word was in fact wrong. They have also reported the further

Fig. 2 Initial photogram in the PhotoStory presentation

advantages of having synonyms. Once their vocabulary was not rich, it happened quite often using the same words in the same sentence and the dictionary was used to overcome this problem.

At a certain time of the year, the teacher considered that the students were able to publish their work directly on the Internet. So, Google Sites became another daily used tool. This was the tool used to support the construction of the final chapter. At this stage it was very evident the advantage of the technology because students, organized into small groups, wrote what appeared to be a good ending to the story. When the time for writing this chapter ended, it was possible to start the presentation and discussion of each of the proposals to the class. The ability to use computers and the Internet was very useful at this stage, because, without it, there would not have been the opportunity to start the discussion immediately.

PowerPoint was also frequently used and students considered that: "It is equal to the Word processor. The main difference is that it has text boxes and slides and you can look better" (student Rui). However, the teacher decided that the book presentation to the other classes should be made using PhotoStory (Fig. 2).

The students had previously worked with this program but a new aspect was introduced… it was necessary to control the time exposure of each image. With PowerPoint this was not necessary, because it could be done with the mouse control. But the presentation, in addition to the challenge of building the chapter's summary,

brought another novelty: it was necessary to read the summary and record it. At this stage the students were confronted with hearing their own reading, which led to the recognition of their weaknesses in reading competences. Thus, they felt the need to make several repetitions when recording their readings, until they were made with good quality.

The ability of self and hetero assessment is evident in some of the recorded dialogues:

> Lourenço began reading too high, then gets lower (student Álvaro).
> It was because I was running out of breath (student Lourenço).
> If you were running out of breath it was because you weren't respecting the punctuation (student Francisco).

Students were very motivated because they were going to present their work to their colleagues. So, there was a great involvement in the tasks and a great desire to make a product with quality. But it was also necessary to ask their colleagues for their opinion about the work and so they had to use Google forms (Fig. 3).

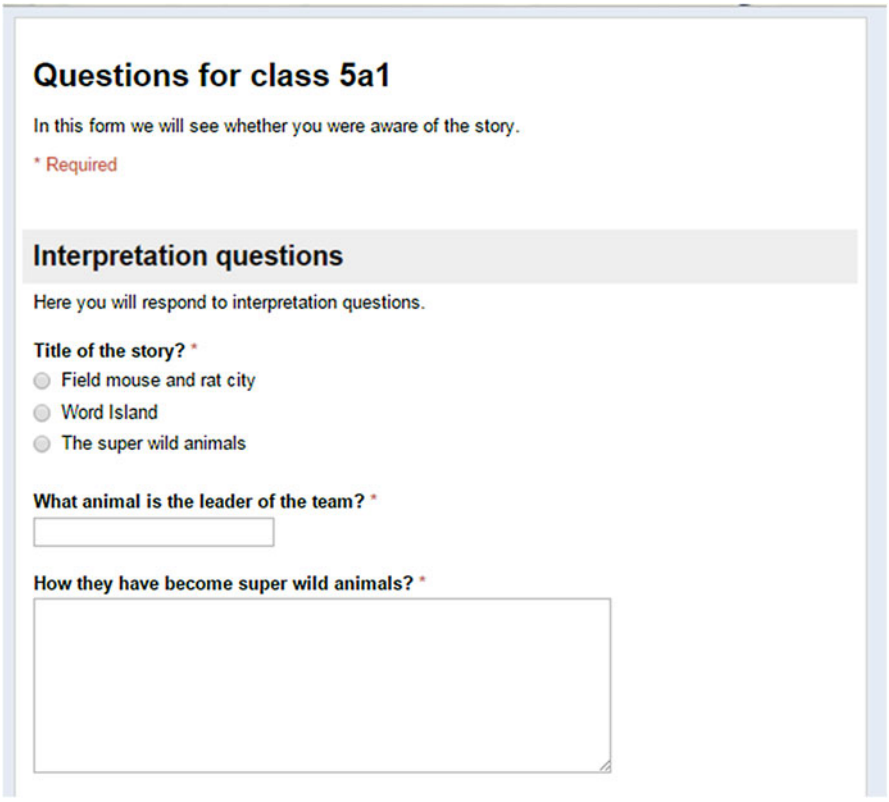

Fig. 3 Extract from the Google form elaborated by students

The questionnaire had the purpose of gathering the colleagues' opinions about the story, but it was also an opportunity for the teacher to include some questions about the Portuguese language.

This task proved to be very rich and worked as a reflective tool, like Jonassen (2000) states, because the questions "can't be very easy or they don't need to think when they are answering them" (student Beatriz). In the case of multiple-choice questions, for example, it was necessary to seek possible alternatives, but only one matched the correct answer, which was not always straightforward and caused much discussion among the elements of the small workgroups. One of the examples we saw was related with one of the students that wanted to develop a question about adjectives. He felt the need to review the concept of sentence building with various adjectives and the response options could not be considered too easy by colleagues.

> In the sentence The cat is ugly and he is called Mars the adjective is:
> Mars
> Cat
> Ugly (student Renato)

The work presentation session to their colleagues took place in their own classroom, where students moved from another class. It was a huge excitement since there were about 40 students in a classroom. The students had prepared the session but felt extremely nervous. The PhotoStory presentation happened without incidents and in the end students responded to the questionnaire using the computers available. The students from the other class sat at the computers and the students from the class supported them when they had doubts. There was a lot of noise in the classroom, but it was a satisfaction noise, because the other students were using the computer and they were helping them, playing the role of tutors.

When they collected all the information needed, it was necessary to treat it and the spreadsheet was the chosen instrument to make graphics and analyse the data collected. Along the data organization tasks, students had the need to group data according to the answers given and count the occurrences in order to have the absolute frequency of each answer (Fig. 4).

This activity allowed them to explore the notion of category and even the need to build new categories to include all data collected. An example of what we are saying were situations where the number of answers was less than the number of respondents. Due to that problem, doubts began to emerge:

> Teacher! Here we have several groups who don't respond. So we have to create a new category. No answer, isn't it? (student Beatriz).

The final phase, interpreting the charts, was also an interesting step because the students made some unexpected learning. For example, we refer to the cases in which all peers gave the same response and that was represented as shown in Fig. 1. They were used to interpret pie charts with various categories with positive frequencies and they tended to consider that the graph shown in the figure was not correct.

Qual é o teu animal favorito?

leão	2
crocodilo	1
tigre branco	2
cisne	1
girafa	1
zebra	1
leopardo	2
águia	2
chita	3
tigre	1

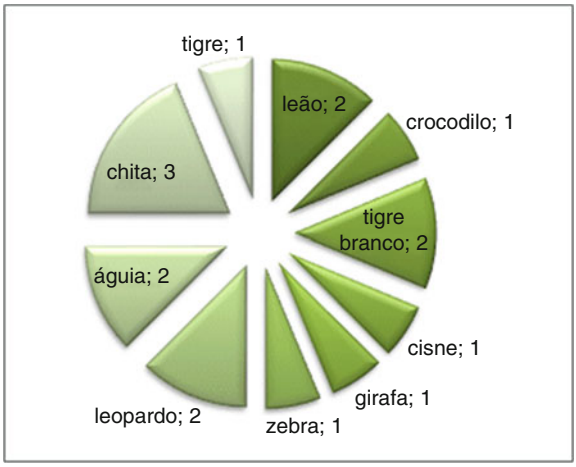

Fig. 4 Using a spreadsheet to organize answers according to categories

Fig. 5 Graph with all the responses in the same category

The graph represents the students' responses to the question "Where does the story begin?" and the alternatives were: at home; in the city and in the jungle. All students answered "in the jungle" (Fig. 5).

Throughout the book construction process and analysis there was the use of a great diversity of production programs adapted to the needs of each stage, but there was not the use of programs specifically designed for learning, but as the teacher said:

> I don't like to guide them so much. I want them to be free to choose and to discover new things. These type of programs [oriented to work a theme] are closed in themselves, they can be useful for a certain thing, but always for a short period of time (Teacher).

6 Final Considerations

We would like to begin these final considerations with two brief notes: one on the availability of the equipment in the classroom and the other on students' achievement at the end of the school year. The Technological Plan for Education (PTE) has provided some equipment for schools and allowed teachers to use ICT in their classrooms. In the particular case of Primary Education, the PTE did not bet on the placement of equipment in schools as it did in other educational cycles. The option was the availability for the students, at a low cost, of portable computers. These computers have proven to be an excellent tool and without them it would be impossible to have a classroom organized where all students had a chance to use the computer at the same time.

However, the perversity of policy changes, in an unfavourable economic context, led to the disappearance of small portable computers, resulting in a clear technological disadvantage for this level of education. Without these small computers, ICT integration will not be possible and students will loose the opportunity to improve learning in some curricular areas. These consequences are especially serious in families with economic difficulties, in growing numbers in our country, for whom technologies cannot be a priority. In these cases, public schools must respond to their students' needs contributing to blur cultural differences and information access that technologies can offer.

As it relates to the educational students' achievement, we have seen that all of them have passed to the fifth grade, with favourable developments in all areas. We believe that the work that we observed had a great influence in that evolution of results in Portuguese (71 % positive at the beginning of the school year and 100 % at the end), because we observed a lot of the students' work in this area: reading, discussion and producing many texts as well as the construction of abstracts and reading out loud to record the presentations.

Although these results are very positive, students' assessment tests typically consist of reading, understanding, writing and re-writing text in addition to the grammar aspects. Thus, the tasks associated with the quality of reading and text production that cannot exceed a certain time are hardly appreciable activities in traditional assessment tests. However, in the activity of construction and presentation of the collective book, the students made a very critical assessment of the quality of reading of almost all of them. Some students worked hard, with several readings "off the record" in order to improve this competence and the final product.

The students' attitude towards school was another aspect that needs to be highlighted. We saw moments of individual work, in pairs and in groups and, consequently, the development of the sense of responsibility and participation in the work done with the other students. Over time the teacher needed to intervene many times to highlight and discuss less correct behaviours of the students whom, for the most part of the times, recognized the error and tried to fix it. Thus, these inappropriate behaviours occurred with decreasing frequency. This idea is confirmed by one of the

students that integrated the Focus Group and who stated: "At first everything was strange, because I didn't know how it was. But then I understood and I liked it a lot." The interactions in the classroom led to an informal environment where the students worked with joy and there seemed to be some pride in the work and productions they were doing.

The students were very independent in the classroom and took responsibility to manage it. We observed discussions in the working groups, on occasions when some element was not contributing. Students were promoting self-regulation of their work which allowed improving the functioning of the groups. An interesting aspect of this accountability was related to the breaks. Whenever they had to make a break, we heard a lot of noise in the playground. In the room all the students kept active, because they should not abandon a job just because it was break time. So, the students finished the sentence they were writing, saved the texts, pasted a picture or text that they had found on the Internet and then, with some calm, they abandoned the room. "If we are doing something, we end it and then we will have a break or else it will be more complicated when we come from that break" (student Rui).

When the book presentation took place, we noticed a great sense of mutual support and accountability where everyone wanted this activity to be a success. In this context we assessed with particular interest a students' behaviour with poor school performance and with several retentions, which was always involved in the tasks, seeking to help other students in all aspects related to technology, solving small problems with hardware (a mouse that had to be changed) or with issues related to the programs themselves (Fig. 6).

Fig. 6 Book presentation session

The teacher also promoted the sense of mutual support and there were several episodes that exemplify what we saw. For example, when the students were doing the form for the evaluation of the collective book, students wanted a multiple response in which the correct answer was not explicit. However, they wanted to write an option called "other." The teacher told the class that there was a group that had built the question that way and suggested that this group could explain how they had proceeded. Student Rui went to the computer, connected it to the projector and explained it step by step. This attitude was a way of showing the student's skills, he was recognized by the group as an expert in this area and he proudly shared his knowledge with his colleagues. The students' involvement in activities using technologies was promoting skills for the knowledge society, with particular emphasis on collaboration, entrepreneurship and technological skills. The group work, usual in this class, required collaborative behaviours of its members in order to solve the situations proposed by the teacher. The skills related to the respect for the opinion of others and the argument based on the ideas that they had and in the information that they gathered were set out in the day plans and were part of the daily classroom practice.

The last of the major areas of skills for the society of knowledge that students should develop is related to the ICT literacy. The diversity of technological tools that students used throughout the project allowed them to realize that the computer is not just for fun, which is already an important advance against the idea that they had at the beginning of the school year. But students also had the opportunity to realize the possibilities of using asynchronous media (e-mail), production software (word processor and spreadsheet), and for presenting information (PowerPoint and PhotoStory). The experience that they lived when using Google utilities also allowed them the contact with the potential of Web 2.0 tools, not only in the aspects of ease of information publishing, but also about the sharing and learning potential associated with them.

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Using Senses and Sensors in the Environment to Develop Abstract Thinking: Evaluating the Utility and Usability of Electronic Sensors

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Abstract This chapter was developed in the context of a project that explores the use of human senses and electronic sensors to develop abstract thinking in authentic learning at the level of Elementary Education. Based on this project's theoretical and instrumental framework, a set of electronic sensors is assessed, in what concerns their potential to be used by children in conjunction with the senses, to explore authentic problems in environmental education, whilst aiming at developing abstract thinking. The set of assessed sensors integrates a digital microscope, a water temperature sensor, a turbidity sensor, a conductivity sensor, and an air temperature sensor. During the developed educational activities, the sensors proved to be robust for environmental exploration by children. The sensors also revealed potential to improve the children's world perception, as well as to be used as an extension of the human senses. The sensory information acquired by children facilitated the interpretation of the more abstract data acquired by the sensors. Finally, the sensors allowed children to observe, represent and control variables in authentic activities that involved complex concepts, this way supporting children's abstract thinking.

Keywords Electronic sensors • Human senses • Children • Abstract thinking • Environment

1 Introduction

The use of electronic sensors, in school science activities, is becoming more frequent and may be very relevant to the exploration of objects and processes in biology, physics, chemistry and environmental science (Fenton 2008). In such activities,

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the sensors are often integrated into data logging systems, which acquire, record, and process data. The data logging system can include one or more sensors, and a computer, linked through a USB port. However, nowadays, electronic sensors are frequent in everyday life, and are increasingly more portable and cheaper (Silva et al. 2009). Sensors are part of everyday small devices, such as mobile phones. For example, most mobile phones include sound and light sensors, and frequently accelerometers, and GPS.

This paper aims at contributing to the assessment of electronic sensors, namely in what concerns utility and usability, in science education. The assessment of a set of electronic sensors is presented, in what concerns sensors' potential to be used together with the senses in authentic activities of environmental education in the first and second cycles of elementary education (specifically, from 6 to 11 years).

This work is integrated in a research project, named Using Sensors and Senses in the Environment to Develop Abstract Thinking (SOS Abstract), whose main objective is to study the potential of the synergistic use of the human senses and electronic sensors to develop abstract thinking in environmental education activities in the first and second cycles of elementary education.

In this context, "abstract thinking" refers to the formal operational thought, characterized by the capacity to simultaneously consider a set of variables and to verify the effects of independent variables in a set of dependent variables (Adey 1999). Nowadays, everybody faces complex problems that require reasoning about evidence (Chinn and Malhotra 2002), leading to the need of using complex mental models, i.e., needing to mobilize abstract thinking (Lombardi 2007). Accordingly, it has been observed the need for the development of such thinking processes by children, namely in school (OECD 2010). This finding also applies to science education (Brites et al. 2011), and particularly to the experimental approach to the environmental complexity (Lombardi 2007). Thereby, an important objective in science education is the design and implementation of activities that develop epistemologically authentic scientific reasoning, i.e., authentic activities (Chinn and Malhotra 2002).

The research presented here evaluates the potential of a set of electronic sensors to be used by children in science education authentic activities in elementary education. The authors give special attention to the synergies produced by the joint use of senses and sensors.

In the next section, the main dimensions of the use of electronic sensors in environmental education authentic activities are briefly introduced. Afterwards, the method used to select and assess a set of electronic sensors is described. In section 4, the main characteristics of the selected electronic sensors are presented. Subsequently, the results of the electronic sensors' assessment are shown and discussed. Finally, the conclusions are outlined.

2 The Use of Electronic Sensors in Authentic Activities of Environmental Education

Authentic activities in environmental education should be developed in real environmental contexts and require the children's physical, cognitive and emotional engagement, aiming at promoting their autonomy (Fenton 2008). The use of human senses and sensors can facilitate the development of authentic activities, as was the case in several projects that used senses and sensors in the didactic exploration of environmental information: Ambient Wood (Rogers et al. 2010), SchoolSenses (Silva et al. 2009), MobGeoSens in Schools (Kanjo et al. 2008), Urban Tapestries and Social Tapestries (Angus et al. 2007), USense2Learn (Silva et al. 2010).

The SOS Abstract project uses the human senses and sensors in authentic environmental activities for the development of children's abstract thinking (Silva et al. 2013). Accordingly, four factors are considered necessary to the successful implementation of authentic activities: the environmental context; the physical (including sensorial), cognitive and emotional engagement of children, the teacher mediation, and the instruments to be used, including the electronic sensors.

In the context of the SOS Abstract project, aiming at developing children's abstract thinking, a theoretical and instrumental framework of the use of human senses and electronic sensors in environmental education was created (Silva et al. 2013). This framework was based on the literature review and on six exploratory case studies, and considers four fundamental dimensions (Silva et al. 2013):

- *The use of sensors by children*, to acquire and record information about multiple environmental variables, some of which are non-observable to the human senses;
- *The use of senses and sensory information by children*, to observe objects and phenomena that will be later explored with the sensors, creating a concrete basis that will facilitate, not only the interpretation of the sensors' abstract data, but also the search for the appropriate conditions for an effective use of sensors;
- *The teacher's mediation* of children's interaction with sensors and environmental information to facilitate the understanding of the relationships between variables: discussing what to do, what happened, why it happened, making predictions and estimations, creating connections between the more abstract information and the more concrete sensations and viewpoints of children;
- *The epistemic practices developed by the children*, such as to observe, describe, interpret, control variables, create multiple representations and models, which constitute evidence of abstract thinking.

3 Method

This chapter includes the presentation of the method used to assess the potentialities and limitations of a set of selected sensors, namely in what concerns the development of children's abstract thinking in environmental education authentic activities.

The selection of the sensors to assess, and of the criteria for that assessment, was based on the aforementioned theoretical and instrumental framework and on the authentic activities designed and implemented in the context of the SOS Abstract project. This research uses a multi-case study approach (Cohen et al. 2007), in which the authors analyze six case studies that were also developed in the context of the SOS Abstract project.

The aim of those six case studies was to improve the teaching-learning process, on the basis of the analysis of: (1) the students' performance in the developed learning activities; (2) the teachers' mediation in such activities (Tuckman 2001). Therefore, the used method includes some of the research-action dimensions, namely the aim of improving the learning process, the participant observation, and the reflection on the developed learning activities (Creswell 2008).

In all the case studies (see Table 1), the participant teachers implemented a set of authentic tasks of environment characterization with their students, using both senses and sensors in experimental science teaching activities. The designed authentic tasks were organized and planned, based on the formative situation model that corresponds to a didactic organization tool that takes into account what the students already know (Lopes 2004). Therefore, starting from students' previous knowledge, learning is scaffolded by teachers' mediation that facilitates the use of appropriate resources or techniques, according to the tasks to be developed (Lopes 2004; Reiser 2004).

The following sensors were selected for evaluation: Digital Microscope; Water Temperature Sensor; Turbidimeter; Conductivity sensor; pH Sensor; Air Temperature Sensor; Sound Sensor. Based on the theoretical and instrumental framework of the use of human senses and electronic sensors in environmental education to develop the abstract thinking, presented in the previous section, the following assessment criteria were defined: sensors' functional requirements; potential for environment exploration; relationship with sensory exploration; presentation of data in multiple representations, namely graphics production; contribution to a more informed sensorial exploration of the environment.

All the selected sensors are suitable for direct use in the environment, but are not suitable to work autonomously on site, given that the android sensors are embedded in mobile phones or tablets, and all the other sensors (see Table 2) require a USB connection to a computer with specific software.

Table 1 Characteristics of the case studies that were used to assess the sensors

Case studies	Specifications
Case Study 1 An experimental approach to the complexity of the life concept (Teixeira 2012)	*Participants*: teacher-researcher and a second grade class *Sensors*: the children used the *digital microscope* together with the Binocular Loup and the Optical Microscope to observe a variety of living organisms *Human senses*: the main sense used in this study case was the *Vision*
Case Study 2 Experimental teaching of biodiversity and temperature in tide pools (Gonçalves 2012)	*Participants:* teacher-researcher and a fourth grade class *Sensors:* the children used the *water temperature sensor* *Human senses:* the main senses used in this case study were the *vision,* the *touch* and the *sense of temperature*
Case Study 3 3 Study activities on water potability	*Participants:* 3 female trainees and 1 male trainee with two classes of fifth grade *Sensors:* the children used the *turbidimeter* *Human senses:* the main senses used in this case study were the *vision* and the *smell*
Case Study 4 Water salinity	*Participants:* teacher-researcher and a fifth grade class *Sensor:* children used the *conductivity sensor* *Senses:* The main senses used in this case study were the *taste* and the *vision*
Case Study 5 From senses to sensors, fostering children's environmental literacy (Teixeira et al. 2015)	*Participants:* teacher-researcher and a second grade class *Sensors:* children used sensors, such as the *conductivity sensor*, the *pH sensor*, and the *sound sensor* to enhance the sensorial environmental exploration and to better understand their senses *Senses:* This case study was focused on sensory awareness
Case Study 6 Somatic senses, heat and temperature (Nogueira 2012)	*Participants:* Teacher-researcher and a sixth grade class *Sensors:* In addition to thermometers, the children used the *air temperature sensor* *Human senses:* The main senses used in this case study were the *vision*, the *touch* and the *sense of temperature*
Case Study 7 Experimental work on germination	*Participants:* Teacher-researcher and a sixth grade class *Sensors:* the children used the *air temperature sensor* *Human senses:* The main senses used in this case study were the *vision,* the *touch* and the *sense of temperature*

Table 2 Specifications of the sensors

Sensors	General characteristics
Digital microscope	Discovery™ USB microscope with 400× magnification—Deluxe model—Veho® ROHS C
Water temperature sensor	PASPORT temperature sensor
	PS-2125
Turbidimeter	PASPORT turbidity sensor
	PS-2122
Conductivity sensor	PASPORT conductivity sensor
	PS—2116
pH sensor	Pasco—PS-2147
Air temperature sensor	PASPORT humidity/temp/dew point sensor. PS-2124A
Sound sensor	Android mobile phone (Samsung Galaxy S4) with Sense-it app, and Tablet (ASUS MeMO Pad) with Sensor Box for Android app

4 Electronic Sensors' Assessment

In this section, the assessment of the set of selected electronic sensors is presented and discussed.

4.1 Assessment of the Digital Microscope

In the Case Study 1, the digital microscope was used by children of the second grade to analyse and compare living beings' characteristics with non-living objects' characteristics. Given the ease of use of this sensor, and despite their age (8 years old), children were able to: (1) use the sensor in an autonomous way (magnification was used as an independent variable); (2) observe how animals and plants were coated (registering the observations in documents expressly created). Moreover, in addition to the observation of living beings' coatings, children magnified and observed other objects (such as printed letters; different papers, namely chromatography and photocopy paper; and animals' hairs). These activities confirmed the robustness and ease of use of the selected digital microscope in experimental science teaching, since it allowed the manipulation of the variable magnification by children, while making multiple observations. Furthermore, the digital microscope made it possible to overcome the difficult use of the microscope oculars, since images are visible on the computer screen (see Fig. 1).

In consequence, using the digital microscope, the children were able to observe images of diverse objects, with various magnifications, whilst also monitoring macroscopically the observed objects (see Fig. 1). Therefore, the sensorial observation was complemented with the use of the sensor. The use of the digital microscope bridged the macroscopically visible world (more concrete) and the microscopic world.

Fig. 1 Illustration of the use of the digital microscope by children

The teacher mediation played a key role in bridging the scale displayed on the sensor and the magnification value that was observable on the computer screen. Moreover, the observation registers drawn by children, made it possible to compare the images of the same object observed with different magnifications, facilitating the understanding of the existence of macroscopic and microscopic worlds.

In observing a microscope preparation that includes some liquid, focusing becomes a very difficult task, because water movement is constant and the image becomes blurred with movement. The ultimate preparations are an exception to this fact. This way, no digital microscope can completely replace the compound optical microscope.

In the same way, the digital microscope cannot completely replace the binocular loupe. For instance, the binocular loupe allows students to observe the colonies in the culture medium inside the Petri dish boxes, with diverse magnifications. This observation is not easy when using the digital microscope, not only because the Petri dish box's cover reflects light, but also because the cover will be magnified, interfering with the observation of the colonies. To observe the colonies with the digital microscope, it would be necessary to remove the Petri box's cover, which wouldn't be safe at all.

4.2 Assessment of Water Quality Sensors

4.2.1 Water Temperature Sensor

In Case Study 2, the water temperature sensor was used by fourth grade children to study, in the classroom, the continuous variation of the water temperature in a glass container, simulating the temperature variation in a tide pool over 24 h.

The water temperature sensor makes possible the direct exploration of the water temperature, for example in a tide pool, but the in situ continuous monitoring becomes not possible, since it would not be adequate to leave the sensor and the computer in the field over 24 h. On the other hand, to monitor the water temperature it is necessary to consider and control several environmental variables, such as the volume of water and the depth at which the sensor is placed.

In this Case Study 2, the children planned the above mentioned experiment, using experiment plans, namely to define the dependent, independent, and the control variables. In fact, it was necessary to repeat this experiment, once the sensor position (a control variable) was modified, during room cleaning. This disturbance was detected and corrected by children. The sensor has proved to be robust and easy to use in experimental setups.

The water temperature sensor can significantly complement children's sensory exploration of this environmental variable, creating bridges between a qualitative and more concrete monitoring and a quantitative and more abstract assessment (Silva et al. 2012). Similarly, with teachers' mediation, the children's sensory exploration can contribute to the planning and interpretation of experiments.

Given the possibility of observing the recorded data, through the analysis of the graphics created by the software with the data acquired by the sensor, this sensor facilitated the perception of data patterns and relationships between variables. In such analysis, the teacher's mediation played a key role (Silva et al. 2012):

- To facilitate the interpretation of the experimental data graphic, some notes were created on it, bridging the gap between the time of experiment (in seconds) and the time of the day (calculations made by children with teacher's mediation);
- With the teacher mediation, the children were able to analyse the variation of the temperature during the day, confirming that this variation was smooth and not abrupt.

A child related the water temperature variation in the classroom to the water temperature variation in tide pools. Moreover, this child also related the variation of solar intensity to the temperature of water along the day.

The graphics annotations were a facilitating basis for the association between the graphic's data and the multi-sensory information acquired by children in their daily lives. Thus, for example, children related the water temperature recorded at 8:00 am (entry time at school) to their sensations regarding the temperature of the air at that time of day (Silva et al. 2012). During the discussion of the experimental data, the following questions were also presented by children (Silva et al. 2012): the temperature of the seawater is the same at all locations? In tide pools with a bigger volume of water, is the temperature similar to the temperature of smaller tide pools?

4.2.2 Turbidimeter

In Case Study 3, the Sensor of Turbidity, or turbidimeter, was used in two internship activities in an elementary school of the Master's Degree in Elementary School Teacher Training, to teach the curricular topic "the importance of water to living beings: water quality," specifically the assessment of water potability in what concerns the turbidity parameter. In a first activity, the turbidimeter was used by fifth grade students, with the mediation of two trainees. The context of this first activity was a previous visit to a stream that crosses a metropolitan area and that was subjected to environmental improvements. During the visit, the students experienced the different environments of the watercourse. They carefully observed the water, and collected samples at different locations. The students' observations made it possible to conclude that the water collected far from the spring was not potable. They said "we cannot drink because it is dirty," "it smells bad." They also concluded that the water near the spring was potable ("it is quite clean," "it is cool" and "it doesn't smell bad").

In the first activity of the Case Study 3, the goal was to study the potability concept, through the evaluation of diverse physical (non-organoleptic) water characteristics, in addition to the sensory ones emphasized in the handbooks (tasteless, odourless, colourless and transparent), this way overcoming too simplified approaches. The children used the turbidimeter to measure the turbidity of a water sample with visible particles in suspension. The technical aspects of the test implementation were explored with the class. Then, children tested the turbidity in the three samples of water from the stream and water from a commercial bottle. The

data gathered with the sensor showed that the water collected near the spring, had invisible particles in suspension, since the turbidity values were higher than the acceptable limit for drinking water.

In this first activity, the turbidimeter proved to be easy to use in the classroom, as the data were quickly obtained and the values easy to compare. The measurement units (NTU) were not explained. The trainees called the children's attention to the newness in terms of vocabulary. The use of the turbidity sensor required the clarification of the meaning of "turbidity." It was explained that turbidity measures the substances in suspension and not the dissolved particles. It was also explained that the dissolved particles may be responsible for the water colour.

In the second activity, the turbidimeter was used by two female trainees in another fifth grade class with the same objectives of the first activity, and different water samples (tap water, well water, rainwater, and fountain water).

Initially, the students performed a sensory analysis of the water samples, describing its colour, odour and turbidity. In a second step of this activity, children filtered the samples and observed results, which were similar for all samples: deposit of particles were not visible on the filter paper. It is important to mention that in the sensory analysis of the water samples, some students reported the observation of particles in suspension in the samples of fountain water and the rainwater, stating that "the samples were a bit turbid."

The sensor showed potential to relate the turbidity data to the information acquired by children through the sensory analysis, since the samples considered as "less transparent" in the sensory analysis were those with higher turbidity values. On the other hand, the use of the sensor made it possible to improve the sensory information. In one of the water samples, the turbidity value indicated particles in suspension, although the students could not observe deposition of particles on the filter paper, after the filtration.

This sensor has specific handling requirements, since the glass containers for analysis of water samples shouldn't have dirtiness (dust, finger prints…), which constitutes a challenge for 10–12 year old children. The turbidimeter should also be positioned on a horizontal surface, as stable as possible (possible shakes of the sensor will influence the obtained values), a condition that is relatively easy to achieve in the classroom, but harder when working in the field.

At the end of this activity, students concluded that all the water samples had a turbidity value within the range legally defined for water for human consumption. However, it could not be concluded that all were potable waters, since other potability parameters had not been analysed.

4.2.3 Conductivity Sensor

Use of the Conductivity Sensor with a Fifth Grade Class

In Case Study 4, the conductivity sensor was used by children from fifth grade to study the salinity of three samples of water of equal volume, which they had previously prepared with different amounts of salt. They analysed these samples using

the sense of taste, classifying them according to a scale of salty flavour intensity. Subsequently they used the conductivity sensor to measure the conductivity of each sample, relating the obtained conductivity values to the amount of dissolved salt. The sequence of concrete activities (preparation of saline samples and their classification based on the senses) has created a basis that facilitated the transition to more abstract activities that involved the use of conductivity sensor.

The conductivity sensor is a useful tool to complement environmental information collected through sensory analysis. Teacher's mediation was fundamental in this process, since the concept of conductivity was new for the participant children, and it is a complex and abstract concept for children of this age. It was also important to scaffold children to understand that conductivity and salinity are directly related variables, and that consequently the increase in salinity produces an increase in conductivity.

The teacher supported the children in filling planning charts. This way, children planned the experimental activity. They reflected on the conditions that should be met for the correct determination of conductivity values. The children understood that the sensor should be placed at the same position, for the same time, in all the samples. Furthermore, the children were aware of the need for washing the probe with distilled water after the analysis of each sample.

In consequence, although facing a complex task and a demanding tool, children used the conductivity sensor in the correct way, and, with teacher mediation, were able to control variables, interpret data and establish relationships between salinity and conductivity.

Use of the Conductivity Sensor with a Second Grade Class

In Case Study 5, in order to study taste, as a human sense, the conductivity sensor was used by 7 year old children of a second grade class. In the first activity, children developed a sensory analysis of water solutions with diverse salt concentration, using a scale from 0 (no salt) to 4 (very salty).

In the second activity, the children used the conductivity sensor to determine the conductivity of the different solutions. Given the children's age, the concept of conductivity was not studied. They were only told that higher values meant the water was more salty. The sensor's data were displayed in a table (Fig. 2), which exposed the slight variation of the acquired data, in relation to each solution. The children interpreted such variation, saying that it was the consequence of the movement of the hand holding the sensor. This way, the children were conscious of the need for controlling variables, such as the position of the sensor.

The data acquired by the conductivity sensor in the water without salt were very different from the data acquired with the sensor in salty water. Afterwards, the children compared the sensory data with the conductivity data, and recognized the subjectivity of the human taste sense. This subjectivity was responsible for the diverse values attributed by different children to a same solution. With the teacher's mediation, children related this subjectivity to each person's diet.

Fig. 2 Illustration of the use of the conductivity sensor

This way, children were able to use, in a meaningful way, a sensor that senses an abstract variable, while learning about taste sense and dissolution. They were able to observe, interpret and relate the acquired data with the taste sensory analysis.

4.2.4 pH Sensor

In Case Study 5, in order to study taste and smell, as human senses, the pH sensor was also used by the 7 year old children of the second grade class.

In the first activity, the children developed a sensory analysis of lemon juice, coffee, vinegar, and milk samples, using a scale to rate the taste and the odor from 0 (not intense) to 3 (very intense). They were able to observe, interpret and relate the data acquired with the taste and smell senses.

In the second activity, the children used the pH sensor to determine the acidity of the above mentioned samples. At first, the teacher explained an iconic pH scale, and presented the acid and alkaline concepts. After smelling and tasting the substances (a pipette was used to put a drop of each substance on each child's tongue), the children were able to handle the pH sensor, registering the values acquired with the sensor and observed on the computer.

Subsequently, the children analyzed the data acquired by the sensor, and related the acidity to the intensity of odor and taste. This way, they observed that lemon juice (pH = 2.88), vinegar (pH = 3.13) and coffee (pH = 5.57) are acid and related this acidity with the intense odor and flavor. In contrast, children witnessed that milk is alkaline (pH = 7.20) and most of them considered the flavor of milk not intense or a bit intense.

During the sensory analysis, depending on how used they were to drinking each substance, the children considered the flavors and odors as not intense or intense. So, for instance, the children who were used to drinking coffee considered its flavor and odor not intense. In the same way, since children were used to drinking milk, they considered its flavor and odor not intense. On the other hand, some odors and flavors, like the ones of lemon juice and vinegar were consensually considered intense. Reflecting on these facts together with the measured pH values, the children were able to understand the subjectivity of their sensations and perceptions and to relate them to their preferences and previous experiences.

Once more, in the case study 5, 7 year old children were able to use effectively a new sensor that senses another abstract environmental variable, as well as to relate acidity values to odors and flavors.

4.3 Assessment of the Air Temperature Sensor

The air temperature electronic sensor was used by children, with teachers' mediation, in two case studies (case studies 6 and 7) with two sixth grade classes to explore the environmental variable temperature in different places of daily school life.

4.3.1 Case Study on Heat and Temperature

In the study of Heat and Temperature (Case Study 6), the air temperature sensor was used to measure the temperature of the classroom, beginning on the windowsill and making four more measurements, each time incrementing by 1.5 m the distance from the window. These measurements were performed with students in two classes, in the same week and started at the same time (8:20 am). The children read the computer records, using the numeric format, and designed graphics of temperature versus the distance to the window.

In both experiments, the air temperature near the window was lower. The maximum temperature was recorded in the centre of the room, slightly decreasing with the proximity of the wall in front of the window wall (Nogueira 2012). Since there were decimal differences between the measured values, hardly perceptible by the human senses, the experiments scaffolded the understanding of the usefulness of the quantitative monitoring of temperature, even in an everyday environment. In dialogue with the teacher, the children interpreted the measured values, relating them to the heat exchanges through the window, during the day and the night.

4.3.2 Case Study on Germination Conditions

In the Case Study 7, the children explored three factors (water, light and temperature) that affect the germination of seeds, namely beans, lentils and peas. Challenged to plan the places where the seeds should be set to study the influence of light and temperature on germination, children explored the classroom with light and temperature sensors. Although the assessment of the light sensor has been very positive, for reasons of space, in this chapter, the temperature sensor is the only sensor analysed.

In the planning task, some children showed that they were aware of the control of variables. It is noteworthy that, at some point, children decided to use a closet to check the influence of the presence/absence of light on germination. Most of the children said that the temperature inside the closet was not equal to the temperature

outside of it. Some children presumed that the temperature was higher inside (because the closet was closed) and the majority of the children considered that it was lower (because the sunlight couldn't enter the closet). They used the temperature sensor to check if their expectations matched the reality. However, they verified that the temperature differences inside and outside the closet were not evident. Therefore, they concluded that they could use the closet to verify the influence of light on seed germination.

The children also used the air temperature sensor for measuring the temperature inside a freezer. In this case, the measured values were more in line with the estimates of the children: some estimated exactly the measured temperature (−18 °C) and most predicted negative values, although not as low as the actual.

One child stated that inside the freezer the temperature is lower, and there was no light. At the end of the experiment, it was observed that inside the closet, without light, there was germination, although the plant could not develop in a proper way, whilst the seeds inside the freezer didn't germinate at all. The children were then able to conclude that the germination was inhibited by low temperatures, but not by the absence of light.

The data acquired with the temperature sensor was observed in numeric format, in real time. Afterwards, the graphics of the sensor's data were observed, and edited by the children that annotated the actions that influenced the temperature measured by the sensor (for instance, to put the sensor inside the freezer).

In case studies 6 and 7, it was possible to confirm that the air temperature sensor is robust, and can be used in multiple experimental activities. Consequently this sensor is appropriate to be used by children, to explore air temperature, indoors and outdoors, at various environmental sites, as well as to assess diverse microclimates.

4.4 Assessment of Android Sound Sensors

In Case Study 5, in order to study audition and to measure sound level in the classroom, two sound sensors were used by 7 year old children of a second grade class: (1) the sound sensor of a smartphone with the app Sensor Box for Android; (2) the sound sensor of a tablet with the app Sense-it.

The Sense-it app was used with the tablet (Fig. 3), because it presents sound level data in a graphic format (*x* axis—time, *y* axis—sound level) and children need a not too small screen to analyze the graphics. The Sense-it app also allows recording the acquired data and its visualization in a table, this way permitting further processing of data, like the calculation of the arithmetic mean.

The Sensor Box for Android app was used with the smartphone, because the size of the smartphone's screen allows children to read the sound level values, shown by a graduated dial pointer (Fig. 3). The use of both sensors and apps evidenced the continuous variation of sound level in the classroom.

Fig. 3 Illustration of the use of the sound sensor

Subsequently, the tablet was used to record the sound level for 2 min in the classroom and to calculate the arithmetic mean. The graphics were used by children to recognize that sound level increases and decreases at different moments. Afterwards, they compared the sound level arithmetic mean with the advice of WHO relating to noise and its risks to health. Due to this comparison, children became aware of the need to control the noise in the classroom for academic and safety reasons.

The smartphone was used to determine the sound level at different distances from a sound source (a computer, in this case). With this activity children understood that sound level increases when the distance to a sound source decreases, and vice-versa. The continued use of the sound sensors familiarized children with sound level values in different situations, such as quiet moments and noisy moments (when shouting, for instance), allowing them to improve their estimations.

The sound sensors used in Case Study 5 contributed to improve the learning of audition in a second grade class. Since these sensors are integrated in a smartphone and in a tablet, they are more portable and affordable, and can be easily used anytime, anywhere.

5 Lessons Learned and Final Remarks

The research presented in this chapter aimed at contributing to improve the educational joint use of the human senses and of Information and Communication Technologies, particularly highlighting the potential and limitations of a set of electronic sensors in facilitating the development of abstract thinking. The use of the

sensors—a digital microscope, a water temperature sensor, a turbidimeter, a conductivity sensor, a pH sensor, an air temperature sensor, and two sound sensors—was assessed and discussed, using predefined evaluation criteria.

The analysis of the educational activities that used the seven referred sensors allowed the following potentialities to be stated:

- The use of the digital microscope, with teacher's mediation, scaffolded children in the transition from macro to microscopic observations. This sensor proved to be more adequate to the observation of solids and less adequate to the observation of non-solid media;
- The water temperature sensor proved to be easy to use by children that were required to use the senses to control experimental conditions (control variables);
- The use of the turbidimeter presented challenges, related to instrumental and conceptual complexity, that were used to develop children's abstract thinking;
- The conductivity sensor showed potential to be used differently in a second grade class and in a fifth grade class, namely in what concerns the complexity and abstraction of the conceptual context and of the developed authentic activities;
- The pH sensor was used by 7 year old children to effectively relate an abstract variable (pH) to odors and flavors;
- The air temperature sensor was used to explore everyday environments, showing that quantitative temperature measurements are necessary to complement human senses in thermal environment characterization;
- Sound sensors, integrated in a smartphone and in a tablet, proved to be useful and usable by 7 year old children to characterize the classroom environment, regarding sound level and noise.

Summarizing, the sensors proved to be robust for use by children in environmental exploration. Moreover, it is noteworthy that all the sensors revealed potential to improve the perception of the world by children, since they could be used as an extension of the human senses.

Nevertheless, the used sensors also showed limitations, which can be faced as challenges, related to the complexity of technical and conceptual handling requirements. The case studies presented in this paper illustrated how important is teachers' mediation in reifying sensors' affordances and in overcoming sensors' limitations. Teachers planned and implemented authentic tasks and activities that progress from the concrete sensorial experiences and from children's point of view to more abstract points of view (for instance when using the digital microscope) and to more abstract representations, such as the graphics or the values of abstract variables, for instance conductivity and pH (Silva et al. 2013).

Consequently, teachers' mediation scaffolded the use of senses and sensors by children, making possible the following results:

- Children used senses and sensors to observe, represent and control variables in authentic activities that involved complex concepts, evidencing abstract thinking;

- Children interpreted sensors' abstract data acquired, grounded on the sensory information previously acquired;
- Children used multiple representations of data acquired by senses and sensors, such as tables and graphics, to make sense of phenomena and representations that otherwise would be too complex for children (Reiser 2004).

In summary and in what concerns the utility and usability of the assessed electronic sensors, the results of this study can contribute to inform future didactical and research activities on the use of senses and sensors in environmental education hands-on authentic activities.

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The Use of Communication Technologies in Personal and Learning Contexts: The Influence of Gender in Higher Education Students in Portugal

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Abstract This article presents and discusses the main findings of a nationwide survey that aims to obtain a deeper insight into the way students of the Portuguese Public Higher Education (PPHE) use Communication Technologies (CT), with particular emphasis on gender issues.

An analysis model was created and used to develop the nationwide online survey used to collect data. This descriptive and exploratory research enabled knowing students' perception on the use of CT, how often they use them and its perceived usefulness in personal and learning contexts. Findings point towards the existence of relevant gender differences in terms of use and perceived usefulness of CT, whether in learning situations or in more personal contexts.

Keywords Gender • Higher Education • Students • Communication technologies • Portugal

1 Introduction

Nowadays, it is clear that technologies are already part of students' daily life in Higher Education (HE) and they are used in a variety of contexts, whether in personal or leisure activities or as a support to learning. The importance of studying the way students use the available technologies has been shown in the diverse works that aim to understand CT use on a national scale (Costa et al. 2011; Coutinho 2008, 2009; Coutinho and Junior 2008; Gomes et al. 2011; Marques and Carvalho 2008)

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and international (Franklin and Harmelen 2007; Grodecka et al. 2009; Grosseck 2009; Hemmi et al. 2008; Selwyn 2007). On the whole, these studies show that CT are able to promote greater participation, collaboration and interaction on the part of students in learning situations.

Nonetheless, no broader nationwide survey in terms of Portuguese Higher Education (PHE) enabling insight into students' perception on CT use, or more specifically a study taking into account gender as a specific dimension of analysis, was identified. A large part of works developed are usually case studies reporting the use of specific tools in very specific situations, not allowing the development of a broader view on this subject.

Countless studies were carried out in Portugal aimed at studying the use of the variety of technologies, impact thereof and integration into learning contexts, but there are still few investigations dealing with the pair 'technology and gender'. The appropriateness of including the gender dimension during the analysis of this phenomenon concerns the fact that several government agencies, such as the European Commission (EC), are concerned with gender differences in terms of enrolment and training in fields such as technology (Wastiau-Schlüter 2005) on one hand and the existence of gender differences in terms of behaviour, preferences and use of ICT on the other, both in learning and leisure contexts (Tømte 2008).

Considering the above mentioned, a nationwide study was carried out that focussed on contributing to the characterisation of CT use, based on the perceptions of PPHE students and with particular emphasis on gender differences.

2 Gender and the Use of Communication Technologies

Within the scope of gender difference studies, several studies have shown significant differences between gender regarding access to and use of technologies.

In general, it is striking that males use ICT more than females and that gender influences the ways in which students use those technologies. Nonetheless, as argued by Selwyn (2004), access to ICT does not necessarily entail the use of those technologies and the fact that ICT are used does not mean that they are highly used.

Regarding technology access and use, mention can be made, on a HE basis, to the investigation conducted by Tekyi-Annan (2005), who sought to understand students' perception and identify gender differences regarding the use of computers for educational purposes. The study counted with the participation of 33 students from a Canadian university and findings showed that both boys and girls had their own computers at home, spending an average of 5 h a day in front of a screen, both for educational and leisure purposes. Girls regarded computers as a very important tool for increasing self-confidence and motivation when using computer programmes. The most common uses are information research, e-mail sending and receiving, and computer games. In the latter case, it was shown that females play as much games

as males, although the types of games played differ significantly. Nonetheless, Bussière and Gluszynski (2004), in a work aimed at identifying gender differences among 15-year-old Canadian teenagers when using software, concluded that boys used the computer to play games twice as much as girls and showed that they used the Internet and the computer at home and at school much more often than girls.

Imhof et al. (2007) monitored a sample composed of 48 students from the University of Frankfurt, in Germany, in order to check if it was possible to identify gender differences regarding access, motivation, performance and use of a computer. In general, no significant visible differences were found between boys and girls in terms of the time spent in front of a screen nor in terms of the activities they prefer doing. Nonetheless, it was possible to identify that males used the computer for private or non-learning-related purposes more often than females and it was observed that boys outperformed girls when using software applications, with girls having lower scores.

Although at a different education level, Volman et al. (2005) researched the access and interest in technology use by 213 secondary school pupils in Holland. They concluded that girls use a computer at home less often and find little interest in computer programming activities and games. In a school context, the same study demonstrated that computers are similarly used by males and females, the difference being that girls use their e-mail more often and boys prefer computer games. Fallows (2005) found similar results in a higher age group, when he sought to understand how North American men and women, ranging from 18 to 65 years old, used the Internet. Hence he showed that men used the Internet for leisure purposes more often and observed that women sent and received more e-mails than men. Caspi et al. (2008) also highlighted female preference for written communication and regarding ICT use. Identical results are also presented by Gil-Juarez et al. (2011), who mention a female tendency to use computers and the Internet for communicative purposes or to do school work, while males preferred creating web pages or programming and used ICT for leisure activities more often.

Moreover, Papastergiou and Solomonidou (2005) researched gender differences in Internet use with 340 pupils from 11 secondary schools in Greece. Results obtained point towards a more frequent use of the Internet by young people in non-school environments, such as at home and Internet cafes, and it was shown that boys had more opportunities to access the Internet. The most common activities relate to information research for personal and leisure purposes, with particular emphasis on the use of the Internet for leisure purposes and website creation mostly by boys. Nonetheless, regarding e-mail sending, conversations in chat rooms or through videoconference no significant differences were observed between males and females.

A study conducted by the OECD (2007) set out to investigate the use of web services of Web 2.0 by young people and it was concluded that the paradigm of this second generation of the World Wide Web appeals to women and men differently. Therefore, boys are particularly driven by video creation and sharing online, whereas girls are rather drawn by writing and upload of photos to blogs and social networks.

The use of the Internet for communicative purposes mostly by women was also confirmed by Jones et al. (2009), in a survey involving 40 USA Universities and the participation of 7421 students. Besides the conclusion mentioned above, the authors also highlighted the following:

- Boys mentioned they used the Internet before girls and indicated they used wireless networks more often than girls;
- Males stated spending more time online than females;
- Boys are mostly online to entertain themselves, whereas girls prefer to be online for interpersonal communication and to do homework.

Technology access and use can also have a different impact on men and women, as concluded in the research by Colley and Maltby (2008), who analysed the posts of 200 men and 200 women, from a variety of countries, in the discussion forum of BBC News website entitled 'Have Your Say—Has the Internet changed your life?'. The analysis of message content suggested that a higher number of women made new friends or reunited with relatives or long-standing friends, as well as that more women mentioned making online purchases, easily accessing learning resources and easily finding information researched online. Men, on their turn, mentioned more often that Internet plays a major role in their professional life, having helped them find a new job. In the authors' opinion, these findings somehow mirror the concerns and motivations related to social roles played by men and women.

3 Analysis Model

The study carried out (Morais 2012) was aimed at gaining an insight into the perceptions of students from the PPHE regarding CT use and had the following general goals:

- Identifying CT used by students from the Portuguese Public Higher Education;
- Presenting the purposes, usage level and locations of access to and use of CT;
- Identifying usages promoted and knowing the opinion of students on the use of CT as a support to learning;
- Knowing the behaviour and preferences of students regarding CT use;
- Identifying differences between CT use for personal purposes and in a learning context;
- Analysing the extent to which CT use is influenced by gender.

Initially, an analysis model aimed at systematizing a set of important concepts within the scope of this research was drawn up. Therefore, the major concepts are: Gender, Higher Education and Communication Technologies. The components and indicators of each concept were identified, serving as a support to the work developed later on (Table 1).

Table 1 Analysis model of the study

Concept	Dimension	Components	Indicators
Gender			– Females
			– Males
Portuguese Higher Education	Institutional		– Identification of Portuguese public HEIs
			University-based subsystem
			Subsystem based on vocational higher education
			– Identification of the scientific areas covered by the courses provided at Portuguese Public HEIs using CT
	Students		– Age
			– Status
			– Institution where they are enrolled
			– Scientific area of the course they are attending
			– Year and stage of academic development
			– Number of enrolments
Communication Technologies (CT)	Identification		– Identification of CTs provided by the HEIs
			– Description and features of CTs
	CT Access and Use	Context	– Support learning and personal purposes
			– Identification of CTs used
			– Identification of the places of access to CT
			– Identification of CT access rate
			– Support learning
			– Provision of CT by the institution
			– Identification of the nature of the course using CTs
			– Teachers' perception on CTs
			– Identification of the type of learning activities performed using CT
			– Identification of the purposes of using CTs
		Overall advantages and disadvantages	– Perception of the benefits related to CT use
			– Perception of the problems arising from CT use
			– Perception of the impact of CT use
		Personal perceptions and expectations	– Perception of the skills for CT use
			– Perception of CT usefulness
			– Perception of the level of satisfaction on CT use
			– Attitudes (positive and/or negative) regarding CT use
			– Identification of preferences on CT use
			– Identification of expectations on CT use in the future

3.1 Concept: Gender

In the characterisation of the concept of Gender, given the nature of this study, we adopted the perspective of Tømte (2012), who regards this concept as a sexual category dividing people into two groups: men and women. According to this author, the features and roles culturally assigned to each gender make more sense when applied to the notions of masculinity and femininity. Actually, within the scope of this study, the concept of gender was characterised on the basis of the indicator regarding student sex, i.e. whether they belong to the female sex or male sex, which allowed us to characterise the gender of participants and thus analyse the influence of this variable in CT use.

3.2 Concept: Portuguese Higher Education

Given that this research regards the Portuguese Higher Education (PHE), it seemed important to us to know and characterise this context using two different dimensions: the Institutional aspect and that of Students.

The institutional dimension, as the name suggests, contributes to the obtainment of information on institutional aspects, such as the identification of PPHEI, location thereof, number of enrolled students, the subsystem to which they belong, etc. This institution-oriented data was obtained by means of document collection, particularly through documents provided by the Directorate-General for Higher Education (DGES)—Ministry of Science, Technology and Higher Education—, as well as through other documents supporting the characterisation of indicators related to the institutional dimension.

Still based on Higher Education, the Student dimension was particularly important in this study. Actually, as we intend to gain insight into the perceptions of these individuals regarding CT use, drawing their profile was highly important. To this end, it was essential to get information on a set of indicators such as: sex, age, PPHEI at which students were enrolled, scientific area of the course they attended, etc. (see Table 1).

3.3 Concept: Communication Technologies

As mentioned above, Communication Technologies are, under this study, technologies that enable communication and are based on the Internet. It seems important to us to delimit this concept, given that this study did not cover the analysis of information technologies or the use of devices enabling and supporting communication.

Table 2 Taxonomy of CT adopted in the study

Communication technologies	
Categories	Examples
Learning management systems	BlackBoard, Moodle, WebCT, etc.
Interpersonal communication technologies	email, MSN, Skype, etc.
Publishing and sharing technologies	Blogs, Wikis, Flickr, YouTube, Podcast, Social Bookmarking, etc.
Collaborative technologies	Google Docs, Social Bookmarking, Mind Maps, Wikis, Blogs, etc.
Content aggregation technologies	RSS feeds, Netvibes, Google Reader, etc.
Social networks	Facebook, Twitter, Hi5, LinkedIn, Ning, Academia.edu, etc.
3D virtual worlds	Second Life, Haboo, etc.

The first dimension of this concept is the identification of technologies, a task which, following the selection and thorough analysis of the proposals from varied authors and the joint collaboration with another researcher, who has also been engaged in work on the use of CT (Batista 2011), resulted in the proposal of a taxonomy (Table 2).

The taxonomy adopted covers seven different types of CT and a set of examples for each type which, in our opinion, suit the context and the goals of this research.

Therefore, the category named learning management systems encompasses a set of solutions that use the Web to provide, in an integrated manner, several features enabling content management and sharing, the use of communication services, collaboration tools, etc. Some of the most famous learning management systems are Moodle, WebCT or Blackboard.

The category focused on interpersonal communication technologies relates to technologies that enable synchronous or asynchronous communication. Synchronous communication is performed by means of CT enabling real-time contact among participants, such as MSN Messenger, Skype, among others. Asynchronous communication does not require simultaneous interaction. The most common examples of this type of communication are email service and discussion forums.

Technologies arise, inspired by the second generation of the World Wide Web—Web 2.0, which allow content posting and sharing, others enabling collaboration, making data aggregation easier, social networks and virtual worlds. Content posting and sharing are probably two of the best notions to characterise the Web 2.0 (Conole and Alevizou 2010) and are one of the CT categories covered by the study. Using this kind of technology, users can post and share different types of content on the Web, such as texts, pictures, videos, music, etc. In this context, it is worth noting blogs, sites such as YouTube and Flickr, tools enabling social bookmarking, Wikis, among others. The category of collaborative technologies relates to CT which enable users to work on a collaborative basis for content development, and thus we thought it was appropriate to highlight solutions such as GoogleDocs, Mindmaps and Wikis.

Web 2.0 also marks the development of content aggregation technologies. This type of CT is useful when users intend to aggregate, in a single site, information obtained in different websites. The varied tools enabling content aggregation include Netvibes and the now extinct Google Reader.

Social networks are probably one of the most successful phenomena in the Web 2.0 paradigm, enabling users to create digital spaces where they share contents with friends, such as messages, videos, texts, and where they can even play games (Conole and Alevizou 2010). Nowadays, Facebook is probably the most widely used social network, but there are others, such as Ning and Academia.edu, which are particularly used in academic contexts.

The category regarding 3D virtual worlds relates to the tools that allow users to surf in virtual spaces and interact with other users by means of characters named avatars (Conole and Alevizou 2010). In academic contexts, Second Life is probably the most widely known virtual world, thanks to the variety of studies carried out using this virtual world.

In addition to the identification of CT, different studies have highlighted the importance of researching areas such as access and use, attitudes and skills for the use of those CT, among others. Therefore, within the scope of this research, CT Access and Use is an important dimension. On the whole, the issue of access regards the possibility for students to physically access a CT, whether at the PPHEI, at home or at another location. The extent of access is probably a more basic issue that limits at a later stage the possibility for pupils to actually use CT according to given purposes (learning, leisure, etc.). In this respect, the access and use dimension is described in this study according to several indicators, organised into three different elements: Context, Assessment of advantages and disadvantages and Self-assessment of CT use.

Regarding the Context of CT use, focus is placed on the context of learning resource and an attempt is made to understand some trends regarding the use of CT in personal contexts. To this end, it is important to consider indicators enabling us to obtain information on: which CT do students use? How often and for what purpose do they use it? Where does this take place? Which CT are provided by PPHEI? Which activities are promoted by teachers using CT?

Still in terms of the dimension of CT use, the Assessment of the advantages and disadvantages is another perspective we intend to understand by means of this study. In this respect, the indicators proposed for this element of assessment of CT use must allow gaining insight into the perceptions of students on the benefits, issues and impacts arising from the use of CT in learning contexts.

Lastly, issues related to Perceptions and personal expectations of students regarding their use of CT are explored. In this context, indicators that seek to identify preferences, expectations, attitudes, level of satisfaction regarding the use of CT and those related to the skills of students and their perception on the usefulness of those CT become especially relevant.

4 Methodology

The analysis model which guided the study is followed by the presentation of methodological choices. From a methodological point of view, it is considered appropriate to connect this study to the quantitative paradigm, although it also has features belonging to the qualitative paradigm, particularly those regarding understanding, interpretation and description of findings on the perception of students in terms of CT use, as well as document collection that supported the review of the state of the art.

It is a research that comes under a descriptive dimension, with many similarities with survey-based studies, particularly if we consider the fact that the questionnaire was the main method for data collection aimed at investigating individuals on their perceptions, attitudes and behaviours (Coutinho 2011). In fact, investigation by means of survey enables the obtainment of information on participants in a study and is mostly used when the aspects one wishes to study cannot be verified directly (Ghiglione and Matalon 2005).

The choice of developing a questionnaire was based on several reasons. On one hand, given that it consists of a descriptive research, an investigation by questionnaire is one of the methods chosen to collect data in this type of research. On the other hand, given the proposed goals, the development of a questionnaire proved to be the most appropriate option within the scope of the study. In fact, it would be impossible to obtain necessary information on student perception, for instance, by means of direct observation or interviews (Ghiglione and Matalon 2005). The same authors also consider that the use of questionnaires is appropriate when one intends to know the opinions, attitudes, perceptions and preferences of respondents (purposes also included in this study). Given the above, we regarded the use of questionnaires as the most suited option within the scope of this research.

The questionnaire was developed on the basis of the indicators proposed on the analysis model (see Table 1). It was duly tested and validated and participants could answer it within 4 months, period in which several diffusion strategies were adopted to promote a high participation on the study.

Regarding the dissemination of the questionnaire, the strategy was based on:

- Institutional dissemination, through the official contacts of PPHEI;
- Dissemination in social networks, in particular through Facebook;
- Dissemination through other means (mailing list, personal contacts, etc.).

In terms of participation, the questionnaire was accessed 4738; 2429 answers were submitted and 2207 answers were validated. Upon close of the participation period, results were analysed and interpreted using statistical methods for data analysis. Regarding questions that tried out gender differences, it was decided to use nonparametric statistics (*Mann-Whitney U* test), inasmuch as dependent variables are qualitative.

Although participants are not a perfect representation in statistical terms of the universe to which they belong, and therefore results cannot be generalised, the conclusions drawn from this study are considered significant in terms of the characteristics

of the current reality on CT use by students of the PPHEI. Effectively, a high number participated in the questionnaire, and most PPHEI are represented. Moreover, several similarities between statistical characteristics of participants and the universe under study were identified (Morais 2012).

5 Results

Although the work carried out enabled reaching several conclusions, this study highlighted those related directly to:

- How often CT were used in personal and learning contexts;
- Places of access to CTs in personal and learning contexts;
- The perception of the usefulness of CTs for the development of personal and learning activities.

In order to make the presentation of results easier, the following abbreviations were chosen:

- $\bar{X}_{ls}$ —the mean value for learning support, used to present results regarding the learning context;
- $\bar{X}_{PP}$ —the mean value for personal purposes, used to present results regarding the personal context;
- $\bar{X}_{sm}$ —the mean value of the answers from male students;
- $\bar{X}_{sf}$ —the mean value of the answers from female students.

The presentation of results regarding gender differences includes the score of the *Mann-Whitney U* test and corresponding level of significance, as suggested in Coutinho (2011).

5.1 Frequency of CT Use

Regarding the frequency of use of the varied CTs (Fig. 1), it is observed that learning management platforms ($\bar{X}_{ls} = 3.75$ vs. $\bar{X}_{PP} = 2.69$) and collaborative technologies ($\bar{X}_{ls} = 3.35$ vs. $\bar{X}_{PP} = 3.15$) are more used as learning supports than in personal contexts.

Social networks become especially relevant for personal activities ($\bar{X}_{ls} = 2.75$ vs. $\bar{X}_{PP} = 3.92$) and technologies enabling interpersonal communication also have a slightly higher average than that observed in learning support activities ($\bar{X}_{ls} = 4.23$ vs. $\bar{X}_{PP} = 4.62$). The same applies to publishing and sharing technologies, whose use averages are higher in a personal context ($\bar{X}_{ls} = 3.13$ vs. $\bar{X}_{PP} = 3.60$).

Content aggregation technologies ($\bar{X}_{ls} = 2.25$ vs. $\bar{X}_{PP} = 2.22$) and 3D virtual environments ($\bar{X}_{ls} = 1.28$ vs. $\bar{X}_{PP} = 1.30$) are infrequently used, both as a learning support and for the development of personal activities.

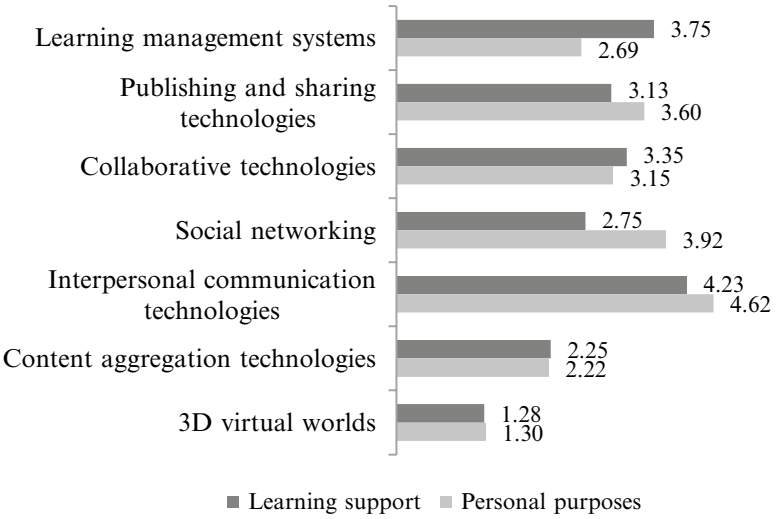

Fig. 1 Frequency of use of CTs as a learning support and for personal purposes

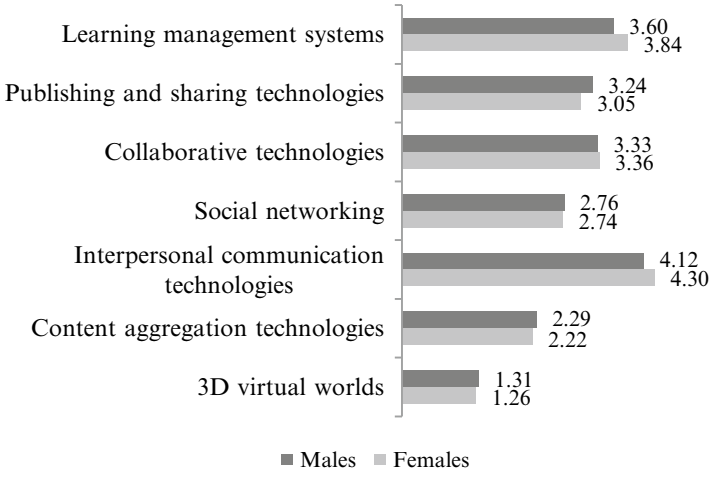

Fig. 2 Frequency of use of CTs as a learning support (by gender)

Taking into account results from a gender perspective (Fig. 2), there are differences in the frequency of use between men and women in all types of CT for learning support.

Nevertheless, differences observed are statistically significant only in the following cases:

- Learning management platforms ($Z=-3.824$, $p=0.000$), where female students mention they use them more often than male students ($\bar{X}_{sf} = 3.84$ vs. $\bar{X}_{sm} = 3.60$);

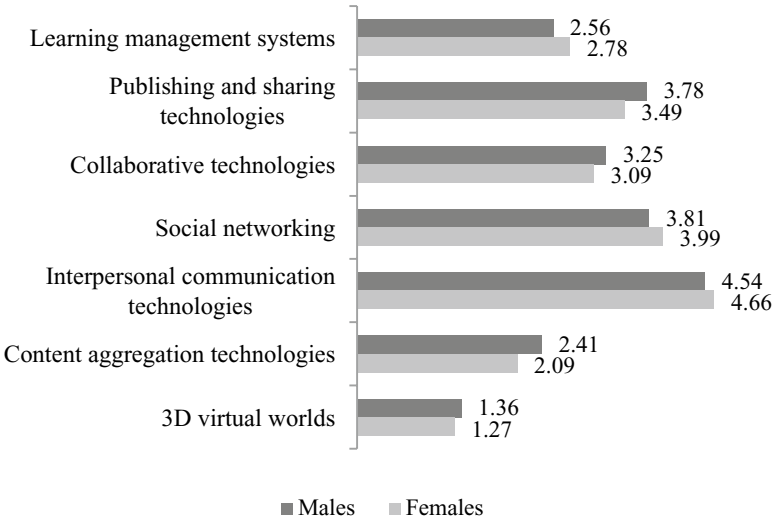

Fig. 3 Frequency of use of CTs for personal purposes (by gender)

- Publishing and sharing technologies ($Z=-3.643$, $p=0.000$), where men mention they use them more often than women ($\bar{X}_{sm}=3.24$ vs. $\bar{X}_{sf}=3.05$);
- Interpersonal communication technologies ($Z=-3.768$, $p=0.000$), where women perceive they use them more frequently than their male colleagues ($\bar{X}_{sf}=4.30$ vs. $\bar{X}_{sm}=4.12$).

Observing the use of CT for personal purposes in terms of gender, significant statistical differences are found between men and women in the frequency of use of all types of CT (Fig. 3).

Regarding learning management platforms ($Z=-3.358$, $p=0.001$), although an infrequent use was observed, it was found that female students use them more often than male students ($\bar{X}_{sf}=2.78$ vs. $\bar{X}_{sm}=2.56$). In the two types of CT that stand out regarding personal use, the female gender mentions using them more often than the male gender (Fig. 3):

- Social networks ($Z=-3.481$, $p=0.000$), female students use them more often than male students ($\bar{X}_{sf}=3.99$ vs. $\bar{X}_{sm}=3.81$);
- Interpersonal communication technologies ($Z=-2.965$, $p=0.003$), women use them more often than men ($\bar{X}_{sf}=4.66$ vs. $\bar{X}_{sm}=4.54$).

In the remaining categories, the trend was reversed and the male sex reports using more often the following CT:

- Publishing and sharing technologies ($Z=5.835$, $p=0.000$), male students use them more often than female students ($\bar{X}_{sm}=3.78$ vs. $\bar{X}_{sf}=3.49$);
- Collaborative technologies ($Z=2.815$, $p=0.005$), men use them more often than women ($\bar{X}_{sm}=3.25$ vs. $\bar{X}_{sf}=3.09$);

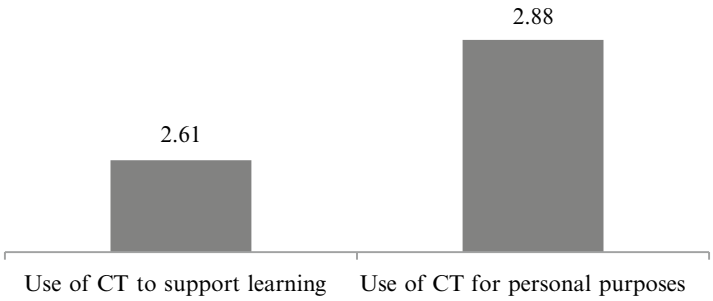

Fig. 4 Daily rate of use of CT

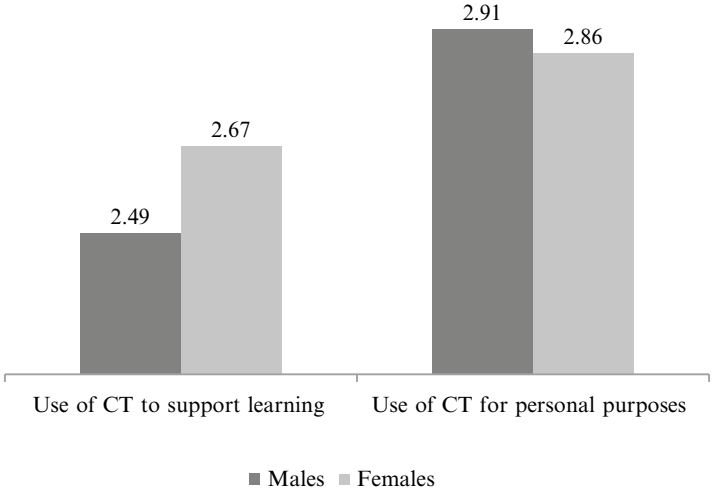

Fig. 5 Daily rate of use of CT (by gender)

- Content aggregation technologies ($Z=5.071$, $p=0.000$), the male students uses them more often than the female students ($\bar{X}_{sm} = 2.41$ vs. $\bar{X}_{sf} = 2.09$);
- 3D virtual environments ($Z=-2.310$, $p=0.021$), male students use them more often than female students ($\bar{X}_{sm} = 1.36$ vs. $\bar{X}_{sf} = 1.27$).

On the whole, results obtained show that on average students from PPHEI use CT daily more frequently for the development of personal activities than as a support for the various learning activities ($\bar{X}_{PP} = 2.88$ vs. $\bar{X}_{ls} = 2.61$) (Fig. 4).

In terms of gender (Fig. 5), differences are observed, with women apparently using CT more often in learning contexts ($\bar{X}_{sf} = 2.67$ vs. $\bar{X}_{sm} = 2.49$) and men mentioning they use them for personal purposes more often than women ($\bar{X}_{sm} = 2.67$ vs. $\bar{X}_{sf} = 2.49$). Nevertheless, those differences are merely significant in a learning context, as shown in the results of the statistical tests carried out.

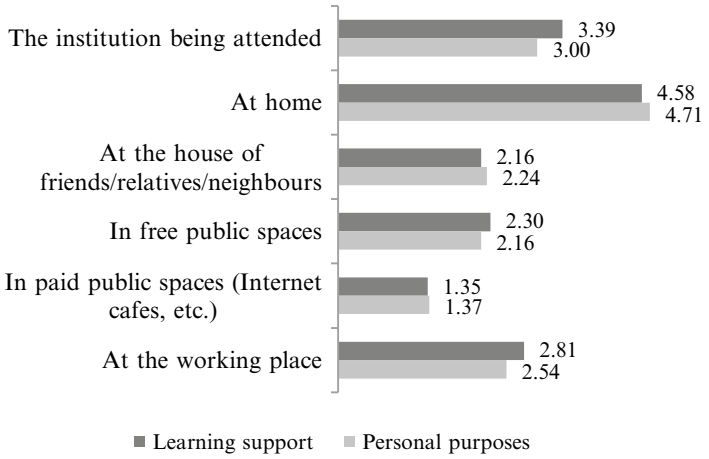

Fig. 6 Places and rate of access to CT

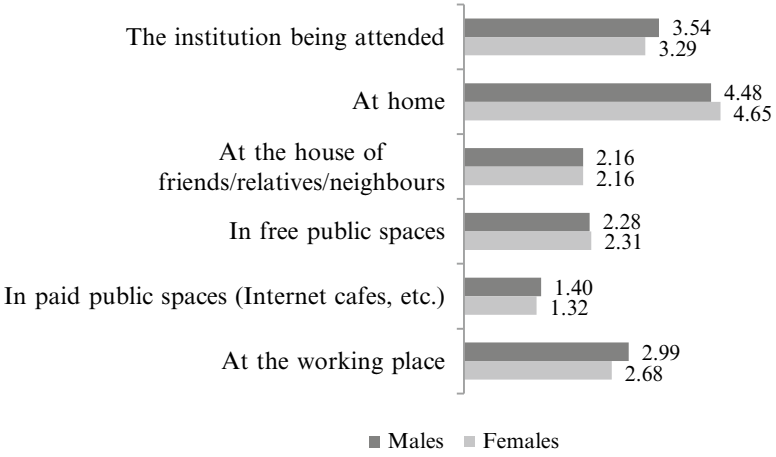

Fig. 7 Places and rate of access to CT as a learning support (by gender)

5.2 Places of Access to CT

The most common place used for accessing CT (Fig. 6) is home and students perform it both for personal purposes and as a learning support ($\bar{X}_{pp} = 4.71$ vs. $\bar{X}_{ls} = 4.58$).

In terms of the places of access to CT in learning contexts, significant statistical differences are found between genders, with male students using CT more often than female students in the various environments considered (Fig. 7).

Concerning the use of CT in the institution they are attending ($Z = -5.020$, $p = 0.000$), male students report a more frequent use than female students

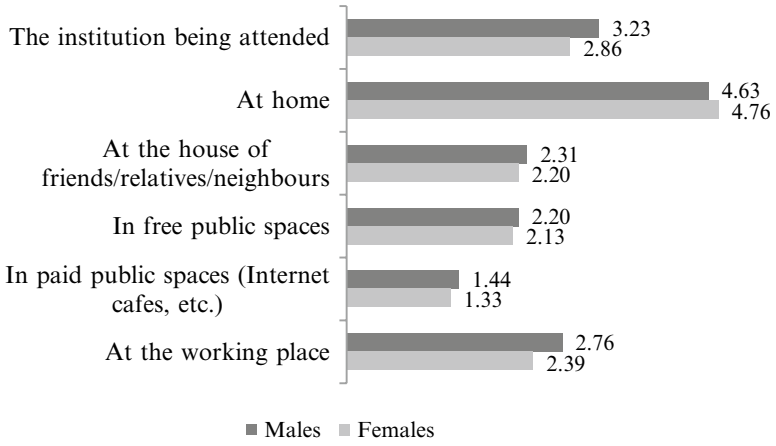

Fig. 8 Places and rate of access to CT for personal purposes (by gender)

($\bar{X}_{sm} = 3.54$ vs. $\bar{X}_{sf} = 3.29$), a trend that is also observed in paid public spaces ($Z=-2.100$, $p=0.036$) where, despite being places of infrequent use, males still have an access rate slightly above that of the females ($\bar{X}_{sm} = 1.40$ vs. $\bar{X}_{sf} = 1.32$). Results from the statistical test ($Z=-4.070$, $p=0.000$) also point to the fact that men access and use CT more often than women at their working place ($\bar{X}_{sm} = 2.99$ vs. $\bar{X}_{sf} = 2.68$). In turn, at home ($Z=-5.040$, $p=0.000$) females access and use the varied CT more often ($\bar{X}_{sf} = 4.65$ vs. $\bar{X}_{sm} = 4.48$) as a learning support.

Similarly, significant statistical differences are found between genders in the places and frequency of access to CT for personal purposes (Fig. 8).

Data illustrate that men use CT more often than women for personal purposes ($\bar{X}_{sm} = 3.23$ vs. $\bar{X}_{sf} = 2.86$) at the institution they are attending ($Z=-6.238$, $p=0.000$), as well as at paid public spaces ($Z=-2.526$, $p=0.12$), where the frequency of use by the male sex surpasses that of the female sex ($\bar{X}_{sm} = 1.44$ vs. $\bar{X}_{sf} = 1.33$). Male students showed a frequency of use higher than that of female students ($\bar{X}_{sm} = 2.76$ vs. $\bar{X}_{sf} = 2.39$) at their working place ($Z=-5.191$, $p=0.000$). Nonetheless, at home ($Z=-4.149$, $p=0.000$) female students are the ones that use CT more often than male students ($\bar{X}_{sf} = 4.76$ vs. $\bar{X}_{sm} = 4.63$) for personal purposes.

5.3 Perception of CT Usefulness

Regarding the perception on CT usefulness (Fig. 9), it was found that the learning management platform is the category that gathers the most favourable opinions in learning contexts ($\bar{X}_{ls} = 4.13$). As for personal purposes, the usefulness of technologies enabling interpersonal communication stands out ($\bar{X}_{pp} = 4.31$), as well as that of publishing and sharing content ($\bar{X}_{pp} = 3.64$).

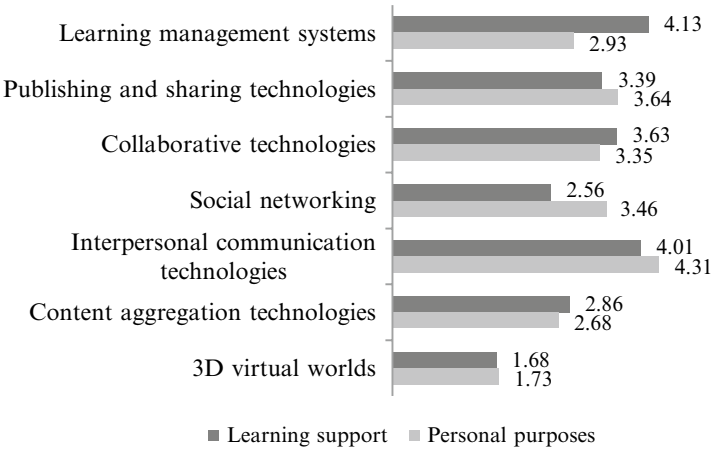

Fig. 9 Perception of CT usefulness

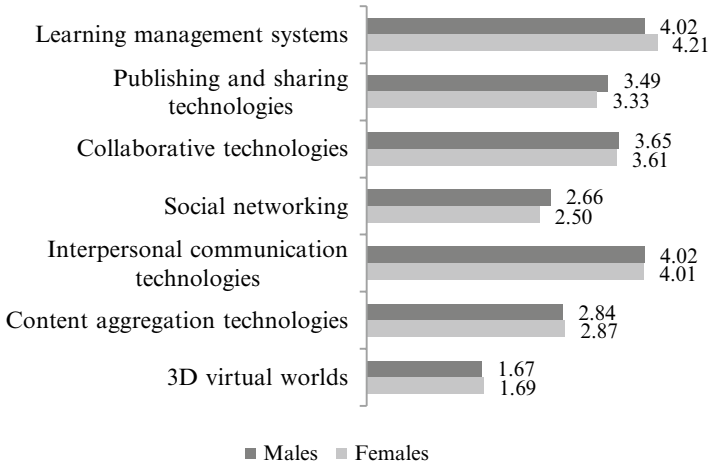

Fig. 10 Perception of CT usefulness to support learning (by gender)

Social networks also gain relevance in a personal context ($\bar{X}_{pp} = 3.46$), as opposed to what occurs in learning support ($\bar{X}_{ls} = 2.56$), a context in which the perception of their usefulness is weak. Content aggregation technologies ($\bar{X}_{ls} = 2.68$ vs. $\bar{X}_{pp} = 2.86$) and 3D virtual environments ($\bar{X}_{ls} = 1.68$ vs. $\bar{X}_{pp} = 1.73$) have, in both contexts, average values below those of the remaining categories, suggesting that participants do not attribute to them a high usefulness, both as a learning support and for the performance of personal activities.

The perception of CT usefulness for learning support seems to be similar between men and women (Fig. 10).

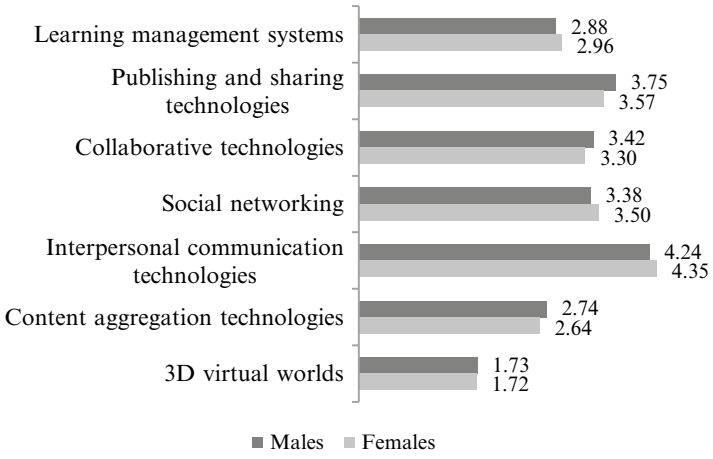

Fig. 11 Perception of CT usefulness for personal purposes (by gender)

Nonetheless, women regard learning management platforms ($Z=-4.572$, $p=0.000$) as more useful technologies ($\bar{X}_{sf}=4.21$ vs. $\bar{X}_{sm}=4.02$) and men, in their turn, regard publishing and sharing technologies ($Z=-4.177$, $p=0.000$; $\bar{X}_{sm}=3.49$ vs. $\bar{X}_{sf}=3.33$) and social networks ($Z=-2.882$, $p=0.000$; $\bar{X}_{sm}=2.66$ vs. $\bar{X}_{sf}=2.50$) as being more useful for learning activities. The remaining categories show extremely similar results between men and women, and the slight differences found were not statistically significant.

As for the perception of CT usefulness for the performance of personal activities, more gender differences were observed in comparison with what was found in learning contexts (Fig. 11).

Male students consider that publishing and sharing technologies ($Z=-4.864$, $p=0.000$; $\bar{X}_{sm}=3.75$ vs. $\bar{X}_{sf}=3.57$), those enabling collaboration ($Z=-2.880$, $p=0.004$; $\bar{X}_{sm}=3.42$ vs. $\bar{X}_{sf}=3.30$) and those enabling content aggregation ($Z=-1.992$, $p=0.046$; $\bar{X}_{sm}=2.74$ vs. $\bar{X}_{sf}=2.64$) are the most useful. On the other hand, female students classify social networks ($Z=-2.275$, $p=0.000$; $\bar{X}_{sf}=3.50$ vs. $\bar{X}_{sm}=3.38$) and interpersonal communication technologies ($Z=-2.727$, $p=0.000$; $\bar{X}_{sf}=4.35$ vs. $\bar{X}_{sm}=4.24$) as the most useful in their personal life.

6 Final Considerations

In the light of what was stated throughout this paper, we can identify a set of differences between the use of CT in a personal context and in a learning context, as well as find significant statistical differences between men and women in the use of CT as a learning support and for personal purposes.

In learning contexts, female students use more frequently learning management platforms and interpersonal communication technologies. On the other hand, publishing and sharing technologies are more often used by male students.

In a personal context, the study indicates the existence of gender differences in the use of all types of CT. In this domain, women use more frequently social networks and, as in the case of learning support, they also use learning management platforms and interpersonal communication technologies more often than men. In turn, men use more often the remaining types of CT than women.

Regarding the perception of usefulness of the varied CT for learning support, results suggest that female students consider learning management platforms more useful than male students. The trend is reversed in the perception of the usefulness of social networks and publishing and sharing technologies, in which case men regard them as more useful for learning.

As for CT usefulness in a personal context, women express a more positive view on the usefulness of social networks and technologies enabling interpersonal communication. Men, in their turn, agree that publishing and sharing technologies, technologies enabling collaboration and those enabling content aggregation are useful more often than women.

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Mousekey Syllabic Virtual Keyboard: An Assistive Technology Tool for People with Physical Disabilities

Claudio Luciano Dusik and Lucila Maria Costi Santarosa

Abstract In the context of an inclusive society committed to guaranteeing that disabled people are not excluded from day-to-day activities, this research presents the conception and development of a virtual keyboard interface called Mousekey, and discusses how this assistive technology may help people with disabilities with their writing. This is a qualitative research, a case study. The participants were five literate people who have motor difficulties when writing. We met with the subjects two times for data collection. They used the technology developed in this research. Two of them had Spinal Muscular Atrophies, two had Muscular Dystrophy, and one had Dystonia. Through an ergonomics assessment protocol, analyses of the interviews, and direct observation, we could verify the importance of using this virtual keyboard in the process of writing, communicating and interacting. The Mousekey made writing easier for three participants, who took less time in the process and suffered from less muscular fatigue; for the other two participants, the technology made writing possible. The potential of technological developments for enabling various human potentials was observed. The texts produced by the participants showed that the syllables on the Mousekey made them rethink their knowledge and writing processes, optimizing time and effort. The typing modes allowed the tool to adapt to different needs from the users. In general, the data showed that the Mousekey-UFRGS can attend to the writing needs of participants and fulfill their expectations. It is Functional, Useful, and Accessible. We conclude with a reflection about human potential, the strength of life in its hopes and aspirations, and how provisory and unpredictable the word "impossible" can be.

Keywords Assistive technology • Virtual keyboard • Inclusion • Disabled people • Writing

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1 Introduction

Technological evolution goes towards making life easier. Technologies went into people's lives and serve as tools for facilitating many chores. Besides, technologies have redefined the concepts of time and space, since they erase distances and enable the communication between peoples and cultures. Our society is, therefore, immersed in this cyberculture which, according to Lévy (1999), is a set of techniques, practices, attitudes, ways of thinking and values that are born along with the growth of the net or interconnection between computers (cyberspace).

From this context emerges the growing need for the development of studies to develop technologies for assisting people with disabilities (PWD): Assistive Technology (AT). This area of knowledge (AT) also brought a set of resources and services that provide or increase the functional abilities of people with disabilities. Researchers have worked to promote a more autonomous life for PWD, allowing them to participate in the community, be it by increasing their communication possibilities and their mobility, by giving them more control of their environment, their learning abilities and work, or by helping them in day-to-day activities, such as feeding, maintaining personal hygiene and monitoring their health. Thus, technologies are considered necessary to the social inclusion of individuals. We may say, then, that technology makes things easier for people without disabilities, but it makes things *possible* for people with disabilities (Radabaugh 1993).

Among these technologies, we emphasize virtual keyboards and voice recognition software products as assistance and support to the act of writing for those who, because of a motor impairment, cannot write in the conventional ways. However, we noticed that even with this great variety of technological resources that assist in the act of writing it is not possible to consider that all needs are fulfilled, since there is a wide range of disabilities, and each one may present itself differently in different individuals and contexts where writing may be carried out, like the job market or an educational environment. Thus, an assistive technology may work for one individual, but not for another, even if they present the same nosological classification:

> Students with the same disability may need different approaches to care […] Before the disability there is a person, a student, with their life story, their individuality, their desires and differences (Ropoli et al. 2010).

Because of that, we must consider technologies as unfinished, and extend their resource variety as much as possible. Information and Communication Technologies (ICT) must be open to their own innovations and flexibilities so they can be applied to different realities, satisfying social needs (Warschauer 2006).

Thus, assistive technologies, inside an educational context, must go beyond the principle of autonomy and concern themselves with two main aspects: lessening the time of typing without diminishing the potential for productivity, and favoring the student's cognitive appropriation of orthographic conventions.[1]

[1] Word prediction or automatically offering words speeds up the writing process, but decreases the need of thinking about the construction of alphabetic writings that respect orthographic conventions.

Fig. 1 Windows virtual keyboard. *Source*: Author (2013). Screenshot. Description: application layout. QWERTY keyboard

It is following this view that this research describes a virtual keyboard interface and how it can favor the writing of people with physical disabilities. We created an application which was thought, planned, elaborated and studied for a specific need (motor impairments), in a specific context (writing). For that, we took interface design into consideration, but emphasizing the ergonomic aspects that should guide accessible software products.

Virtual keyboards (Fig. 1) are generally only alphabetical, that is, they are keyboards with an interface that has letters of the alphabet, just like a standard computer keyboard. This forces whoever is using the keyboard to hit one key at a time, that is, one letter at a time. This makes writing slower and can discourage people to write texts.

One alternative was optimizing the typing, including keys that have two or more grouped letters (syllables), simulating two or more devices for simultaneous activating. This is what we propose when developing a syllabic-alphabetical virtual keyboard (Fig. 2).

Thus emerges our research question: does the syllabic-alphabetical virtual keyboard help the writing process of people with physical disabilities?

2 The Inclusive Education Paradigm

> The concept of inclusive education that guides educational policies and the current normative and legal frameworks breaks a trajectory of exclusion and segregation of people with disabilities, altering educational practices to guarantee equality of access and that people with disabilities stay in school (Ropoli et al. 2010).

Inclusive Education has been a topic of discussion in all levels and modalities of the educational system where it is thought how schools will face diversity and teach students with disabilities.

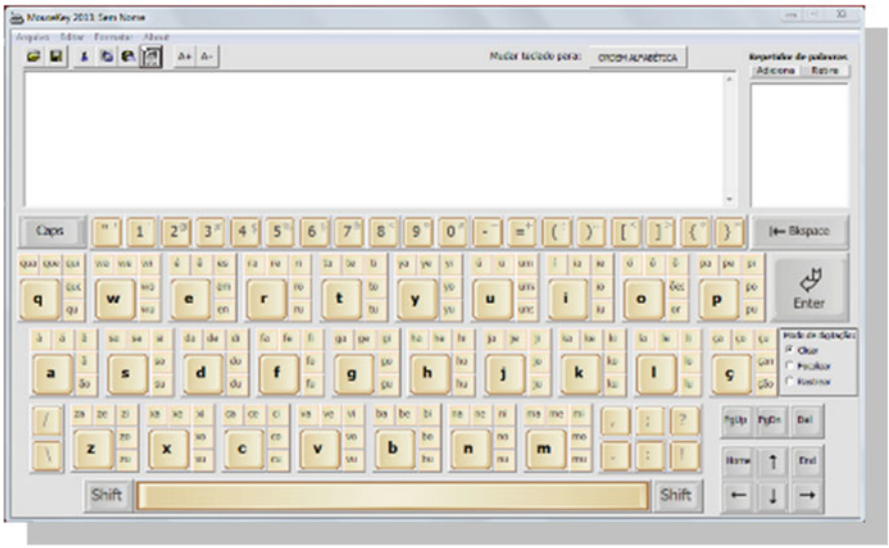


Fig. 2 Syllabic-alphabetical virtual keyboard. *Source*: Author (2013). Screenshot

The definition of special educational needs is being amply re-discussed. When emphasizing the interaction of individual characteristics with the environment, the concept of special educational needs moves the focus from the disabilities and disadvantages centered exclusively on the student to the school and its context. Thus, the possibility appeared of organizing an educational system capable of creating strategies, resources and services for attending to the specific needs of the students and producing diverse answers from the schools.

Pedagogical practice is collective, multifaceted, dynamic and flexible. It requires significant changes in the structure and functioning of schools, in the teacher's humane education and in the family-school relationship. As a transforming force, inclusive education points towards an inclusive society, and this demands changes of ideas and practices.

Mantoan (2003) states that inclusion is a possibility for perfecting School Education and that it benefits all students, with disabilities or not. It depends, however, on an internal availability for facing innovation.

Thus, social inclusion is defined by Sassaki (2006) as:

> […] the process through which society adapts itself to include in its general social systems people with special needs. Simultaneously, these people prepare themselves to assume their roles in society. Social inclusion, then, is a bilateral process in which people, still excluded, and society seek, together, to set out problems, decide about solutions and effectively create equal opportunities for all […].

This way, Inclusive Education is part of this bilateral process when it disseminates a culture that does not accept discrimination against people with disabilities. Its benefits are not felt only by the people who were excluded, but by society as a whole. To seek this new way of seeing people with special educational needs,

reviewing the concept of society, giving it new sense and meaning, is to create new pathways where solidary education can be built cooperatively and fraternally.[2]

The society in which we live is also an information society. The condition for it to advance is that everybody has access to Information and Communication Technologies, which are present in our day-to-day lives and are indispensable for personal and work communication, and for leisure (Polizelli and Ozaki 2008).

Because of that, an inclusive society must also enable the inclusion of individuals in the information society. Therefore, we must speak of digital inclusion. "However, for achieving this reality it is necessary to assure that human diversity has access to these tools and, for that, it is necessary to obey accessibility rules when planning and building these resources" (Dusik et al. 2012).

Social interaction and participation in human activities are essential to all individuals. Even with the paradigm of inclusion and the goal of an inclusive society that is in accordance with the rules of a universal design, there will still be people who need assistive technology services and diverse tools that enable the relationship between the use of these instruments and the development of language. Among these people are those with motor impairments who need AT tools to write.

3 Objectives

The general objective of this study was to develop a syllabic-alphabetical virtual keyboard and analyze the writing processes of people with physical disabilities, aiming to include them in the information society.

The specific objectives were:

- To add alternatives to the available free virtual keyboards;
- To develop a syllabic-alphabetical virtual keyboard with the help of PWD;
- To observe and analyze the interaction of PWD with the virtual keyboard while they were writing, so as to validate the tool;
- To assess the potential of the keyboard for helping PWD to write, enabling their digital inclusion.

4 Methods and Procedures

For achieving the objectives of this study, we adopted, for each objective, the procedures described below:

(a) To add alternatives to the available free virtual keyboards:

- Developing a virtual keyboard based on the technology and computer resources available for the process of writing, as well as using biomotion capture devices;

[2] That is, it affects all social classes, affects all people, with no exception, respecting them in their dignity.

- Adding the solution we find to the Mousekey, adapting it and increasing its resources and accessibility.

(b) To develop a syllabic-alphabetical virtual keyboard with the help of PWD:

- Validating the syllabic-alphabetical virtual keyboard with the help of PWD, through different case studies;
- Observing the mediaton potential of this technology.

(c) To observe and analyze the interaction of PWD with the virtual keyboard while they were writing, so as to validate the tool:

- Analyzing, based on the collected data, the aspects that emerge from the interaction of the participants with the tool we developed, searching for an answer for the research problem.

(d) To assess the potential of the keyboard for helping PWD to write, enabling their digital inclusion:

- Assessing the usefulness of the AT we developed, considering if it is a useful tool for the writing process of PWD, and if it fulfills their expectations.

We opted for a qualitative research in order to answer to all our objectives for this study. Data collection was done through: (a) semi structured interviews; (b) direct and participant observation; (c) ergonomics assessment protocol; (d) instruments for multiple records in video (screen, face and context capture).

While we searched for an answer to this question in other studies from the same scientific field, we also offered a technological tool that helps people with motor impairments to overcome their functional limits for writing. That is why, according to Laville and Dionne (1999), basic research is a type of research that has the goal of increasing the knowledge that is available in a certain area.

The participants of this research were five literate people who "cannot" or "have great difficulty to" write without technical help because of motor impairments.

4.1 Characterization of the Participants

We had great difficulty finding physically disabled people who had[3] motor impairments which prevented them from writing and who were literate. The search took place in municipal schools in the metropolitan area of Porto Alegre and the people we located who had these physical characteristics were not literate yet. So, we used social networks to find people who wanted to participate in the research.

[3] A physical disability may be permanent, but a difficulty or limitation in one action can be temporary if overcome with technical help.

Chart 1 Research participants

Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Cooperative Julio	Playful Anna	Reserved David	Active Joe	Affectionate Timmy
				
Male	Female	Male	Male	Male
67 Years old	31 Years old	22 Years old	17 Years old	13 Years old
Dystonia	Spinal muscular atrophy	Muscular dystrophy	Muscular dystrophy	Spinal muscular atrophy
Cannot write	Cannot write	Cannot write	Has great difficulty to write	Cannot write

After we posted about the research, in a few minutes the post had been shared and a lot of people were referred to us. From these referrals, we selected a few and invited them to participate in the research, considering the criterion of having difficulty to write. We selected five participants who are described below. They received fake names so as to preserve their identity (Chart 1).

4.1.1 Participant 1: Cooperative Julio

Participant 1 is 67 years old and acquired Dystonia about 30 years ago. It makes it impossible for him to write. He used to be a supervisor in a big petrochemical company, which required him to manually register reports and conference proceedings; after he acquired Dystonia, he could not do that anymore.

He looked for different specialists who could help him overcome this impairment, but he did not succeed. He had to stop working. After a few years he wanted to go back to work, but his inability to write prevented him from doing it. He tried resources like the spider spring (Fig. 3), using both hands, using his left hand, among many others, but nothing worked. With each new option he felt more anxious and embarrassed for not being able to write.

He decided, then, to go back to school and increase his professional choices. He graduated from a Youth and Adult Education course, but was dismissed from the writing activities. He received copies of the materials and was evaluated orally.

He recently learned to use the computer, which enables him to write, but with difficulty. He talks about how slowly he writes, since he can only use his index finger for typing. He says he would like to type faster so he can register conference proceedings and write long texts, like reports.

Fig. 3 Spider spring. *Source*: Issue 01 (MEC/ Ropoli et al. 2010) Description: A student writes with a pen fitted in the spider spring that is around his fingers

4.1.2 Participant 2: Playful Anna

Participant 2 is a 31-year-old female who suffers from Spinal Muscular Atrophy (Werdnig-Hoffmann disease). Because of her disease, she stopped being able to write during preadolescence. She cannot move her body, with the exception of a few movements of the hands. She needs help with all everyday actions. She always studied in regular schools. Teachers asked classmates to help her with activities that involved writing. When she entered university, the direction of the Social Service course suggested that she stop studying, since she could not write or use her materials; the director of the course claimed that social service would be too bureaucratic for her. She changed her major to Psychology. A person went to class with her to help her write, but the professor started demanding that she wrote autonomously, with the help of technology. She learned how to use the computer and started to develop an interest for writing.

She uses the Windows Virtual Keyboard and a mini-mouse for writing, but she rarely does it, since she feels too slow to type using this tool. She can only click the mouse if it is in a reverse position, that is, with the buttons turned in her direction. That forces her do reversed, mirrored movements. For example, to move the cursor to the right, she has to move the mouse to the left.

4.1.3 Participant 3: Reserved David

Participant 3 has Muscular Dystrophy and is 22 years old. He can make only a few movements and cannot autonomously perform the activities he used to be able to perform, like feeding and maintaining personal hygiene. He finished elementary school and did not wish to study anymore, since he could not write even though he received a laptop from school. He did a computer course, but does not currently use the computer since if causes muscular fatigue, which he avoids, since his disease tends to progress faster when muscular fatigue occurs. His mother says she does not like to see him doing nothing and would like for him to go back to school or to talk to his friends on the Internet.

4.1.4 Participant 4: Active Joe

Participant 4 also has Muscular Dystrophy. He is 17 years old. He and Participant 3 are brothers, but he can move more. He uses a motorized chair to move around and uses the computer to participate in social networks. He can write and type with difficulty, but needs to stop when he feels muscular fatigue so as to avoid the progression of the disease. He is in the last year of high school and wishes to continue studying. In class, he writes on the notebook with difficulty until he feels too tired. When this happens, he is dismissed from the activities. Because of that, the school avoids giving him activities that demand the writing of long texts. He was not familiar with virtual keyboards.

4.1.5 Participant 5: Affectionate Timmy

Participant 5 is 13 years old and cannot move his body, with the exception of his little finger on the right hand and his eyes. He has lived with this condition of complete dependence since he was 2 years old. For breathing, the participant has a tracheostomy and mechanical ventilation through electromedical equipment. He is fed through a tube. For communicating, he babbles and is understood by his family.

Even though he never went to regular schools, he was alphabetized at home by a teacher from a special school, who does not teach him anymore. When he wants to write, he dictates or spells the words to his mother, but he does not do it frequently. His daily activities are limited to watching television or watching his younger brother play video-games, which he enjoys a lot, according to his mother, especially when his brother puts the Participant's hand on the joystick and pretends he is the one that is playing.

The family was not familiar with the tool "Letter Board" (Fig. 4), virtual keyboards and other assistive technology resources that could help the Participant to write.

Despite knowing that the Participant can move his little finger, the family was not familiar with any use for this biomove.

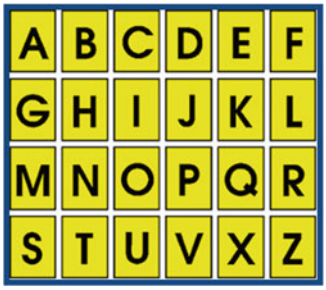


Fig. 4 Letter board. *Source*: Issue 06 (MEC/ Sartoretto and Bersch 2010) Description: a sheet with six columns and four lines of squares containing press letters set out alphabetically

4.2 Research Procedures and Validation

We met twice with each Participant individually, in their homes, to validate the Mousekey. On the first meeting we performed a semi-structured interview, trying to find information about the use of resources by the Participant and about the use of the technology we were proposing. After that, we explained the purpose of this technology. We showed the buttons and their functions and the methods for typing, that is, "Clicking," "Focusing" and "Tracking."

In a later moment of the same meeting, the participants explored the application in order to get used to it. At the same time, each one, according to their specific needs, found the best position and way for using the computer and the necessary computer devices.

After about 20 min of getting used to the application, we asked questions about the use of the Mousekey-UFRGS, based on the ergonomics and usability assessment protocol—not using it as a script, but as a guide to clarify factors that could not be perceived by direct observation.

When we perceived that the participant was having difficulty using the technology with complete autonomy, we made the necessary adjustments so this assistive technology was efficient for the needs of the participant. After the adjustments, we had the second meeting.

On the second meeting, the participants explored the Mousekey-UFRGS again. We then asked them to produce a text: a sentence or a paragraph.

The semi-structured interview allowed us to get to know the participants and their history regarding the act of writing, their use of strategies to overcome their difficulties, successful or not; it allowed us to know which resources did not work and what were the aspirations or hopes of the participants in relation to writing.

The direct and participant observation, along with the instruments for multiple recording in video, enabled us to observe how the participants used the computer, their tiredness or physical wearing, the facial expressions that expressed doubts, satisfaction, indecision, curiosity and other feelings and perceptions. The observation was fundamental for having an idea of the problems and positive aspects.

The ergonomic assessment protocol served as a guide for observing the participants, as a check-list for visualizing the performance condition during the tasks without interfering with the conditions of the participants, that is, its usability.

After collecting the qualitative data using the instruments and procedures described here, we started evaluating the operational competence of the participants (usability) and the functional competence of the tool (functionality). The goal was to identify points that emerge from the interaction of the participants with the technology we developed. Using Content Analysis as a method, we were able to categorize, describe and interpret—essential steps of this methodology.

5 Results

We created two categories by classifying the items according to meaning: (1) operational evaluation of the participant; (2) functional evaluation of the tool. Each of these categories was divided into subcategories.

5.1 Category 1: Operational Evaluation of the Participant

Regarding the ability to write without the use of a computer, only one of the participants (Participant 4) can still do it, but with great difficulty.

Although one of the subjects of the sample has motor capacity for writing with paper and pen, it was relevant to keep him in the research due to his great difficulty and to the fact that this motor skill is probably temporary, since the loss of his motor skills is progressive and tends to go faster with each episode of muscular fatigue.

Among the participants, three cannot use a regular computer keyboard and two can use it, but with great difficulty. The use does not correspond to their needs and expectations because of physical wearing and the long time they take to type (Chart 2).

Regarding the use of virtual keyboards, only Participant 2 used them, but none of the ones available fulfilled her expectations of typing faster and diminishing physical wearing.

As to writing activities in school, four participants said they were always dismissed from these activities, and one said he was dismissed from activities that demanded longer texts.

From the participants of this research, four reported episodes when they felt excluded from work or school activities because of their inability to write (Participant 1: at work; Participant 2: during a course; Participant 3: he did not wish to keep studying; Participant 5: never went to school). Only participant 4 did not relate any episodes like that, maybe because he can still write, even if with great difficulty.

Below we present the data collected in this research.

Chart 2 Ability to write without using a computer

Participant	Ability
Participant 1	Great difficulty
Participant 2	Cannot write
Participant 3	Cannot write
Participant 4	Great difficulty
Participant 5	Cannot write

Source: Author (2013)

5.1.1 Participant 1: Cooperative Julio

Participant 1, fictitiously presented as Cooperative Julio, was the participant with less motor limitations in this study. He performs his daily activities autonomously and was the only one from the group that could walk. He was accepted as part of the sample because of his curious[4] inability to write without using a computer and his exclusion from work because of it. He relates having tried to use many assistive technology resources, such as spider-spring, grip thickeners and others, but all without success. He did physical therapy, took medicines, but could never find a solution. Using a regular keyboard does not correspond to his expectations of being able to type faster.

The "name" Cooperative is because of his expectation of being able to take part in writing activities in school, going back to writing conference proceedings and reports in his old workplaces and in the church he goes to. He was very excited to use the application and "cooperate with the research," as he said.

Julio has basic knowledge of computers. He found it very easy to understand the initial instructions for the use of the application. He tried all the buttons and resources present in the Mousekey-UFRGS.

He did not take long to get used to the disposition and organization of the Keys in the application.

Julio:	Oh, it follows the same order as a keyboard, the syllables are easy to find … but here there's the cedilla, which I don't have in my computer, yeah, that's very good! But the numbers and these signs are like on your laptop, in my computer they are on the right.
Mediator:	And what did you think of it being like this?
Júlio:	Ah, it's easy, I'll get used to it very quickly.

Before actually starting the test, Julio adjusted the laptop on the table, keeping it slightly removed from him, with the mouse to the right. While he was using the tool, a few of the keys he clicked on did not work. This happened because the speed of the mouse cursor was too fast (too sensitive). Because of that, before he released his click on the mouse, the Windows had already interpreted a movement, and when that occurs the Windows cancels the click. The problem was solved by adjusting the speed of the mouse.

Julio only noticed some letters were missing after he had typed the whole word, because he was focusing on the cursor and the buttons. When he noticed his mistakes, he used the backspace button on the regular keyboard to erase the whole text until reaching the mistake. After testing the buttons for zooming in and out of the text, he commented that when the text looked bigger he could accompany the evolution of the typing.

Mediator:	you can use the backspace of the Mousekey.
Júlio:	Wow! That's true! Here it is! I just have to get used to it.

[4] Curious because even though it has been known for more than one century, no cure or treatment has been found for writer's cramp.

Julio started, then, to use the backspace button from the Mousekey-UFRGS, and started to click on the mistake for correcting it instead of erasing the whole text.

During his first attempts Julio used mainly the letters, but he quickly started to use the syllables. As an example, when typing the word "*testando*" ("testing," in Portuguese), Julio used: /t/, /e/, /s/, /t/, /a/, /n/, /do/. He used seven clicks.

Julio: Look at how distracted I am! I can use the syllables, but we're so used to typing each letter, right?! I have to get used to this facility.

Julio then erased the whole word and typed again as follows: /te/, /s/, /ta/, /n/, /do/. He used five clicks.

Julio: See! Way easier! How cool! I believe that if I get used to this I will be able to type conference proceedings again! If I weren't on vacation I could take my laptop to class and write texts!
Mediator: And how did you write the texts? Did you dictate them to someone?
Julio: No, I only talked about the subject. I didn't need to write anything, the teacher told me the important thing is to be able to argue about the subjects.

Julio tested all the options present in the Mousekey-UFRGS without the mediator telling him to do it. He said the zooming option was interesting, but he though the auto clicker was too slow. At this moment the auto clicker could not be made to go faster. Julio did not find the "tracking" method interesting.

The test was done again and Julio wrote using the syllables with great frequency. But when typing the word "*trabalho*" ("work," in Portuguese), he said:

Julio: There is no "lho", I can't write "trabalho".
Mediator: Click on /l/ and then /ho/.
Julio: Oh, sure! There should be syllables like "lha", "nho", like here, where "que" is ready. I also thought that /l/ was /i/. But if there are so many buttons they will be too far from each other. It's good like this, I just have to practice more.
Mediator: And do you think the distance between the letters is good, their size?
Julio: Yeah! It's good that the letters are big so I can find them quickly and know that the syllables with that letter are around it. And I can also increase the size of the letter in the text, so when you're typing you can see it.
Mediator: And do you think the size of the syllables is good?
Julio: I'm not wearing my glasses and I can see perfectly, yes, it's good!

On this second test the option of regulating the time of the "focusing" method was already available, but he preferred the option "clicking" for typing, saying that the time counter made him anxious.

When asked about his general perception regarding the Mousekey-UFRGS, Julio answered:

Julio: Very good! I think it can work. I'll be able to write again. If I practice, I believe I'll be able to write reports like I did before. Maybe I'll even be able to write conference proceedings. I'm already retired, but there are not a lot of people with my experience you know, and where I worked the doors are always opened for me.

About the use of the regular keyboard, Julio says he does not have the same expectation about it, since he makes many mistakes and writes too slow.

Chart 3 summarizes the results from the operational evaluation of participant 1 (Julio).

Chart 3 Operational evaluation of participant 1

	Participant 1
	Cooperative Julio
	Male, 67 years old
	Dystonia
	Cannot write without AT
Task	Results
Semi-structured interview	Inability to write without a computer
	Exclusion from work
	Desire to go back to work
Presentation of the tool	Facility to understand the initial instructions for using the application
Getting to know the application	He did not take long to get used to the layout and organization of the keys
Best position and way of using the computer	Laptop on the table, slightly removed from him with the mouse to the right
	Cursor speed set to medium
Typing of a free text	Some letters failed (problem solved by adjusting the speed of the cursor); At the beginning he used more letters, but quickly started using syllables
Ergonomic and usability assessment: perception of the participant	Adequate size and layout, speed, saves time
	Complained about the lack of digraphs
Adjustments for the application	Insertion of the option to adjust the speed of the auto clicker in the "focusing" mode

5.1.2 Participant 2: Playful Anna

Participant 2, introduced as Playful Anna, has many physical limitations and is completely dependent on other people for performing daily activities. She can make some movements with her hands, which allow her to use a mouse, but only in a reverse position. During her first years in school she already had difficulty writing, but with the progress of her disease her limitations became greater. She was always allowed to have help in school for taking notes, but at the university professors demanded she wrote autonomously.

Her expectations related to writing are to write poetry and Biblical studies, and to participate in social networks. She says that when she needs to write short words she uses the Windows Virtual Keyboard, but when there is the need to write longer words or texts, she needs to dictate them to someone, which does not make her comfortable.

The "name" Playful was given to her because of her sense of humor and the comic remarks she made while using the Mousekey-UFRGS, which showed she was satisfied with the new version of the application.

Anna found it easy to understand the initial instructions for using the Mousekey-UFRGS, since she used the original version for a while. This participant was

selected to be part of this research because she fit the inclusion criteria, but also because she found flaws in the original version of the Mousekey that led her to stop using that technology. Thus, this participant could compare both applications and say if the new implementations are valid.

When she was getting to know the application she already understood the arrangement and organization of the keys, but not of the changes and implementations. She did not take long to get used to the new configuration.

Anna cannot sit completely; she stays in a 45° position. Because of that, she prefers to place the laptop on her lap, with cushions for elevating it until her line of vision. While her career helped her, putting the equipment on her lap, Anna says:

> Anna: You know I can't get used to it, and it's not your problem it's mine, because I was alphabetized to use letters, right?! Not syllables, you understand?!

Despite making this comment, she was the participant that took less time to start using the syllables, certainly because she had already used this method.

When adjusting the laptop on her lap, she preferred to use the touchpad, although it was not the best way. This way, Anna took 34 s to write "love you," clicking on: /l/, /o/, /ve/, /space/, /yo/, /u/ (six clicks).

This shows that even though she said she was not used to typing using syllables, on her first attempt to use the Mousekey-UFRGS she did not use the syllable keys in only one occurrence, "lo," on the word "love." In later trials she used the syllable keys 100 % of the time.

Anna asked her career to get her mouse:

> Anna: Give me my mouse, get it. Let me see if it's faster with the mouse… put it in reverse… Oh! It's just like mine! (mini-mouse)

The mouse cursor was set to very fast (too sensitive). This way, Anna wrote "*Eu te amo*" ("I love you," in Portuguese) in 10 s, that is, in less than $1/3$ of the time it took before she clicked the same amount of times: /Shift/, /E/, /u/, /space/, /te/, /a/, /mo/.

In 70 s Anna wrote the sentence: "*Eu te amo Lucinho*! *Maninho chato*!" ("I love you Lucinho! My annoying brother!", in Portuguese) in 28 clicks. This is an average of 2.5 s per click. With the letter-by-letter keyboard, she would need 36 clicks and would take 90 s, that is, 33 % more time, with an effort of eight more clicks and movements.

Soon she started to ask about the "focusing" and "tracking" modes. When testing the "focusing" mode, she expressed joy and surprise.

> Anna: Aaah! so it can stop (the cursor) and not press (click)! And the thing appears all the time oooh!! Uuuuuh! This is great! I like it! Ah, focusing is great! But I don't have enough patience to wait for it.
> Mediator: But you can adjust it to go faster!
> Anna: Really?! Let me adjust it! I like it! Ok, and can't I, like, leave the two options, if I want to, I can click?
> Mediator: But you can do that, try it!
> Anna: This is great!

Anna, when she wanted to capitalize a letter, went straight to the shift button. This button was not necessary in the original version, because it had buttons with the capitalized letters, which were taken out of this version for aesthetic reasons. We were concerned about the fact that users might not like the fact that they need one more action to capitalize letters. However, Anna did not seem to miss the buttons; on the contrary, she found it interesting that she did not need to press shift again to let it go.

During the tests, she complained about the lack of digraphs.

Anna: Ugh, you didn't put the "n", "h" and "o" together.

When she clicked on a letter by mistake, Anna used the backspace button of the Mousekey-UFRGS and clicked on the mistake to correct it. This was not possible in the original version, but Anna used it intuitively, as if she was already aware of this possibility.

Anna did not wish to use the "tracking" mode. When asked about her general perception of the Mousekey-UFRGS, Anna answered "playfully," but truthfully[5]:

Anna: (laughs) Advertisement for the Mousekey, ok! (laughs) Alright then! (laughs) This new Mousekey is better than the old Mousekey because you can focus, you can click, and you can track! It's good that it doesn's track boyfriends, right?! (laughs) Once upon a time there was a virtual keyboard, a virtual keyboard where I got used to type by letter! It takes forever, but it works in the end. Then they made the Mousekey where you can type by syllable, but sometime, depending on the position I am sitting, I can't use it because I have to use the mouse. But the new Mousekey has the focusiiiiing mode! It's like a boyfriend: we focus, stop, look and it works! But with this one we can cliiiick and track! And that's it!

Chart 4 summarizes the results from the operational evaluation of participant 2 (Anna).

5.1.3 Participant 3: Reserved David

Identified as Reserved David, Participant 3 was the most inhibited from all the participants of the study. We needed to observe his facial expressions more attentively to infer his perceptions of the use of the application, since he did not talk much, even when we asked him questions. Due to the advanced stage of his disease, David cannot perform daily activities by himself. He cannot write anymore, even on his laptop. Because of that, he stopped going to school and does not wish to study anymore. David's mother says that typing on a regular keyboard requires too much effort from him, since he does not have much strength to move his hand, and too much effort accelerates the progress of his disease.

David wants to be able to write again, and write what he feels. Although his mother expects him to go back to school and to writing to his friends, David did not

[5] We opted to maintain her original speech, without cutting anything, for evidencing her peculiar way of showing satisfaction.

Chart 4 Operational evaluation of participant 2

	Participant 2
	Playful Anna
	Female, 31 years old
	Spinal muscular atrophy
	Cannot write without AT
Task	Results
Semi-structured interview	Wants to write poetry, Biblical studies, and participate in social networks
	Excluded from a course
	At the university she needed autonomy when writing
Presentation of the tool	Understood everything easily
Getting to know the application	Understood the arrangement and organization of the keys
	Got used to the configurations of the implementations quickly
Best position and way of using the computer	Sat in a 45° position
	Laptop on her lap, with cushions to elevate it to her line of vision
	Mouse cursor set to very fast (very sensitive)
Typing of a free text	Used 100 % of the syllable keys
Ergonomic and usability assessment: perception of the participant	Less time and effort
	Complained about the lack of digraphs
	Used new resources intuitively
	Like the focusing option: "focus, stop, look and it works!"
Adjustments for the application	No adjustments necessary

show the same expectations. It seemed to us that being able to write about his feelings and emotions was enough for him.

David has advanced computer knowledge, and had no problem understanding the initial instructions for the use of the Mousekey-UFRGS. While getting to know the application he got used to the arrangement of the keys very quickly, but he needed to adjust the mouse cursor to a slower speed.

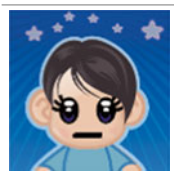
The best position for using the computer was putting it on a chair in front of his wheelchair. He needed help to put his hand on the mouse, which was placed on a board on his lap.

The participant spent a long time looking at the keys, thinking about what to write. So we suggested he should copy a paragraph from a book. When he started typing he showed fluency (he did not make mistakes), but not a lot of speed. He used all the possible syllable keys, effectively capitalized letters, and also used accents and punctuation marks. When he found facilities that are not present in regular keyboards, like the "*ão*" in "*não*" ("no," in Portuguese), his face showed satisfaction, with a little smile and slight movement of the brows.

He said that the Mousekey-UFRGS is better than regular keyboards because it does not make him tired. He said that he probably would not be able to hold the shift button while pressing other keys, that is, he has difficulty using more than one key simultaneously.

David tested the other typing modes, but preferred to focus on the "Focusing" mode. Initially he repeated the same key many times, because he kept the focus on the button even after having typed. The mediator explained that keeping the focus on the button is the same as keeping the keyboard key pressed. David soon understood and typed using this mode, using almost all the possible syllable keys. David's facial expressions and the time spent on it allows us to infer that he preferred the "Focusing" mode (Chart 5).

Chart 5 Operational evaluation of participant 3

	Participant 3
	Reserved David
	Male, 22 years old
	Muscular dystrophy
	Cannot write without AT
Task	Results
Semi-structured interview	Does not have strength to move his hands
	Too much effort accelerates the progress of the disease
	Wishes to be able to write his thoughts and feelings
Presentation of the tool	Understood the initial instructions easily
Getting to know the application	Got used to the arrangement of the keys very quickly
Best position and way of using the computer	Laptop on a chair in front of his wheelchair; A board on his lap for the mouse
	Mouse cursor set to a slower speed (less sensitive)
	Needed help to put his hand on the mouse
Typing of a free text	Did not know what to write
	Typing showed fluency but not much speed
	Used all the syllable keys
	Effectively used capital letters, accentuation and punctuation marks
Ergonomic and usability assessment: perception of the participant	It is not tiring
	It allows the use of functions that would require simultaneous keys
Adjustments for the application	No adjustments needed

5.1.4 Participant 4: Active Joe

Active Joe, Participant 4, is in high school and finds it difficult to write without the help of assistive technologies. This difficulty increases progressively as the disease evolves. The loss of his motor skills is inevitable due to his disease, and it happens faster when there is muscle fatigue. Thus, even though he can still write without the help of AT, he was accepted as part of the sample because of his great difficulty in writing and the need to avoid muscle fatigue when writing. Besides, his inclusion might be made easier if Joe knows how to use these tools when his physical disabilities are more severe.

In class, he writes until he feels tired; then he is dismissed from the activities. Because of that, the school does not give him assignments that demand the writing of long texts.

Joe seemed to be very active. He moved around the house in his motorized chair and says he wants to keep studying and have a profession. He feared the loss of the ability to write and says that now he knows his ability will last, because he will be able to write using a mouse.

This participant had basic computer knowledge and found it easy to understand the initial instructions about the Mousekey-UFRGS. When he was getting to know the application, he was easily familiarized with the arrangement of the keys.

The best way for him to use the application was by putting the notebook on a small table in front of his wheelchair. The mouse was to the right, and the cursor speed was set to medium.

When he started typing he used the letter by letter function a lot, but with speed and precision. He made some spelling mistakes, but no typos. He noticed the mistakes by himself and corrected them using the backspace and *del* buttons of the Mousekey-UFRGS.

As he used the application more, he started choosing the syllable keys, but his tendency was to look for the next letter as if he had not typed a syllable. For example, on the word "*barraco*" ("hut," in Portuguese), he clicked on /ba/, then took the cursor to /a/, but before clicking he realized he already had the "a" in "ba." After that he clicked twice on the /r/ button, resulting in "barr." When searching for the letter "a." he noticed he could have clicked on /ra/, and so he did, resulting in three "r": "barrra." He corrected it by clicking on the mistake and on backspace. To finish the word he clicked on /co/, "*barraco.*"

The participant tested the other typing modes, but did not spend much time on them; he preferred the "Clicking" mode.

Active Joe said he found the application to be very user-friendly and that, contrary from other writing forms, this did not make him tired. He said that when he got used to the syllables he would type even faster, especially when copying long texts in school. He said that now he felt more encouraged to go to the university and find a job (Chart 6).

Chart 6 Operational evaluation of participant 4

	Participant 4
	Active Joe
	Male, 17 years old
	Muscular dystrophy
	Has great difficulty when writing without AT
Task	Results
Semi-structured interview	Wants to avoid muscular fatigue when writing
	Wants to continue studying and get a job
	Will be able to write with the mouse
Presentation of the tool	Facility to understand the initial instructions for using the application
Getting to know the application	Got used to the arrangement of the keys very quickly
Best position and way of using the computer	Laptop on a small table in front of his wheelchair
	Mouse to the right, cursor speed set to medium
Typing of a free text	Used letter by letter typing a lot
	Showed a lot of speed and precision when clicking
	Used the buttons *backspace* and *del* of the Mousekey-UFRGS
	The more he used the application, the more he used the syllable keys
Ergonomic and usability assessment: perception of the participant	User friendly
	Not tiring
	Enables him to type more quickly
	Possibility of copying longer texts
Adjustments for the application	No adjustments were necessary

5.1.5 Participant 5: Affectionate Timmy

Participant 5, introduced as Affectionate Timmy, was the participant with more physical limitations in this study. He cannot move his body, except for the little finger on his right hand and his eyes. His electromedical equipment make moving him difficult; he is usually laying down. Timmy could never write before.

Both Timmy and his family had a lot of expectations for our visit, since they all wished that the boy could write, but could not imagine how it would be possible—according to them.

With the help of his mother, we found the best way and position for Timmy to use the computer. A pillow was put on his lap, with a tray on top of it as if it were a table; the laptop was elevated until it was on his line of vision. With the help of small cushions, his hand was placed on the touchpad. In this position, Timmy could use his little finger to move the cursor and even click.

The cursor speed was set to maximum (very sensitive) for taking advantage of the few movements Timmy could make with his little finger.

Since it was his first time using the application, Timmy needed some time to get used to the movement of the cursor. Timmy's happiness was mixed with that of his parents for the possibility of being able to move the cursor by himself. His father said, happily:

Timmy's Father: See, Timmy! Now you only need to learn motor coordination! Now your finger has an important function!

Timmy's Father told us:

Timmy's Father: he never used this finger for anything, it had no function. Now he need to learn motor coordination!

Timmy does not have any knowledge about computers, and it was hard for him to understand the initial instructions about using the application. However, he clicked on random letter and said "Look! Look!"

When he was asked to write his name, Timmy had difficulty finding the letters, and the mediator understood that he did not know the QWERTY arrangement of the keyboard. We then asked if it would be better to put it in alphabetical order, to which Timmy answered yes, that he knew the alphabet. At this moment this option was not available, so Timmy kept using the application.

The "Focusing" mode was easier for him, because he did not need to click so much. But, it had to be adjusted to a slow speed. In this mode Timmy could write his name, but without differentiating between capital and lower case letters, and choosing letters instead of syllables.

The scanning mode did not fit Timmy's need at the moment, since he could not press any keys on the regular keyboard.

After this moment, although Timmy and his family considered that the application met their needs, we made new adjustments to the application. A new possibility of choosing between QWERTY and Alphabetical order was inserted, and a Virtual Actuator was added so that Timmy could use the scanning mode if he wanted to. With the screenshots we noticed that when Timmy dragged the cursors it went back and forth, and the boy had to make many moves until the cursor reached the letter he wanted; we also noticed he had a lot of difficulty moving the cursor up and down, because the movements of his little finger are to the sides. Thus, we understood that the Tracking mode would benefit Timmy the most.

So, on the second meeting (1 week after the first one), Timmy was much more used to the Mousekey-UFRGS, because he used the application every day, according to his mother. His father said that during this time he attempted to use the HeadMouse with Timmy for simulating the use of the mouse while using the Mousekey-UFRGS. He said that it almost worked, but that they would need to build a table for placing the laptop right in front of the boy's face, and to adjust the configurations of the HeadMouse.

Timmy tested the Alphabetic layout and thought it was easier to find the letter, but it still took him a while. When asked about how the boy put words together, how he had

been taught to read and write, the mother said that they showed a word to Timmy and he spelled it. She said it was always that way, spelling letter by letter. We understood that Timmy had never had to find one letter among others, like in a moving alphabet or letter board. This is the reason why Timmy took so long to find the letters.

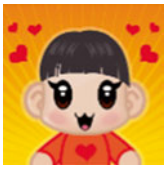
The boy used the Focusing mode and the alphabetical layout, where he started using a few syllable keys. He omitted a few letters, showing that he is still in the syllabic-alphabetical stage of alphabetization. Still, his writing process was compatible to that of a child in the third grade (9 years old).

For testing the Tracking mode, we took a paper letter board and taught him the letter scanning method, first with his parents, so they could help him. After Timmy and his parents had learned the method on the board, we went to the Mousekey-UFRGS. Soon Timmy understood the Tracking mode and compared it to a "writing game." He felt that this was the less tiring mode, but that he needs to practice.

Timmy was excited and affectionate during the whole time. He said he wished the researcher were his new teacher.

Timmy expects to write, play, study and use social networks with the Mousekey-UFRGS. He also wants to write a book. His family and the health team that cares for him say it brought Timmy new quality of life (Chart 7).

Chart 7 Operational evaluation of participant 5

	Participant 5
	Affectionate Timmy
	Male, 13 years old
	Spinal muscular atrophy
	Cannot write without AT
Task	Results
Semi-structured interview	Wants to write, play, study, use social networks and write a book
	Moves the little finger on his right hand
	Could never write before
Presentation of the tool	Difficulty in understanding the initial instructions for using the application
Getting to know the application	Timmy had difficulty locating the letters, since he was not familiar with QWERTY keyboards
Best position and way of using the computer	A pillow on his lap and a tray on top of it for improvising a table and elevating the laptop to his line of vision
	Timmy's hand over the touchpad with the help of small cushions
	Cursor speed set to maximum (very sensitive)
Typing of a free text	He wrote his name, but without differentiating between capital and lower case letters, and choosing letters instead of syllables
	Started using a few syllable keys
Ergonomic and usability assessment: perception of the participant	Enabled Timmy to write using only his little finger
Adjustments for the application	Layout option between QWERTY and Alphabetical
	Insertion of a Virtual Actuator for the Tracking mode

5.2 *Category 2: Functional Evaluation of the Tool*

The Mousekey-UFRGS prototype resulted in the interface showed on Fig. 2:

Syllables and second plan (Fig. 5):

Typing modes: "Clicking," "Focusing" and "Tracking" (Fig. 6).

Layout adjustment so the users can choose between the QWERTY and Alphabetical forms, according to their needs (Fig. 7):

We found that the Mousekey-UFRGS fits all the subcategories (Functionality, Usability and Accessibility). Fundamental factors for this were:

- The typing modes can be adjusted to the different needs of the users;
- The buttons and menus of the application worked as expected;
- It showed no evidence of problems when interacting with other applications and programs;
- It was easily understood, learned and used by the participants;
- It fits the POUR accessibility principles (Perceivable, Operable, Understandable and Robust).

As to the issues of Trustworthiness and Efficiency, it fulfills 80 % of the quality attributes. It was not difficult for it to maintain an adequate performance level, even

Fig. 5 Cutout from the letters. *Source*: Author (2013). Screenshot

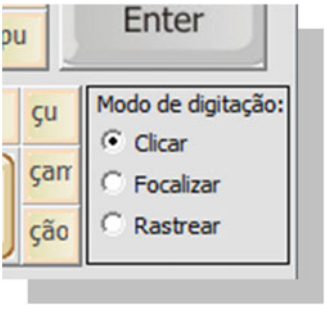


Fig. 6 Typing modes. *Source*: Author (2013). Screenshot

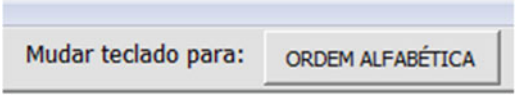


Fig. 7 Layout adjustment. *Source*: Author (2013). Screenshot

when used in multiple task conditions. But, it showed problems in the following factors: the texts written by the users are not recoverable if the system is shut off abruptly and they have not been saved previously; it fails to copy texts of more than 120,000 characters; it takes about 3 s to answer again when changing from the Alphabetical to the QWERTY layout.

The Mousekey-UFRGS fulfills 80 % of the quality attributes regarding Maintenance. It allows modifications for including corrections, improvements or software adaptations. However, the Mousekey-UFRGS is not a fail-proof application; it only tolerates them. Thus, it can be difficult to test it, and its stability may improve with the change of programming version from VB 6.0 to VB.Net.

As to Portability, it did not fulfill the attributes completely, since there was no evidence of the possibility for the Mousekey-UFRGS to be adapted to different operational systems, since it was developed for Windows.

Generally, for the aspects which are relevant to the research right now, the data show that the Mousekey-UFRGS meets the writing needs of the participants. It is Functional, Useful and Accessible.

5.3 Results from the Operational Evaluation of the Participants and Functional Evaluation of the Tool

It was possible to notice that both *allowing* and *facilitating* are important verbs that the Mousekey-UFRGS can give its users in relation to writing. *Allowing* or *speeding* the process of writing and *lessening physical wearing* were fundamental factors mentioned by the participants, not just because of comfort, but for maintaining their physical integrity, like in the cases of muscular dystrophy.

Writing was perceived by the participants as important for their social inclusion. Four of the participants said that not being able to write was their reason for not studying or working.

The statements from the participants of this study show that schools prefer to dismiss students from writing activities instead of helping them find other ways of writing.

The movements from the little finger of Participant 5 allowed him to use the Mousekey with a touchpad mouse. Thus, it becomes evident that the smallest biomove by an individual can be used for developing technologies that help them to perform social tasks. The “Focusing” mode of the Mousekey allowed Participant 2 to use the mouse in the correct position, since clicking is not necessary. This shows that finding the best position and way for the subject to use the resource, in this case, the computer, directly interferes in the production, time, and weariness of the user.

The expectations of the participants about writing were: to use social networks (2), to work (2), to write in school (3), to write for leisure—poetry, diaries, notes (4), to write long texts—proceedings, reports (4). These expectations show the desire these people have of participating in the community in a productive and effective way, with equality in opportunities and tasks, and not in a way that dismissed their potential.

The production of texts showed that the syllables on the Mousekey-UFRGS led the participants to rethink their writing processes for optimizing their time and effort. Thus, writing stopped being a merely mechanical activity and started demanding and developing higher psychological functions. In this sense, the writing *production* will be directly connected to the writing *construction*, to making and thinking. And, as any intellectual act, it will improve with practice. Like three participants from the research said: it is a question of getting used to it and practicing.

6 Final Considerations

Disabled people are subject to many aspects of the social understanding of their "being in the world," experiencing different views on their condition. Attitudes, beliefs, studies and research gave a new meaning to human life, independently from how it presents itself in an infinite set called diversity. But there is still a lot to resignify and eliminate from what remains from the historical understandings regarding that which is invariable: the value of life.

Facing that, much more than searching for an answer to a problem, or a solution for a social activity, what is important is a review of what it means to be "disabled" or "deficient." But, above all, it is important to reflect upon human potential, the strength of life and its desires and aspirations, and how temporary and unpredictable the word "impossible" can be.

But to achieve this dignity it is necessary to be conscious of your own value; only then will a person satisfy their human needs and achieve the necessary for their individual desires. That is why the area of knowledge called Assistive Technology (AT) is so valuable: it brought a set of resources and services that contribute for providing or broadening functional abilities to people with disabilities, with the goal of answering their desires and needs.

Each individual gives different meanings to their disability, and this meaning is not understood anymore by the presence or not of diseases or lesions, but by the degree of conservation of their functional abilities, which allow to live better with the disability and to have a more satisfactory life. Because of that, to presuppose quality of life depends on a subjective evaluation by the individual, which is connected to the impact of their state of their ability to live fully.

Another important thing to remember is that the lifestyle of a PWD is gradually built throughout their development as an individual, becoming, often, a learning process. In it are reflected the habits, customs, beliefs, values and knowledge of the individual, as well as their aspirations and hopes. To lead someone to believe that they can go beyond, taking them beyond, but making them believe that they cannot or do not need to go, makes them stagnant. That is why the individual's family, school and social context will directly influence how much they will learn to deal with their potential, using it for their own empowerment. Thus, excluding an individual from their work, their school, or simply exempting them from a writing activ-

ity, as was seen in this research, is far from focusing on the value of life or human potential; it only contributes for building a self-image of an individual who cannot overcome their own limitations.

Each day it becomes more necessary to think of the increasing life expectancy and of life in general, and to seek results from the decisions and desires from PWD to modify themselves and their context so as to obtain healthier and more sociable behaviors.

It is fundamental to notice, and this study has shown it, that it is the desire of these individuals to keep active with day-to-day activities and to reduce the impact of their disability on their daily roles, as well as to control the emotions related to their disability. Not to be able to perform these tasks leads the individual to a type of exclusion, be it real or only in their perception of belonging. Thus, among the day-to-day chores, in this research we focused on writing activities to guide the path to this reflections, each one with their expectation, each one with their needs, but all with one goal: to write. We chose this human activity because writing is an element from our social lives.

In this sense, we felt the need of studies for developing a tool, the Mousekey, which focused on the results of writing, but also on the process, and which offered minimal conditions so that the individual could develop their potential to its maximum, feeling productive and efficient. When able to write, people find their own value and have more space for communication and interaction, which will also result in a greater inclusion, be it social or digital, in school or at work.

In view of these reflections, we can report that it is in this way that a syllabic-alphabetic virtual keyboard can favor the writing process and inclusion of people with physical disabilities. That is, (a) enabling writing; (b) contributing to the perception of quality of life and adaptation to the disability; (c) reconstructing the self-image; and other affective and cognitive components.

As to the act of writing, it was demonstrated that the UFRGS-MouseKey enabled a decrease of time and effort, and increased textual productivity. As for the perception of quality of life and adaptation to disability, new hopes of working, studying and feeling active were evidenced.

As to the cognitive component, this study found the need for more studies and future reflections, since the Mousekey-UFRGS demonstrated that syllabic typing led the participants to rethink their way of writing and the way they learned to write. From this we can infer a metacognitive development and the development of higher mental structures. But these conclusions need more evidences.

Since we validated this technology with the help of PWD, we can say that the application was developed for them and with them. So we could consider the tool as validated, since the specific requirements were fulfilled.

As to the more relevant aspects for the research at this moment, the Mousekey-UFRGS proved to be Functional, Useful and Accessible. Facing this fact, we point to the need to continue this research and improve the software, for example, increasing Portability, since some users might not have access to computers that use Windows. In this sense, we want the Mousekey-UFRGS to be usable in different operational systems and online.

Since the Mousekey-UFRGS also seemed to encourage a reorganization of the knowledge for the construction of writing, this study can also be continued as a Learning Object in the alphabetization stage.

Finishing these reflections, we can say that developing an application that appears to be able to redirect working trajectories and help other people face concrete situations, we intended to write, or type: "P-O-S-S-I-B-L-E" in the histories of those who were probably impossible.

Acknowledgement We thank CAPES[6] and UFRGS[7] for the opportunity.

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[6] Coordination for the Improvement of Higher Level Personnel.

[7] Federal University of Rio Grande do Sul.