Educator-Oriented Tools for Managing the Attention-Aware Intelligent Classroom

Evropi Stefanidi, Maria Korozi, Asterios Leonidis, Maria Doulgeraki, and Margherita Antona
Institute of Computer Science
Foundation for Research and Technology – Hellas (FORTH)
Heraklion, Crete, Greece
email: {evropi, korozi, leonidis, mdoulger, antona}@ics.forth.gr

***Abstract*—The emergence of Intelligent Classrooms and in particular classrooms that are equipped with appropriate infrastructure for identifying the students' attention levels, has raised the need for appropriate educator-friendly tools that facilitate monitoring and management of these educational environments. This paper presents two such systems: LECTORviewer and NotifEye. LECTORviewer is deployed on the educator's personal workstation and offers an overview of the students' attention levels. Additionally, through its intuitive user interface, educators can provide their input regarding ambiguous behaviors or scheduled interventions that aim to reengage distracted, tired or unmotivated students to the educational process. NotifEye is a smart watch application for educators that aims to communicate, in a mobile fashion, important events occurring during a lesson (e.g., 60% of students are tired). This work presents the functionality of these tools and the usability findings of a heuristic evaluation experiment conducted with UX experts for LECTORviewer.**

Keywords-Classroom management; intelligent classroom; monitoring student attention.

I. INTRODUCTION

The introduction of technology in the school environment has been associated with enhancing the students' performance and has encouraged several technology-driven curriculum renewal projects [1]. The rate of technological development is ever increasing, a fact that influenced the emergence of innovative approaches towards incorporation of Information and Communication Technologies (ICTs) in the classroom environment. Whereas once the overhead projector was considered a cutting-edge tool in the classroom [2], today the concept of the smart classroom is a reality [3].

According to researchers, technology can be used effectively as a cognitive tool as well as instructional media, and can be helpful in classroom settings by promoting inquiry, helping communication, constructing teaching products, and assisting students' self-expression [4]. Research in [2] shows that by combining Ambient Intelligence (AmI) technologies [5] with social and behavioral analysis inside a smart classroom, an active analysis of the effectiveness of the lecture can be conducted. Moreover, ICT can monitor learners' behavior during learning activities to improve the educational process, such as identifying whether a learner is paying attention to the lecture or not [6]. Student attention monitoring has been proven to lead to better student achievements [7] and a more pleasant and effective learning process.

Research has shown that live monitoring of a class is possible and beneficial, not only in the more obvious case of distant learning [6][8], where monitoring is deemed necessary, as the educator cannot rely on physical observation to perceive the status of the participants, but also in a physical classroom [8], as the large number of students hinders the educator's ability to quickly draw conclusions. The kind and extent of monitoring in each case naturally varies, but students' management is necessary in both cases, since the educator has to adjust and adapt the lesson according to the students' needs at any given moment. Nevertheless, this is a cumbersome task for the educator to perform while pursuing specific educational goals in the short time frame of a lesson period. Technology can automate trivial monitoring and managing tasks, and present appropriate information to the educator either during classroom downtime (e.g., quiz, problem-solving, essay writing), or after class as a reflection on the overall process. Moreover, it has the ability to collect information from multiple visible and invisible sources, that can not only reveal problematic behaviors that the educator missed to detect (e.g., mind wandering), but most importantly provide indications about the reasons of inattention; the latter is especially important in classrooms with a large number of students, where the educator cannot focus on every student.

In such settings, educator-friendly tools, which aim to help educators in managing and monitoring the attention-aware smart classrooms effectively, are necessary. This paper presents LECTORviewer and NotifEye, which equip educators with intuitive interfaces for performing the necessary managing tasks. Their functionalities include monitoring student attention levels and applying targeted interventions to distracted, tired or unmotivated students in order to reengage them in the educational process.

Regarding the structure of this paper, in Section 2, related work is discussed, while Section 3 presents the requirements that guided the design and development process. Section 4 describes the features of the in-vitro Intelligent Classroom that currently hosts these systems, while Sections 4 and 5 focus on LECTORviewer and NotifEye respectively. Finally, the findings of a preliminary heuristic evaluation are analyzed in Section 6, while conclusions and plans for further improvements are described in Section 7.

II. RELATED WORK

The ability to handle disruptive student behaviors in a classroom is a critical factor in any educational setting and greatly affects the overall learning process [9]. Effective and efficient classroom management and active monitoring of student progress and attention have been long since identified as key instructional factors, with significant relationships to positive student achievement outcomes [7]. Equipping educators with context-aware visualization tools [8] allows to

 ISBN: 978-1-61208-619-4

quickly detect problems stemming from inattentive behaviors and identify their causes.

Towards addressing inattention, class monitoring is augmented with attention-aware artifacts embedded in the physical environment that observe relevant parameters and report their findings [10]. Upon inattention detection, targeted interventions are delivered to the inattentive students [11]. Such instructional interventions have been proven to both re-engage students in the learning process and promote self-monitoring and self-regulation [12]. Specifically, in educational contexts, interventions positively influence the students' performance, independent of their educational background or their learning abilities [13].

Various Graphical User Interface (GUI) applications have been developed which simplify classroom management activities, such as teacher-student communication [14], management of learning assets [15][16], distant learning [17], real-time activity monitoring [18], and on-the-fly creation of educational software [19]. These applications utilize the data resulting from monitoring and management of the classroom in order to produce appropriate visualizations that the educator can explore so as to reflect and improve lecturing.

Classroom monitoring has been the focus of multiple research attempts. Intelligent Tutoring Systems (ITS) [20] monitor and assess learners' affective and cognitive state. Their potential to influence learning is greatly enhanced by the tutor's ability to accurately assess the student's state in real-time and then use this state as a basis to provide timely feedback or alter the instructional content. Thus, tailored and personalized educational experiences can be provided through monitoring student interactions in real-time and adapting learning events to the individual. In [21], the emotional state of the user is monitored via sensors that measure physiological signals (i.e., Electrocardiogram (ECG) and Galvanic skin response (GSR)) and appropriate interventions are provided when necessary.

In [22], a monitoring instrument to assess students' perceptions of their learning environments was developed and validated. The purpose was to assist teachers, teacher educators and researchers to monitor and guide changes towards outcome-based classroom learning environments. Biofeedback methodology is used in [23], to investigate interactions among learners' affective states, metacognitive processes, and learning outcomes during multimedia learning. The developed model emphasizes cognitive processes and metacognitive monitoring and control.

It is therefore obvious that the advancement of technology has allowed various monitoring techniques to be developed. Although quite a lot of research has been conducted on monitoring the classroom with respect to student interactions, physiological variables, and physiological signals in real-time [24], there is a lack of research and development of tools for educators that can monitor attention and take appropriate actions in the classroom setting.

III. REQUIREMENTS

This Section presents the requirements for both LECTORviewer and NotifEye, which have been collected through an extensive literature review and an iterative elicitation process based on multiple collection methods, including brainstorming, focus groups, observation and scenario building.

R1. Real-time Classroom Monitoring: The system should permit real-time behavior monitoring of individual students and the entire classroom.
R2. Intervention Management: When interventions are about to start, educators should be able to cancel, postpone or easily configure them.
R3. Educator's Control over the System: The educator should always have full control of the system and be able to turn on or off the monitoring and intervention mechanisms (either for the entire classroom of for specific individuals).
R4. Educator's Input: The educator should be able to (i) disapprove system decisions regarding identified behaviors, (ii) disambiguate behaviors (e.g., thinking vs. mind wandering), and (iii) override system suggestions in case they do not serve the students' needs.
R5. System Analytics regarding Intervention- and Attention- related Data: Statistics and data about the overall operation should be visible, such as attention and inattention percentage, total times that an intervention was initiated, and success rates of interventions.
R6. Full Overview of System's Decisions: The educator should have access to the detailed log of events that occurred during the lesson time.
R7. Reduce Educator's cognitive Load: The UI should be educator-friendly so that the teaching activities are not burdened by cumbersome interfaces. Furthermore, there should be alternative representations of the same information to serve different situations.
R8. Do not hinder the lecture: The acquired information should be presented in a subtle, yet effective, manner.

All these requirements are realized by LECTORviewer and NotifEye, which aim to support educators in their daily activities within the attention aware intelligent classroom.

IV. THE INTELLIGENT CLASSROOM

The systems presented in this paper are employed in-vitro inside a technologically augmented classroom, where educational activities are enhanced with the use of pervasive and mobile computing, sensor networks, artificial intelligence, multimedia computing, middleware and agent-based software [25]-[27]. In more detail, the hardware infrastructure includes both commercial and custom-made artifacts, which are embedded in traditional classroom equipment and furniture. In particular, the classroom contains: (i) a commercial touch sensitive interactive whiteboard, (ii) technologically augmented student desks [27] that integrate various sensors (e.g., Kinect, eye-tracker, camera, microphone.), (iii) a personal workstation and a smart watch for the educator, as well as (iv) various ambient facilities appropriate for monitoring the overall environment and the learners' actions (e.g., microphones, user-tracking devices).

The Intelligent Classroom relies on the AmI-Solertis middleware infrastructure [28] that facilitates: (i) the deployment, execution and monitoring of the various artifacts in the classroom, (ii) their encapsulation in an interoperable ubiquitous ecosystem and (iii) the collection, analysis and storage of environment-related data.

A sophisticated framework, named LECTOR [29], is responsible for identifying inattentive behaviors and intervening to re-engage distracted, tired or unmotivated students to the educational process. Specifically, LECTOR observes the students' actions (SENSE), identifies the individuals who show signs of inattention (THINK) and consequently undertakes the necessary actions to restore their engagement by applying appropriate interventions (ACT). Actually, interventions are applications running on private (e.g., student's desk, teacher's watch) or public (e.g., classroom board) hosts, instantiated at a key point in time with appropriate content. Currently, LECTOR features two types of interventions, namely quizzes and multimedia presentations that aim to ensure active student participation in the main course. Furthermore, taking into consideration the fact that most students thrive in encouraging environments, their private artifacts are equipped with a messaging mechanism able to provide encouraging messages when deemed necessary. The same mechanism is employed on the teacher's smart watch in order to display subtle messages suggesting changes in the lecture format (e.g. recapitulation of the lecture topics, initiation of a discussion relevant to the current course, repetition of specific material, etc.).

However, LECTOR would be ineffective without exploiting the expertise of educators. To this end, two interconnected tools are introduced, namely LECTORviewer [6] and NotifEye; the former provides an overview of the students' attention levels and asks the educator's opinion regarding ambiguous behaviors or scheduled interventions, while the latter provides notifications regarding important events occurring during the lesson time and can serve as an input to the former. The architecture of the intelligent classroom is depicted in Figure 1.

V. LECTORVIEWER

LECTORviewer is a web-based tool for managing the attention-aware intelligent classroom. It is deployed on the educator's personal workstation and allows the observation and customization of LECTOR's decisions regarding either individual students or the classroom as a whole. In more detail, LECTORviewer offers the following:

- One-click enabling or disabling of the LECTOR's monitoring facility.
- One-click enabling or disabling of the LECTOR's intervention mechanism.
- An overview of the attention level of the entire classroom that also facilitates focusing on particular students.
- A mechanism that asks the educator's opinion regarding ambiguous student behaviors.
- A mechanism that gives educators control over approving or dismissing an intervention.

These functionalities are provided through an intuitive user interface which mainly consists of (i) a main dashboard that displays information regarding all the classes an educator teaches, and (ii) the representations of each class (i.e., class view) containing details about its students, displayed either in a seating chart layout or a list view.

All the classes that an educator teaches can be found in a sortable list on the main dashboard, where valuable information is available to the educator: (i) the schedule of the class (e.g., the assignments that are close to a deadline), (ii) reminders of important events (e.g., scheduled exam), (iii) details about the fluctuation of the attention levels during the last lesson, and (iv) number of successful interventions. This type of information not only helps educators to have an overview of the class and better organize future lessons, but also to judge the efficiency and quality of past lessons based on the students' attention levels. Moreover, by viewing the statistics about the effectiveness of past interventions, educators can acquire an understanding of the kind of interventions that are appropriate for a specific class or student, and therefore more effectively choose and manage interventions in the future.

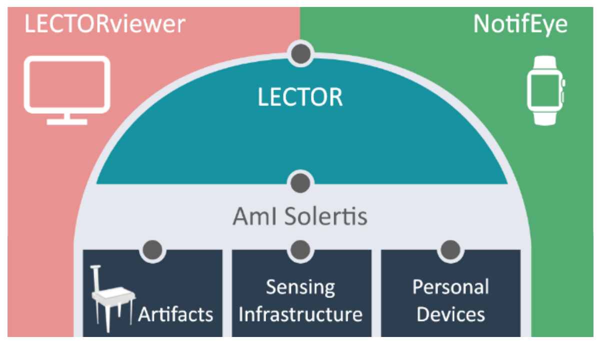

Figure 1. The architecture of the intelligent classroom.

During a lesson, through LECTORviewer's class view, the educator can get insights regarding students that are not paying attention due to factors like fatigue, mind wandering, or lack of motivation. However, in some cases, the ability to disambiguate student activities depends on information that only a human can provide. For instance, students laughing at a teacher's joke is not an indicator of inattention. To that end, when the system identifies a behavior that can be misinterpreted, it asks for the educator's opinion. These three states (i.e., attentive, not attentive and needs revision) are coded with appropriate colors (i.e., green, red and orange) which are used throughout the user interface so as to help educators easily distinguish the current status of the students.

At the top of the "class view" (see Figure 2a), the educator can see at a glance the attention percentage of the classroom as a whole. A pie chart, located at the top left of the page, uses the aforementioned colors to display the percentage of attentive or inattentive behaviors, and situations that require revision. At the center of the chart, the percentage of attentive students is displayed using bold and large fonts so as to ensure that the educator will be able to see it even from a distance. Furthermore, the legends of the chart can be used as filters that modify its contents, thus enabling educators to customize it according to their needs. The representation as a pie chart was

 ISBN: 978-1-61208-619-4

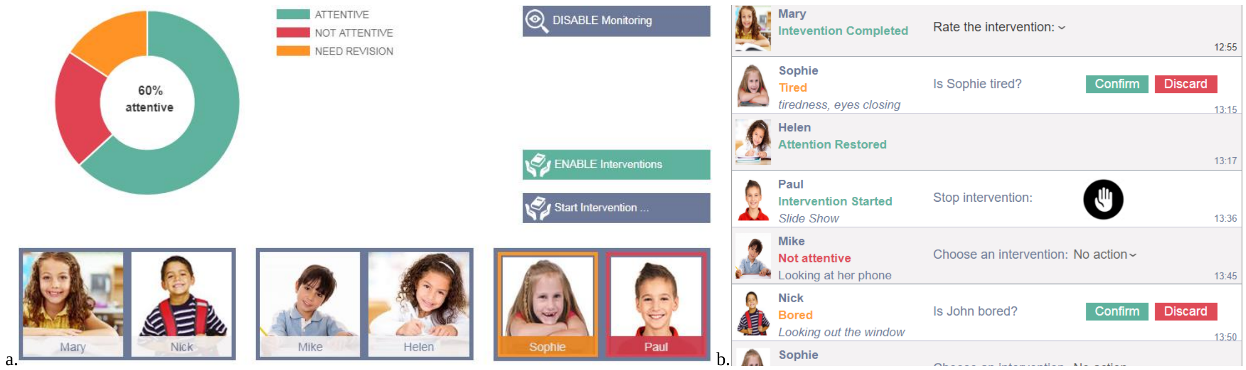

Figure 2. Snapshots of LECTORviewer's (a) class-view and (b) detailed log.

considered as the most appropriate alternative to communicate this type of information to educators by displaying all the data simultaneously; that is because a person's visual system needs less time to understand graphs (rather than tables), which give numbers shape and form [30].

In addition, in order to ensure that educators can freely activate or deactivate the monitoring and intervention mechanisms according to the class's needs, the top of the page contains the appropriate controls so as to be easily accessible. This functionality is important for an environment full of students where unforeseen situations can emerge; for example, the educator could observe that interventions are not effective or disrupt the course's flow at a given moment, and may wish to stop the system from making suggestions. Apart from merely (de)activating interventions, educators can select to start a specific intervention when deemed necessary. The latter ensures that educators do not rely on the system's decisions alone; on the contrary, they can initiate custom interventions in case the system (i) fails to identify that the students require remedial actions, or (ii) suggests an inappropriate one.

Apart from managing the classroom as a whole, the educators can focus on individual students as well. In more detail, there are two alternative layouts available for browsing through the classroom students and observing their status. By default, a "seating chart" layout is displayed, where students are represented in a form that resembles their actual seating arrangements, while the educator can easily switch to a "list view" layout, with a rich sorting functionality (e.g., alphabetical order, attention level order). For each student, LECTORviewer displays useful information regarding their status, as well as the likely reason a student is inattentive.

When the list view of the class is enabled, more functionality regarding each individual student is displayed. For each student, additional information is available, such as details regarding their learning style, attention level, and the reason that led the system to identify that they have lost focus, if that is the case. Furthermore, in order to provide enough context to the educator, in case of inattention or behaviors that need revision, relevant tags that reveal the reason are available. An indicative tag is "Mobile", which is used to annotate the behavior of students who are not paying attention because they are looking at their smartphones. Finally, next to each student the educator can find the appropriate controls for enabling or disabling LECTOR's monitoring and intervention mechanisms for that individual. This is required in a class that is constituted of different students with varying backgrounds, personalities, behaviors, needs and learning patterns [31].

Additionally, a detailed log (see Figure 2b) is available for each classroom that allows educators to revisit –even at a later time– LECTOR's decisions and mark them as accurate or not. A mini view of the log is always available at the sidebar of the "class view", enabling educators to observe in real time LECTOR's decisions without navigating to a new page. However, if needed, the educator can select to view the entire attention log, through which they can (i) confirm or invalidate an identified student behavior, (ii) stop an active intervention and optionally replace it with another one, and (iii) rate elapsed interventions. Providing such information is really important for "calibrating" LECTOR to a specific classroom environment and its students, since this process makes the decision-making mechanisms more accurate and less prone to false positives. This is a cumbersome task, which requires recalling various incidents that occurred during a significant amount of time. In order to minimize the amount of information someone has to remember, LECTORviewer's log is equipped with a sophisticated filtering mechanism, while each log entry is accompanied with abundant contextual information (e.g., timestamp, teacher's activity at the time).

Finally, on the top right of the screen, important upcoming activities concerning the current lesson are visible. This enables the educator to have a quick overview of tasks that are time-critical, thus giving the opportunity to better organize activities, while also serving as a reminder. Icons visible next to each upcoming activity aid the fast recognition of the activity with just a quick glance.

VI. NotifEye

NotifEye (see Figure 3) is a smart watch application able to provide subtle interventions to educators. Employing such wearable devices to act as intervention hosts seemed natural, since in addition to indicating time they: (i) are increasingly available in the market, (ii) support notifications and reminders, and (iii) are appropriate for private interventions.

To this end, NotifEye can be used to provide informative interventions regarding important incidents that occur during a lesson. In more detail, the application is able to display messages dictated by LECTOR, while at the same time the watch vibrates to alert the user. For example, when the entire classroom displays signs of inattention, NotifEye is instructed to deliver the short yet meaningful message "CLASSROOM TIRED", accompanied with an exclamation mark icon. The use of self-explanatory icons that require little effort to see and understand was imperative for an application running on a wearable small-screen device whose target audience must not be distracted from its main task (i.e., teaching tasks).

Figure 3. Snapshot of NotifEye.

Furthermore, apart from delivering notifications, the educator's smart watch is used as an input device through which useful information to LECTOR can be communicated. Specifically, when a class-wide intervention is about to start, NotifEye displays a message asking for approval; in case the educator rejects it, LECTOR is notified so as to increase the cancelation percentage of the selected intervention accordingly.

VII. PRELIMINARY EVALUATION

An iterative design process was followed throughout the development lifecycle of LECTORviewer and NotifEye. The first phase involved the creation of low fidelity paper prototypes exhibiting the entire functionality of the system. These were initially assessed by three (3) Human Computer Interaction experts during a cognitive walkthrough evaluation experiment in order to uncover any usability errors [6].

In the case of NotifEye, no important problems were identified. On the contrary, the evaluation of LECTORviewer revealed some issues related to the complexity of the most frequently used screens, and secondly to the metaphors used in the design, suggesting their refinement in order to simplify the interaction paradigm used to execute time-critical or common functions expected to occur on a daily basis. Subsequently, an improved vertical high fidelity interactive prototype [32] was created integrating the feedback received and was re-assessed by five (5) UX experts via heuristic evaluation [33] in order to test the overall usability and address any problems before conducting a full-scale user-based evaluation with the target audience (i.e., educators).

The problems identified through that experiment where ranked according to their severity by the evaluators. The severity ratings range from zero ("not a usability problem") to four ("Usability catastrophe") [33][32][31][30][29][33] and are used to indicate how serious each problem is and how important is to fix it. Next, the development team ranked each problem with an ease-of-fix ranking ranging from zero ("would be extremely easy to fix") to three ("would be difficult to fix") to designate the amount of effort needed to address it. This process revealed 16 usability issues out of which 2 were ranked as cosmetic problems only, 7 were identified as minor usability problems, and the remaining 7 were ranked as major issues, hence the most important to fix. Major and minor issues have been prioritized in the list below, with the most severe and hardest to fix problems listed first.

Priority 3

- The extra information that is provided in the list view should also be available in the seating chart view (ease-of-fix 1)
- There should be a summary log for each class, containing diagrams that display how many interventions have been done during a lesson, and the success rate of interventions (ease-of-fix 1)
- It was not clear that the pie chart of attention had filters (ease-of-fix 0)
- The percentages of the pie chart should be immediately visible without having to hover over them (ease-of-fix 0)
- The focus of the main screen should be the students, everything else is of secondary importance. The pie chart and buttons in the upper part of the screen is of secondary importance and should be located elsewhere (ease-of-fix 0)
- There should be a way to see in which mode I am viewing the class: while the lesson is taking place, or not? (ease-of-fix 0)

Priority 2

- There should not be paging in the log for the same day, for each day there should be infinite scrolling (ease-of-fix 1)
- Instead of the label "need revision" the label "uncertain" should be used (ease-of-fix 0)
- In the seating chart layout, there should also be an indication of where the educator's desk is located, for orientation purposes (ease-of-fix 0)
- Current time should be visible somewhere on the interface (ease-of-fix 0)
- The messages displaying the status of a student should be clearer (ease-of-fix 0)
- It is not clear that the orange color represents the state that the educator must revise the system's decision (ease-of-fix 0)
- It is not clear that the STOP hand icon stops an active intervention (ease-of-fix 0)

According to the above list, fixing the identified issues requires minimum effort on behalf of the developers.

 ISBN: 978-1-61208-619-4

VIII. CONCLUSIONS AND FUTURE WORK

This paper has presented the educator-friendly tools LECTORviewer and NotifEye, which aim to assist educators in monitoring and managing the attention-aware intelligent classroom. In particular, LECTORviewer provides an overview of the students' attention levels and asks the educator's opinion on ambiguous behaviors or automatically initiated interventions, while NotifEye aims to bring to her knowledge important events occurring during the lesson time. The heuristic evaluation of LECTORviewer, conducted with UX experts, revealed various usability issues, which will be incorporated in the next version, to be used to conduct a full-scale user-based evaluation of the tool with the targeted end-users (i.e., educators) to fine-tune it before its final release. Similar evaluation experiments are being planned for NotifEye.

ACKNOWLEDGMENT

This work is supported by the FORTH-ICS internal RTD Programme 'Ambient Intelligence and Smart Environments'.

REFERENCES

[1] C. Moersch, "Levels of technology implementation (LoTi): A framework for measuring classroom technology use," Learn. Lead. Technol., vol. 23, pp. 40–40, 1995.

[2] M. M. Groves and P. C. Zemel, "Instructional technology adoption in higher education: An action research case study," Int. J. Instr. Media, vol. 27, no. 1, p. 57, 2000.

[3] D. C. Niemeyer, Hard facts on smart classroom design: Ideas, guidelines, and layouts. Rowman & Littlefield, 2003.

[4] Y. Baek, J. Jung, and B. Kim, "What makes teachers use technology in the classroom? Exploring the factors affecting facilitation of technology with a Korean sample," Comput. Educ., vol. 50, no. 1, pp. 224–234, 2008.

[5] D. J. Cook, J. C. Augusto, and V. R. Jakkula, "Ambient intelligence: Technologies, applications, and opportunities," Pervasive Mob. Comput., vol. 5, no. 4, pp. 277–298, 2009.

[6] E. Stefanidi, M. Doulgeraki, M. Korozi, A. Leonidis, and M. Antona, "Designing a Teacher-Friendly Editor for Configuring the Attention-Aware Smart Classroom," in International Conference on Human-Computer Interaction, 2016, pp. 266–270.

[7] R. Spicuzza, J. Ysseldyke, A. Lemkuil, S. Kosciolek, C. Boys, and E. Teelucksingh, "Effects of curriculum-based monitoring on classroom instruction and math achievement," J. Sch. Psychol., vol. 39, no. 6, pp. 521–542, 2001.

[8] L. France, J.-M. Heraud, J.-C. Marty, T. Carron, and J. Heili, "Monitoring virtual classroom: Visualization techniques to observe student activities in an e-learning system," in Advanced Learning Technologies, 2006. Sixth International Conference on, 2006, pp. 716–720.

[9] A. Brouwers and W. Tomic, "A longitudinal study of teacher burnout and perceived self-efficacy in classroom management," Teach. Teach. Educ., vol. 16, no. 2, pp. 239–253, 2000.

[10] D. Börner, M. Kalz, and M. Specht, "Lead me gently: Facilitating knowledge gain through attention-aware ambient learning displays," Comput. Educ., vol. 78, pp. 10–19, 2014.

[11] J. Cain, E. P. Black, and J. Rohr, "An audience response system strategy to improve student motivation, attention, and feedback," Am. J. Pharm. Educ., vol. 73, no. 2, p. 21, 2009.

[12] A. B. de Bruin and T. van Gog, Improving self-monitoring and self-regulation: From cognitive psychology to the classroom. Elsevier, 2012.

[13] R. J. Waller, "A review of single-case studies utilizing self-monitoring interventions to reduce problem classroom behaviors," Freeman, vol. 1999, no. 2005, 2008.

[14] I. D. Beatty, "Transforming student learning with classroom communication systems," ArXiv Prepr. Physics0508129, 2005.

[15] J. Cole and H. Foster, Using Moodle: Teaching with the popular open source course management system. O'Reilly Media, Inc., 2007.

[16] M. Loving and M. Ochoa, "Facebook as a classroom management solution," New Libr. World, vol. 112, no. 3/4, pp. 121–130, 2011.

[17] M. Turoff and S. R. Hiltz, "Software design and the future of the virtual classroom®," J. Inf. Technol. Teach. Educ., vol. 4, no. 2, pp. 197–215, 1995.

[18] G. Mathioudakis et al., "Ami-ria: real-time teacher assistance tool for an ambient intelligence classroom," in Proceedings of the Fifth International Conference on Mobile, Hybrid, and On-Line Lerning (eLmL 2013), 2013, pp. 37–42.

[19] Y.-J. Lee, "Empowering teachers to create educational software: A constructivist approach utilizing Etoys, pair programming and cognitive apprenticeship," Comput. Educ., vol. 56, no. 2, pp. 527–538, 2011.

[20] M. Chaouachi and C. Frasson, "Mental workload, engagement and emotions: an exploratory study for intelligent tutoring systems," in Intelligent Tutoring Systems, 2012, pp. 65–71.

[21] K. Brawner and B. Goldberg, "Real-time monitoring of ecg and gsr signals during computer-based training," in Intelligent Tutoring Systems, 2012, pp. 72–77.

[22] J. M. Aldridge, R. C. Laugksch, M. A. Seopa, and B. J. Fraser, " Development and Validation of an Instrument to Monitor the Implementation of Outcomes ‐ based Learning Environments in Science Classrooms in South Africa," Int. J. Sci. Educ., vol. 28, no. 1, pp. 45–70, 2006.

[23] A. C. Strain, R. Azevedo, and S. D'Mello, "Exploring relationships between learners' affective states, metacognitive processes, and learning outcomes," in International Conference on Intelligent Tutoring Systems, 2012, pp. 59–64.

[24] P. Chalfoun and C. Frasson, "Cognitive priming: assessing the use of non-conscious perception to enhance learner's reasoning ability," in International Conference on Intelligent Tutoring Systems, 2012, pp. 84–89.

[25] A. Leonidis et al., "A glimpse into the ambient classroom," Bull. IEEE Tech. Comm. Learn. Technol., vol. 14, no. 4, pp. 3–6, 2012.

[26] [26] C. Stephanidis, A. A. Argyros, D. Grammenos, and X. Zabulis, "Pervasive Computing@ ICS-FORTH," in Workshop Pervasive Computing@ Home, 2008.

[27] C. Savvaki, A. Leonidis, G. Paparoulis, M. Antona, and C. Stephanidis, "Designing a technology–augmented school desk for the future classroom," in International Conference on Human-Computer Interaction, 2013, pp. 681–685.

[28] A. Leonidis, D. Arampatzis, N. Louloudakis, and C. Stephanidis, "The AmI-Solertis System: Creating User Experiences in Smart Environments," in Proceedings of the 13th IEEE International Conference on Wireless and Mobile Computing, Networking and Communications, 2017.

[29] M. Korozi, A. Leonidis, M. Antona, and C. Stephanidis, "LECTOR: Towards Reengaging Students in the Educational Process Inside Smart Classrooms," in International Conference on Intelligent Human Computer Interaction, 2017, pp. 137–149.

[30] U. M. Fayyad, A. Wierse, and G. G. Grinstein, Information visualization in data mining and knowledge discovery. Morgan Kaufmann, 2002.

[31] R. M. Felder and R. Brent, "Understanding student differences," J. Eng. Educ., vol. 94, no. 1, pp. 57–72, 2005.

[32] J. Nielsen, Usability engineering. Elsevier, 1994.

[33] J. Nielsen, Severity Ratings for Usability Problems: Article by Jakob Nielsen. nnGroup, 1995.