A UBIQUITOUS, PEN-BASED AND TOUCH CLASSROOM RESPONSE SYSTEM SUPPORTED BY LEARNING STYLES

Emerging Technology Research Strand

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1. ABSTRACT

The Active Learning Model (ALM) is an educational model which proposes that students should participate, along with the teacher, as direct agents of their own learning process. Computer systems created to implement and support the ALM through activities are known as Classroom Response Systems (CRS). The CRS, usually supported by traditional pen-based Tablet PCs, allow the teacher to propose activities to students, receive back their answers, discuss the results and provide feedback.

However, researches point several problems regarding the CRS use, like the inadequacy of the traditional pen-based Tablet PCs, which have disadvantages related to their size and weight, hard configuration and usability problems. Also, another problem is the pedagogical approach applied to build these systems, which don't take into account individual student's needs, learning characteristics and behaviors, like their learning styles.

Still, we have the ascension of new pen-based and touch mobile devices (e.g iPad), light and thin enough to support novel educational approaches, like the Ubiquitous Learning. This approach proposes the use of context information to measure and customize the applications according to each student's needs, thus supporting the creation of a Ubiquitous CRS (UCRS).

Thus, in this work we describe a UCRS supported by the prediction of student's learning styles. Initially focused in higher education, it supports the automatic identification of the students' learning styles and the submission of activities that best fit each one of the students. We expect it will enhance the students learning experience, thus better supporting the ALM.

2. PROBLEM STATEMENT AND CONTEXT

2.1 The Active Learning Model

Currently there is a trend to insert technological resources in the classroom, with the use of laptops, tablets, smartphones and similar devices. As mentioned by Cermak-Sassenrath [1], within this new learning context institutional power relationships and individual roles of teacher and learner can be inverted, or may become fluid and provocative enough to challenge traditional pedagogical expectations.

In this way, the adoption of these technologies can be used to support and improve the teaching and learning process, like for example supporting the use of specific teaching methodologies, such as the Active Learning Model (ALM) [2, 3]. The ALM is an educational model which proposes that students should participate, along with the teacher, as direct agents of their own learning process. Usually this model is applied to create a collaborative environment where the teacher proposes activities to students. After the activities are solved by students, the teacher is able to provide feedback to them. Also, the answers can be grouped, analyzed and commented by the teacher and students, allowing everyone to participate together in the knowledge construction process.

2.2 Classroom Response Systems (CRS)

In literature [4,5,6,7] computer systems created to implement and support the ALM through activities are known as Classroom Response Systems (CRS). The CRS, usually supported by traditional pen-based Tablet PCs, allow the teacher to propose activities to students, receive back their answers, discuss the results and provide feedback.

However, these systems have drawbacks, like disadvantages related to traditional Tablet PCs size and weight and student's loss of attention and focus [5,6,8]. Also, these systems don't consider students' personal characteristics, needs and behaviors, which negatively affects the ALM environment.

2.3 Ubiquitous Classroom Response System (UCRS)

In earlier work [8,9], we described the initial design of a Ubiquitous Classroom Response System (UCRS). The UCRS is a context aware CRS that allows the creation of a dynamic environment where students can use any available mobile device (*e.g.* pen-based and touch) to answer activities proposed by the teacher, interact with colleagues and receive feedback.

In order to enhance the collaborative process, some context variables were defined, denominated Context Factors [8], which are updated using context information obtained during the UCRS use. These factors measure, for example, how productive was the collaboration among students (e.g. when two students solve together an activity); how difficult is for each student to solve determined activity and how educationally relevant was considered an activity proposed by the teacher. However it is still necessary a UCRS that considers individual and unique characteristics of each student, like for example their learning styles, as described in the following section.

2.4 Learning Styles

As explained by Hsieh *et al.* [10], the learning styles describe the way information is processed by students or the way is better or easier to people to learn. The Felder and Silverman Learning Style Model [11] describes the teaching and learning styles in Computer Engineering.

As described by Felder and Silverman [11], Latham *et al.* [12], Felder [13], and Felder and Soloman [14] the four learning styles dimensions are:

- **Active and Reflective Learning:** Active learners tend to retain and understand information best by doing something active with it, like discussing, applying or explaining it to others. Otherwise, the reflective learners primarily prefer to think about the received information, introspectively manipulating it.
- **Sensory and Intuitive Learning:** Sensory learners prefer facts, data and experimentation, for example solving problems through the application of standard and traditional methods. Otherwise the intuitive learners prefer the related principles and the theoretical basis.
- **Visual and Verbal Learning:** Visual learners prefer the content that is presented and discussed as graphical charts, pictures, diagrams, demonstrations and time lines. Otherwise the verbal learners prefer written and spoken language.

- **Sequential and Global Learning:** Sequential learners prefer the information described in logical and sequential steps, following a linear and reasoning thinking process. Otherwise, the global learners usually make intuitive leaps, learning content almost randomly and then all of sudden getting the big picture about all the content.

The learning styles approach is applied successfully in Intelligent Tutoring Systems (ITS). ITS are adaptive systems, which usually do not require the teacher's presence and use intelligent technologies to personalize learning according to individual student characteristics [12]. Some ITS [12,15] are able to identify and automatically adapt their behavior accordingly to the students learning styles, thus enhancing the student's learning experience.

Similar approach, as described in the next section, can be used to enhance the UCRS, helping the teacher to propose the most effectively activities to students, also allowing them to collaborate with peers in a more effective way.

3. METHOD EMPLOYED

3.1 Learning Styles Mapping

The first step in order to allow the learning styles support was the analysis of the Felder teaching styles method [11,14], thus mapping the activities features according to the learning styles dimensions. Table 1 shows the learning styles dimensions mapping that can be used by the teacher in the activity creation process.

Learning Style	Activity Mapping
Sensory	Activities associated with real world and practical examples
Intuitive	Abstract and theoretical activities
Visual	Activities with pictures, flow charts, diagrams and demonstrations
Verbal	Activities with predominance of written language
Sequential	Activities addressing mainly the current topic, preferably in a logical manner
Global	Activities that address the current topic by relating it to previously topics already seen by the students.

Table 1: Activities Learning Styles Mapping

For example, if the teacher is creating an activity with a practical example, he sets its Sensory/Intuitive learning style dimension to "Sensory". The same procedure happens to the Visual/Verbal and Sequential/Global dimensions. The Active/Reflective dimension was not mapped because its application is associated with the student's preference to work in groups or alone, and thus can't be directly associated to the proposed activities.

In order to reach all students, for the same subject the teacher must create distinct activities, each one focused on a specific learning style. This allows the UCRS to submit the activity that best suits each student learning style, thus enhancing the collaborative process and the learning environment.

3.2 Students Learning Styles Prediction and Application

The Index of Learning Styles[1] (ILS) is an on-line instrument composed by 40 questions used to assess preferences on the four dimensions of the Felder R. and Silverman [11] Learning Style Model. However, as Latham A. *et al* [12] and Yannibelli *et al.* [16] explain, this test takes time and students can consider it long and tiring, which could compromise its accuracy. It also doesn't consider the possible changes in the learning style over time.

In their ITS research, Latham *et al.* [12] associated the learner success in theoretical and practical activities to the Sensory/Intuitive and Active/Reflective learning styles. Similarly, we propose an approach that uses the activities mapping, as showed in Table 1, to predict the Sensory/Intuitive, Active/Reflective and Visual/Verbal dimensions of the Felder and Silverman Learning Style Model in the CRS domain.

The system keeps for each learning style a value between 0 and 1. These values indicate the student's preference regarding each learning style. The Formula 1 [12] indicates how these values can be obtained for each learning style dimension:

Formula 1 [12] $x = \frac{\text{number of right answers}}{\text{total activities}}$

For example, in the Sensory/Intuitive dimension the extremes (sensory and intuitive) can be defined by the proportion of correct answers in the total of the proposed activities of each extreme. If a student answered 10 questions defined as "Sensory", and 3 was correct, his "Sensory Style Value" would be 3/10 = 0.3. In the same way, if a student answered 5 questions defined as "Intuitive", and 4 was correct, his "Intuitive Style Value" would be 4/5 = 0.8.

Thus, the students' preference for a specific learning style dimension is directly proportional to the result obtained through the Formula 1. In the above example, as the student's "Intuitive Style Value" is greater than his "Sensory Style Value", an activity eventually defined as "Intuitive" by the teacher would best fit his learning style than an "Sensory" activity.

The following section describes a use case scenario.

3.3 Use Case Scenario

In some computer science introductory discipline, the teacher will address the topic "Linked List" (a data structure consisting of a group of nodes which together represent a sequence) in his next class. Figure 1 shows a linked list example:

Figure 1: Nodes of a Linked List.

Before the class starts, the teacher inserts into the UCRS two activities related to the linked list subject:

- **Activity A:** shows a set of diagrams (similar to Figure 1) proposing a linked list problem. To solve the activity the student is able to interact with the diagrams elements, for

[1] http://www.engr.ncsu.edu/learningstyles/ilsweb.html

example, moving them to new positions. This process can be done through pen-based or touch interaction, according to the device used by the student. Also, the teacher sets in the system the right answer (in this case, the right sequence) expected from students. The teacher then classifies this activity as “Visual”.
- **Activity B:** shows a textual alternative question related to linked list, with 4 possible answers. To solve the activity the student must check (using touch or pen-based interaction) the option that he believes is the correct one. The teacher then classifies this activity as “Verbal”.

During class, after explaining the theoretical concept, the teacher starts the UCRS. It automatically submits to students the previously defined activity, following these steps:

1) The system accesses the students' profile, submitting the "Activity A" to students who have a visual learning style greater than the verbal learning stile. Otherwise, "Activity B" is submitted.
2) The system identifies the mobile device used by each student, submitting the activity formatted according to each device features (support to touch or pen-based, screen size adjustments, etc.)

After solving the activity, the students submit their answers to the teacher. The UCRS automatically corrects the answers, updating the student’s learning style profiles through the application of Formula 1. Also, the teacher is able to review, analyze and organize the answers, providing feedback to students about their performance in the activity.

4. RESULTS, EVALUATION AND ACKNOWLEDGEMENTS

The UCRS application and evaluation will be done in two steps: a) validating if the UCRS correctly identifies the students’ learning styles, through the comparison of the system results with a test made by the students in the ILS online tool and b) identifying if the new collaborative process enhances the students learning experience, thus supporting in a better way the ALM approach. Also, we want to adapt the system to support multi-dimensional activities, what we expect will make it more efficient for both students and teacher.

The initial evaluation focuses on undergraduation and graduation courses of Computer Engineering, where students are familiarized with the use of computational devices inside the classroom. Even so, in future work we intend to extend the system use to other areas, adjusting if necessary the adopted learning styles model to support other university courses.

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