Designing and Supporting Cooperative and Ubiquitous Learning Systems for People with Special Needs

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Abstract. Cooperative work in schools helps students to learn behaviour norms, tolerate their partners and educators, and make decisions or accept the decisions from other people. In case of students with cognitive disabilities, cooperative work contributes to the socialization of the students by improving the communication and the integration in the classroom. New technologies foster guided and cooperative learning through didactic exercises and educational activities that adapt the educative context to user's needs and abilities. For this objective, the design must take into account non-funcional requirements for provide a future adaptation. This paper presents the design of one of such systems and the main decisions made in order to improve usability, adaptation, flexibility, and accessibility in ubiquitous spaces of it. The general architecture of the system and the platform that supports the development process of its software for educational activities are described in a real case study.

Keywords: Disability, Adaptation to User Impairments, Mobile Devices, Social Integration, Cooperative Learning, Adaptive Technologies.

1 Introduction

End users must be considered from the early phases of software development. The design of applications for users with (special) educative needs and/or cognitive, sensorial or mobility impairments must take into account non-functional requirements, such as accessibility, usability, flexibility and adaptability to be obtained from a deep analysis of the system.

Accessibility and usability policies call for the design of easy-to-use applications, ensuring that the users can interact with them and understand the tasks to be accomplished, and also the response of the system. Due to the fact that users may have different abilities, capacities and needs, tools must be flexible in order to adapt to different users. Configuration of applications allows their personalization in order to create customized applications for specific users from a generic design.

Regarding educative applications, students with special needs special have requirements of autonomy, communication, socialization and cognitive increase.

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Cooperative learning contributes to these aspects by providing [1][2]:

- Opportunities to do, to say and to feel.
- Self-regulation and group regulation.
- Models to be imitated: e.g. the educator and their classmates.
- Constant positive backing.
- Development of social, cognitive and affective abilities.

At a cognitive level, the main difficulties of these students are perception, memorization and attention [3]. Didactic exercises help to improve these aspects because they are the basis of learning. Several interactive environments such as learning and teaching tools have been developed, for example:

- VTech [4] has commercialized multiple products that combine entertaining electronic formats and engaging contents that help children learn. However, these products are not targeted at children with special needs.
- Clic [5] is an environment that allows the creation of individual activities, but it only runs on desktop computers.
- Some learning applications have been developed for the iPhone system: iWriteWords [6] teaches children handwriting while playing an entertaining game; Proloquo2Go [7] is a product that provides a communication solution for people who have speaking difficulties. These applications are designed for individual use only and they are not configurable.

None of the just mentioned systems propose an adaptive approach that takes into account professional directives in an educational context and user specific needs, neither provides mobility capabilities together with functionalities for cooperative work.

During the last years, we have been working on applications for users with special needs, in concrete the Sc@ut Project [8]. This project consists of a platform to create adapted, ubiquitous, augmentative and alternative communication systems for people with communication problems (Fig. 1).

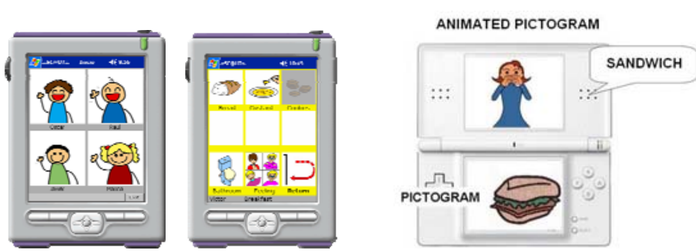

Fig. 1. Sc@ut Communicators for Pocket PC and NintendoDS

Based on this platform and on our experience in the requirements elicitation of this kind of users, we have devised a new platform to design educative applications for users with special needs [9]. The objective is to create individual and cooperative didactic exercises, which can be personalized at content and user interface levels through a design mainly centred on user requirements. Furthermore, in order to facilitate the participation of families and professionals during the learning process, we improve the ubiquity of the learning platform by enabling it to run in mobile devices, specifically the iPod touch and iPhone devices.

Section 2 shows the characteristics of the platform. The advantages provided by the selected mobile devices are described in Section 3. Section 4 presents conclusions and future work.

2 An Interactive, Cooperative and Ubiquitous Learning Platform

Our research aims to promote the set-up of mobile applications in order to complete the more traditional psychological and educational procedures by offering a platform to support the learning process in the classroom. For this aim, we have designed a platform called *pica*[2] (Interactive and Cooperative Platform to Support Learning). The objective is integrating in a single application features that allows children and experts (or teachers) to interact with different elements, according to the actions they will carry on and the educational approach (Fig. 2):

- Teachers or educators will be able to design personalized learning exercises for people with special needs and impairments.
- Students may perform the exercises cooperatively in order to increase their socialization and improving the learning process, and may do it anywhere thanks to use of mobile devices.

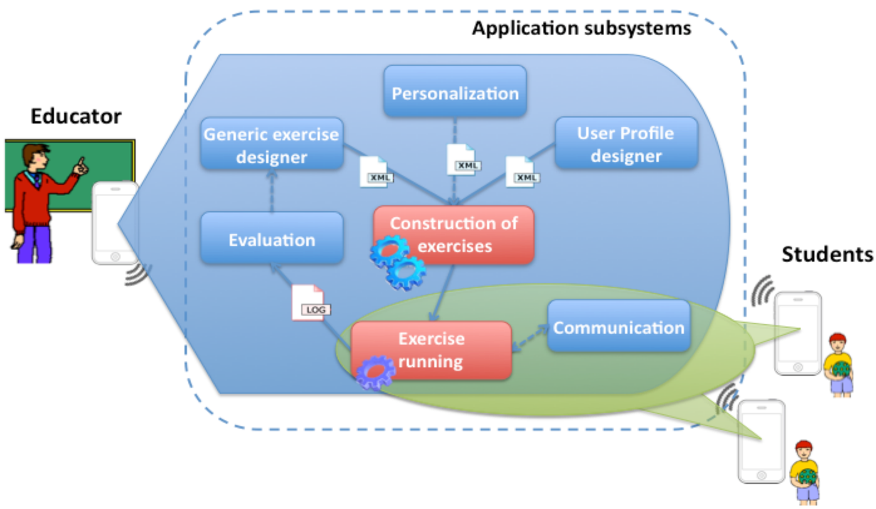

Fig. 2. System architecture

More innovating factors of the platform are:

- It is designed like a mobile platform, following an approach where activities run on entertainment mobile devices that turn out to be more attractive to users. Moreover, mobility gives the chance to new interaction alternatives with physical

objects and new mobile devices' accelerometer built-in lets systems to react to movements and rotations of devices, allowing innovative interactions.
- It provides support for group work, fostering integration and interaction with other students.
- It has the capability of user adaptation: learning activities must be sufficiently flexible to adapt to the characteristics of each user and integrate the personal data of his own world, respecting his own work pace, and can be modified by educators according to user progress or changes in his environment. User adaptation is based on the model obtained from the observation of user interactions, the knowledge of therapists and our previous experience developing software for people with special needs [4]. We have analysed which aspects from the activities can be personalized (at individual and group level) and designed the applications to support the adaptation to the users at run time.

Our approach aims to bring flexibility and adaptability in the education of children with special needs. Taking into account all previously mentioned requirements, we have devised a modular system architecture on the basis of a separation of concerns intended to facilitate the system design and implementation.

The subsystems of the platform are related to the process followed by educators to create exercises and the support of the execution. They are (see Fig. 2):

- User profile designer subsystem.
- Generic exercise designer subsystem.
- Personalization subsystem.
- Construction and use of exercises subsystem.
- Communication subsystem.
- Evaluation subsystem.

2.1 User Profile Designer

In order to make a design centred on the users, their impairments, abilities, skills and capabilities must be determined. Contents to be taught in the exercises, awareness information (for cooperative use), structure and user interface of the applications are adapted depending on such requirements in order to get accessible applications.

As each person is different, with limitations and needs at different levels, his/her singularities are to be considered by defining his/her user profile [10]. Table 1 shows which adaptations are necessary for different kinds of limitations (e.g., sensorial, cognitive or mobility impairment).

Educators and families must fill a template to determine what specific adaptations are necessary for each user. As a result of this process, a XML specification capturing the user profile is generated. The sample template in Table 1 shows an example that includes questions about colours, size, contrast and magnification of pictures to be used in the exercises and whether the use of subtitles is necessary. Educators may also choose the best interaction mode from several types available taking into account user

Table 1. Example of a user profile template

User limitations	Adaptations	Example of personalization required for a specific user profile
Visual	Colors, size, contrast, magnification. Do not use color as information	Multimedia: Exercises require big figures, without colour.
	Conversion of graphical information to text and use of synthesis of voice	
	User interface components accessible by means of mouse or keyboard	
Hearing	Alert sounds coded as text or graphic	Multimedia, Interaction: Reinforcement by means of gesture language.
	Adapted vocabulary	
	Use of subtitles and language of gestures	
Mobility	Adapted input and output devices	Interaction: User interaction must be tactile, without pen or stick.
	Alternative selection of components (alt-keys, voice as input, scrolling,…)	
	Time of scrolling, time for user selection, pace of the application	
Cognitive	Simple interface without distracting elements	Multimedia, Interaction: No more than 4 images in the screen to be selected. Multimedia: Images must be pictograms, no photos. Awareness: Use of a pictogram to advertise when is his turn during cooperative work
	Prioritary use of graphics	

mobility, cognitive level and sensorial capabilities. The educator decides, using the template, the characteristics that he/she thinks that are ideal for the user. If the exercises are tried but they do not meet user needs, the educator may use the template in order to perform changes in the user profile, and thereby adapting the exercise to the new profile.

2.2 Generic Exercise Designer

The platform allows defining three kinds of exercises to be performed by the users that we have chosen in order to cover the main learning task prompts [11]. These kinds of activities are:

- **Association:** the student must indicate relationships between elements (components) that belong to several sets. This activity covers *exploratory* task.
- **Puzzle:** a decomposed image must be rebuilt from multiple pieces (components). Number, size and shape of pieces can be configured. It covers *relational*, *cause and effect* and *interpretation* tasks.
- **Exploration:** navigation-based histories that let students learn concepts through the navigation of a hypermedia system with components (Fig. 3). This activity covers next learning tasks: *action*, *priority*, *extension* and *examine assumptions*.

Fig. 3. *Exploration* activity: touching an element causes it to be rendered in full screen size. Touching a second time or shaking the device an associated sound is reproduced.

Using a template, the educator must select a kind of exercise and determine some aspects of it: number of components or concepts to be taught, screen composition, screen position (rotation or not), multimedia used to represent the components, difficulty level (goals of the exercise, calculus of the punctuation), reinforcements and helps to the users. Additionally, some rules to be considered during the performing can be defined as, for instance, the order to be followed when selecting components.

If the learning exercises are going to be performed in a cooperative way, other characteristics must be specified (using a template to facilitate the task to the educator): the number of participants, the obligation or not of participation of all the users, if orderly turns are established or if the users can perform the exercise simultaneously, and the kind of awareness (context information) to be shown to the user. Goals and punctuation of the exercise when a group performs it must be also defined. The final result is a XML specification containing all of these aspects.

2.3 Personalization

This subsystem generates XML specifications that can be used by the construction subsystem to personalize specific exercises modifying:

- Multimedia, interaction and awareness (see example in Fig. 4).
- Aspects relative to the exercise: components, difficulty, reinforcements, etc.
- Characteristics of cooperation: participants, turns, etc.

Personalization allows the creation of customised applications for specific users.

2.4 Construction and Use of Exercises

From the generic exercises, specific exercises are constructed automatically, adapting the multimedia used, the interaction type and the awareness information to the user profile characteristics. Then, the personalization subsystem, varying some aspects more as we have seen above, can personalize the specific exercises.

Fig. 4. A same exercise running with different personalisation according to users needs

Fig. 4 shows two different versions of the same application generated for two different users from the same generic exercise. The exercise consists in associating animals with their natural environments. Differences between components, multimedia used and awareness information can be observed. For example, the application on the left hand side of Fig. 4 makes use of a landscape layout, while the one shown on the right hand side displays all the interface elements using the portrait mode. The interaction is also different: the first user must drop the animal component on its natural environment. The second one has limited mobility and is not able to displace his/her finger on the screen. He/she would only need to touch each component in order to associate one another. Backgrounds are also different to stimulate or not to distract the user. Awareness information about which users are playing and their punctuation is not shown to the second user in order to avoid he/she could head off and misinterpret it. Other differences are the multimedia used in the components (the first one needs pictograms instead of text because the user has difficulties to read), the number of concepts and the difficulty of the exercise, which are higher in the second one (perhaps because his/her cognitive level is higher).

2.5 Communication

Cooperative learning requires appropriated communication mechanisms that allow students to interchange information; and coordination services so as to support group work in a same activity. Establishment of sessions (Fig. 5) offers a useful way to allow users to cooperate with each other.

Peer-to-peer connectivity allows applications to create an ad-hoc Bluetooth or WiFi network between multiple mobile devices, providing ubiquity. Several copies of the application running on multiple devices may discover each other and exchange information, providing a simple and powerful way to perform activities in group.

Furthermore, context information as the user location, time or state of the exercise (e.g., punctuation, objectives reached, etc.) can be used to decide how the exercise may be performed. For example, the application could get the number of students that are in a specific classroom and synchronize them in order to cooperatively perform an appropriate exercise for that classroom and time-slot.

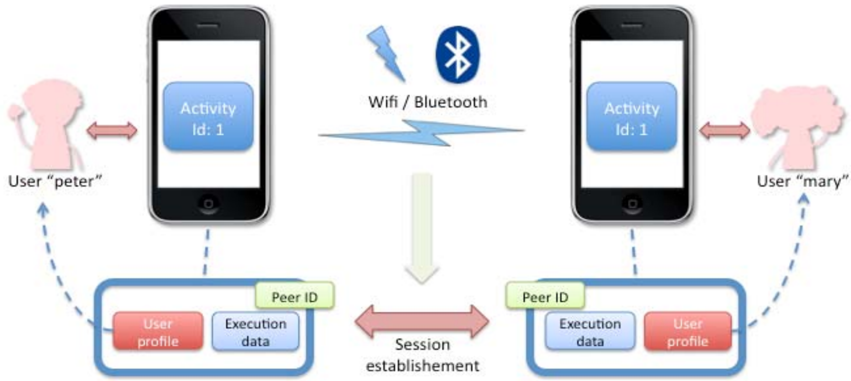

Fig. 5. WiFi or Bluetooth networking between applications

During the accomplishment of the task, information about students' actions is propagated so as to provide feed-through. Feed-through concerns implicit information delivered to several users reporting actions executed by one user [12]. A very simple way to generate feed-through consists in multiplexing feedback information to several users [13]. Feed-through (Fig. 6) is essential so as to provide group awareness and construct meaningful contexts for cooperation.

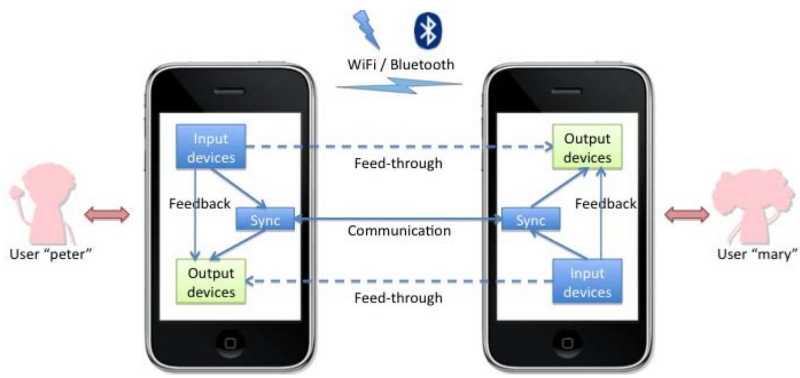

Fig. 6. Information flows while an activity is performed in group

2.6 Evaluation

This subsystem allows the log of user interactions with two purposes:

- Help the educator to evaluate the user progress along time or the accomplishment of an exercise at run time.
- Detecting automatically anomalous behaviours of the users. This can be used to adapt the applications to fit better to the users at run time or in future executions.

3 iPod Touch and iPhone Advantages

Apple's IPod touch and iPhone have been the selected devices for implementing the learning applications. Their main features are:

- *Mobility and desing*: they provide portability necessary. Using integrated GPS and digital compass it is possible to know spatial position and orientation and make decisions according to this context information. Besides, their minimalist design (include only a frontal button) makes user acceptation easier.
- *Touch screen*: the iPhone is the first fully finger-based (rather than stylus-based), multi-touch mobile. It has high quality responsiveness thanks to the incorporation of a capacitive touch screen and can detect interactions by means of gestures.
- *Interaction through motion*: a built-in accelerometer detects the movement when a user rotates device from portrait to landscape and changes the display accordingly. Rotations or shakes can also be interpreted like a user input.
- *Accessibility*: devices feature higher contrast function, zoom and a gesture-based screen reader.
- *Connectivity*: Peer-to-peer connectivity using Apple Bonjour Services [14] allows applications to create an ad-hoc Bluetooth or WiFi network in group.

4 Conclusions and Future Works

The use of mobile technologies and multimedia increases the interest of students, helping them to learn while they are entertaining. In the case of students with impairments, learning exercises must be individualized in order to meet their special needs. In this context, educators usually intervene during the learning process as qualified experts in order to foster the unfolding of their students' capabilities. Educators are to prepare the exercises to be carried out, personalize them, and supervise and guide students during their accomplishment.

With the objective of facilitating the use of the technology in class, we have designed a single application which runs in mobile devices and which is firstly used by the educators to create and modify exercises when they desire, and then, by the students to learn while carrying out such exercises. The mobility and connectivity functionalities of the devices to be used enable the cooperative achievement of the exercises in ubiquitous spaces, promoting the participation of the stakeholders in the learning process and the socialization of the students. We have selected a concrete device with recognized ease of use and accessibility required by this group of users and their educators, and supports communication and mobility.

An architecture composed of several subsystems has been proposed in order to separate these concerns and following different phases in the design and use of the application: User profile design, Generic exercise design, Personalization, Construction of exercises, Communication and Evaluation.

We are participating in a national project with several schools of Especial Education, which are collaborating with us. Their professionals are eliciting requirements that are being addressed in our specifications, design and prototypes. Prototypes allow functional and non-functional requirements to be specified, completed and validated. Up to now, we are obtaining encouraging results. We plan to finalize the implementation and undertake a study with a selected group of users the next year. This will allow the benefits of our platform to be evaluated and suggestions from families and professionals to be obtained in order to improve it.

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