CognitOS: A Student-Centric Working Environment for an Attention-Aware Intelligent Classroom

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Abstract. The emergence of Intelligent Classrooms, and in particular classrooms equipped with facilities for identifying the students' attention levels, has raised the need for appropriate student-friendly tools that not only facilitate application hosting, but also acts as the means to re-engage inattentive students in the educational process. This work presents CognitOS, a web-based working environment that hosts several types of applications (i.e., exercises, multimedia viewer, digital book) that are utilized as channels to present interventions dictated by the intelligent decision-making mechanisms of the attention-aware classroom. This paper presents the functionality of CognitOS and the design process followed for its development.

Keywords: Intelligent classroom · Educational interventions
Educational working environment

1 Introduction

Paying attention to an educational activity is often considered as a fundamental prerequisite of learning [1, 2]; students need to be focused and motivated in order to benefit the most during their journey towards knowledge [3]. However, maintaining a constant focus of attention inside a classroom for a long period of time is difficult, since distractions either by internal stimuli (e.g., thoughts and attempts to retrieve information from memory) or external stimuli (e.g., sounds) are quite frequent [4–6].

Literature suggests several strategies to regain student attention and increase the level of engagement in learning activities; among them, Active Learning was acknowledged as the most effective instructional method in terms of resetting the students' concentration and decreasing attention lapses during lectures [7–9]. Currently, there is minimum technological support available to assist educators in maximizing student engagement, even in technologically advanced classrooms.

Envisioning an Intelligent Classroom capable of identifying inattentive behaviors and properly reacting to re-motivate students, the LECTOR framework [10] utilizes

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ambient facilities to observe the students' actions, identify the individuals who show signs of inattention and undertake the necessary actions to restore their engagement by applying appropriate interventions. This work presents CognitOS, a sophisticated web-based working environment that hosts educational applications utilized as channels to present LECTOR interventions. In this context, interventions are intended as system-guided actions that subtly interrupt a course's flow so as to re-engage distracted, unmotivated or tired students in the educational process.

2 Related Work

Desktop Graphical User Interfaces (GUIs) assist the user in easily accessing and editing files, while encapsulating the underlying complexity of the operating system. In [11] it is suggested that students prefer physical environments over desktop environments, especially if they create a unified working environment for performing educational activities. To that end, many approaches simplify the desktop environment of existing operating systems so as to and make it simpler and more child-friendly (e.g., 'Edubuntu' [12] and 'Puppy Linux' [13]), or create safe sandboxed environments that provides children with educational content and combine entertainment and learning [14–18].

Compared to passive working environments, attention-aware systems have much to contribute to educational research and practice. These systems can influence the delivery of instructional materials, the acquisition of such materials from presentations (as a function of focused attention), the evaluation of student performance, and the assessment of learning methodologies (e.g., traditional teaching, active learning techniques) [2]. However, existing approaches [19–23] concentrate mainly on computer-driven educational activities or self-paced learning environments [24] for monitoring and supporting student engagement in learning activities.

Subsequently, despite the fact that many approaches have tried to create child-oriented desktop environments that provide educational content in a fun and engaging manner, currently there is no infrastructure that transforms them into reactive attention-aware ecosystems that monitor student behaviors in a real classroom setting and intervene by suggesting improvements for the learning process.

3 The Intelligent Classroom Behind CognitOS

A traditional classroom consists of the students' desks and a board placed at the center of the room. Moving towards a technologically enriched intelligent classroom, new computer-equipped artifacts replace the class board and students' desks, enhancing educational activities with the use of pervasive and mobile computing, sensor networks, artificial intelligence, multimedia computing, middleware and software agents [25].

CognitOS is deployed permanently on the technologically augmented desks residing in the in-vitro simulation spaces of an Intelligent Classroom located at the FORTH-ICS AmI Facility Building. Each desk features a 27-in. multitouch-enabled All-in-One PC which integrates various sensors (e.g., eye-tracker, camera, microphone, etc.) and cooperates with other students' personal devices (e.g., smartphone, tablet, smartwatch).

The software architecture (Fig. 1) of the Intelligent Classroom consists of the AmI-Solertis middleware infrastructure [26], which is responsible for (i) the collection, analysis and storage of the metadata regarding the environment's artifacts, (ii) their deployment, execution and monitoring in the AmI-Solertis-enabled systems to formulate a ubiquitous ecosystem. Additionally, LECTOR [10] is an extensible framework offering a versatile mechanism for identifying behaviors that require system actions (e.g., unmotivated student) and an extensible intervention mechanism for intervening when the users need help or support. These mechanisms follow the trigger-action model [27, 28], which has been in the spotlight as a form of programming Ambient Intelligence (AmI) environments, using simple "if then" rules. LECTOR's sophisticated authoring tool, named LECTORstudio [29], supports both developers and educators in creating rules that dictate the behavior of the classroom.

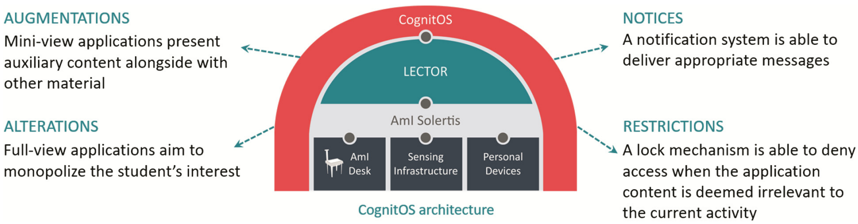

Fig. 1. CognitOS architecture and supported intervention types.

4 CognitOS as a Student Desktop

A desktop environment aims to offer an intuitive way for the user to interact with the computer using concepts similar to those used when interacting with the physical world, such as files and folders. In CognitOS, the Desktop constitutes the main working area – the base application – that covers the entire screen, manipulates the overall layout, prevents students from launching irrelevant applications and most importantly maintains and customizes the available educational applications and acts as the main control center that facilitates their execution (Fig. 2). The CognitOS desktop follows the metaphor of an actual desk containing virtual student items (e.g., books, pencils) that can be used to launch the respective applications. In more detail, the desktop contains: (i) a **pile of books** that offers a shortcut to the student's collection of books; the topmost book is related to the current course and through it the student can quickly launch the book application with the respective content, (ii) a **pile of notebook** pages that acts as a shortcut to student's collection of completed or pending assignments; the first page filters the assignments' list and displays only those related to the current course, (iii) the **personal card** that displays the student's name and provides access to the profile application with the detailed academic record of that student, and a **computer monitor** that can be used to launch the multimedia player.

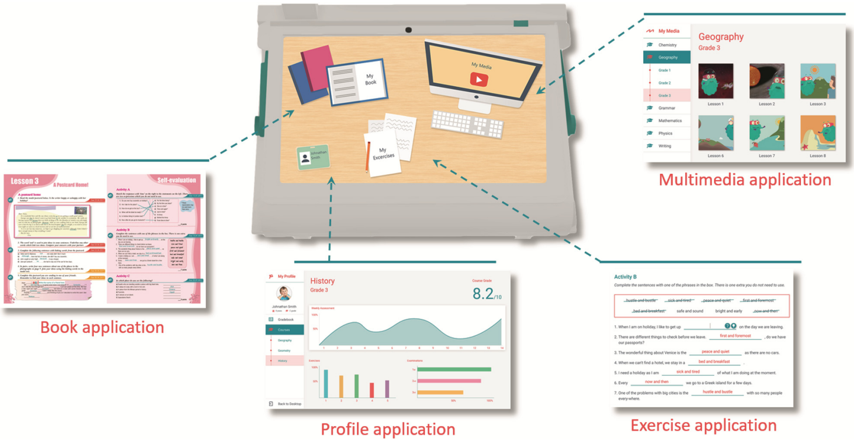

Fig. 2. Snapshots from the CognitOS applications.

A digital educational working environment should allow students to launch multiple applications simultaneously; therefore, it requires a mechanism that decides the placement of each newly launched application. To this end, a sophisticated algorithm was introduced ensuring that (i) if an application displays additional information related to another application, then they should always be launched next to each other, (ii) the application with which the user had interacted last will remain on top and (iii) secondary applications (e.g., calendar, calculator, etc.) will occupy less screen real-estate if more important ones are already or should be presented. Nevertheless, in addition to automatic layout, CognitOS permits the rearrangement of any launched applications so that each student can customize the environment according to his/her personal preference.

5 CognitOS as an Intervention Host

Apart from acting as a passive working environment that simply deals with application management, CognitOS has a more important role to fulfill. It is responsible for providing interventions to inattentive or unmotivated students so as to reengage them in the educational process. For example, a mini-quiz can be launched either explicitly by a student who selects a specific exercise on her book, or automatically when LECTOR intervenes to display a humorous quiz to keep her motivated in the reading assignment.

Literature review reports that several intervention techniques can prove to be beneficial in various situations occurring in an educational setting. Currently, two intervention techniques have been created in order to ensure active student participation in the main course (i.e., Active Learning). Particularly, the student desk is able to instantiate quizzes and multimedia presentations with appropriate content to keep students motivated. Furthermore, taking into consideration the fact that most students thrive in encouraging environments [30, 31] where they receive specific feedback, CognitOS is able to provide encouraging messages when deemed necessary.

CognitOS is able to present four types of interventions: (i) notices, (ii) augmentations, (iii) alterations and (iv) restrictions (Fig. 1). As soon as LECTOR plans a specific intervention, CognitOS receives a command via AmI-Solertis to launch the appropriate application(s). Particularly, an advanced notification mechanism is featured for delivering appropriate messages (e.g., notice) to the students who seem unmotivated, troubled or disengaged from the task at hand. Furthermore, CognitOS' applications (i.e., exercises, multimedia, book) can be launched on demand with specific content, so as to present motivating material. Each application is available in a mini- and a full-view; a mini-view is employed to present auxiliary content alongside with other material (i.e., augmentation), while full-view applications aim to monopolize the student's interest (i.e., alteration). Finally, they can get locked (i.e., restriction), denying access, when either the teacher or LECTOR deems them irrelevant to the current activity.

6 Design Process

Since CognitOS's philosophy evolves around the students' benefits, it was of foremost importance to concentrate on their needs, wants and limitations. In order to efficiently address this requirement the User-Centered Design (UCD) [32] approach was selected.

The users' characteristics and their tasks were analyzed through literature review and brainstorming sessions with a team of experts, which included members of various backgrounds, skills and perspectives (i.e., teachers, psychologists, designers, usability experts and developers). CognitOS focuses on students who have reached the formal operational stage [33]. At this stage, the children's thinking process is similar to that of adults, while their tastes and interests remain different. Consequently, students are able to apprehend – if not already familiar – abstract concepts (e.g., gestures, folders etc.) supported by computer systems. This is also a consequence of the fact that today's children are exposed from a very early age to a wide range of technologies, including multimedia systems, electronic toys and games, and communication devices.

According to [34], teenagers have much less research experience than adults, and therefore have more difficulty combing through and making sense of complex information. Furthermore, they tend to have less patience, thus they like getting answers quickly and dislike complicated interactions. Finally, as they are sensitive about their age, they prefer a clean and modest design, with visually meaningful icons and age-appropriate instructions easy to comprehend and remember [35], over a childish one.

Druin et al. [36] have found that children when using technology want to be in control, use technologies with others, and have at their disposal expressive tools. They pay attention to whether an application is "cool", easy to learn, appealing, and if multimedia is available. Regarding the latter, Said's studies [37] indicated that children (9–14 years old) become more engaged with multimedia when immediate feedback is provided, as well as when the environment allows them to be in control and set their own goals.

Socializing is another characteristic of children at this age; however, it is not limited to talking to classmates, but includes activities like sharing interesting resources with friends or collaborating to solve an exercise. Kaplan et al. [38] revealed that even though children (10–14 years old) may be co-present in the same space, they would like to be supported with tools to share their experiences with their friends and teachers.

Regarding student's goals and motives as drives for learning, several studies have taken place since the early 1960 [39–41]. Based on these studies, a list of tasks that the students should be able to perform was devised: (i) solve exercises of various types (e.g., multiple choice), (ii) get assistance on exercises, (iii) submit exercises that have been completed either during the lesson or at home, (iv) retrieve additional resources about something interesting or about an assignment dictated by the teacher, (v) have access to assistive applications (e.g., calculator, dictionary, etc.), (vi) have access to multimedia, (vii) maintain a personal area with access to history of homework, and (viii) collaborate with classmates to complete a task.

A scenario-based approach was adopted to further elaborate the characteristics of the aforementioned student tasks. Scenarios are really useful for providing realistic examples of how users carry out their tasks in a specified context. As soon as the developed scenarios were finalized, a series of interviews with children (5 children 11–15 years old) were conducted, in order to view them through the students' perspective. The children's opinions about the system during the interviews ranged from positive to enthusiastic. They were excited about the applications and the fact that they could share with the entire classroom interesting resources. Furthermore, the fact that they could work from their netbook appealed to them, as two of the children said: "studying would be much easier". Additionally, the interviews revealed that children enjoy playing educational and cooperative games both at school and at home, while they pointed out the importance of assistive applications, such as an organizer that displays homework or predefined exams, and a vocabulary that stores a list of words specified by the student for further studying.

In order to visualize plausible solutions, a set of prototypes were created and evaluated by children during a formative evaluation experiment. The goal of this experiment was to collect students' opinions about the functionality and applications supported by CognitOS. The results of this evaluation were taken into consideration during the development process in order to better meet the end users' needs. Once the development phase had advanced and interactive prototypes had been created, a heuristic evaluation was conducted, aiming to eliminate serious usability problems before proceeding to user testing. CognitOS was then improved according to the heuristic evaluation results. Finally, a full-scale user-based evaluation experiment is planned to be the next step of this work so as to acquire valuable feedback regarding the efficacy of CognitOS as an intervention mechanism and its acceptance by both students and educators.

7 Conclusions and Future Work

This work has presented CognitOS, a student-friendly web-based working environment for students that hosts a variety of educational applications. These applications also comprise the communication channel through which the attention-aware Intelligent Classroom presents interventions to students that need help or support. The formative and heuristic evaluation experiments revealed various usability issues which were incorporated in the current version of CognitOS. However, a full-scale user-based evaluation with students is being planned to fine-tune it before its final release.

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