Application for Measuring The Preferred Learning Style

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Abstract: This project presents some new problems facing the study process in the distant learning system (DLS), and also tries answering the central question: “Why do we need personalized e-learning curricula?”. Web application was developed in order to detect changes in learning styles and measure the level of satisfaction of the students with the presented e-curriculum for C++ programming language. This research would contribute to creating those type of learning objects which will be preferred for each student with different learning style. Also, the data collected from the students can help educators in choosing type of learning activities or in the design of those activities which can suit all types of learner.

Key-Words: - e-learning, learning style, personalized curriculum, distant learning system, adaptive hypermedia, web based learning

1 Introduction

The purpose of this work is to present the concept of implementing an adaptive technique in a web-based learning and self-assessment environment for the Java and C++ programming languages.

Acquisition of the Java and C++ programming languages presents a serious challenge for numerous students. Learning these programming techniques, understanding and applying them requires a significantly different set of skills from students than other general subject matter, thus it is heavily dependent on the students’ specific set of skills. The programming process can be taken to be creative, there are no predefined standards which would readily offer the solution to a give problem. The teaching community uses different approaches as how to teach programming to a student with no previous programming experience; but there is no definitive solution. Some instructors prefer the classical procedural view, while others will opt for the modern object-oriented approach [1].

Further problems in teaching programming may arise from the fact that some of the students will grasp the theory much faster and will be able to use in practice sooner than their peers. This means that those “gifted IT students” [2] have more developed set of skills needed in the acquisition of programming than others.

2 Problem Formulation

The aim of the authors is to provide some help for those students who find it difficult to acquire a programming language and the connected programming techniques. This help comes in the form of a web-based learning (WBL) system, a dynamic web application to complement the classical face-to-face teaching method.

The increasing use of an Internet improved Internet Technologies as well as web-based applications. Also, increasing effectiveness of the e-Learning has become one of the most practically and theoretically important issues in both educational engineering and information system fields. The online training environment enables learners to undertake customized training at any time and any place [3].

When designing this project the authors relied on their experience gained from creating previous e-learning materials, including two distant learning systems (DLS), one for C++ programing language, Php and XHTML and one for English course, and several e-curricula for microcontrollers, digital electronics and physics. These experiences, along with other experts’ research results [4] supporting the authors’ assumptions, all called for caution when designing a DLS or e-curriculum.

Computer-based learning (CBL) as well as web-based learning systems are seen as a special form of teaching environment with different circumstances, and where different rules apply. If these are not taken into consideration, it may happen that the student will not use the system nor the curricula as the author intended it to be used, or worse, the student will refuse to use it altogether [5]. This would be a complete waste of the time

and energy invested into designing the learning system.
The following section will focus on the specific factors that have to be considered when designing WBL systems or e-curricula.
1. **The student is just a person, not a machine.** The main approach when developing an e-learning curriculum is still defined by assuming that the student in a DLS is an ideal student. This student is always motivated, likes to learn via the PC and is satisfied with the level of communication provided by the Internet. But the reality shows a different picture.
The advantages of DLS and using e-curricula are often not enough to overcome the negative effects which are the result of studying in an isolated and stand-alone environment. To sum it up: most people are not able to study independently.
It is also true that every student has different requirements and goals for a given course. When designing an e-learning curriculum these facts must also be considered. Today it is widely accepted that during the design and development of educational materials attention must be focused on the learner's characteristics and requirements. This implies that personalized courses must be developed.

2. **Inadequately designing WeBL systems**. When designing such teaching systems often the pedagogical aspects are not integrated and the designers do not know for what subject they are designing the WBL system. The system developers often claim that they only provide tools for e-learning, and they cannot tell educators how they should use it.
Another problem with these systems is manifested in the fact that the majority of these systems are nothing more than a course management system (CMS) whose primary tasks are distributing certain learning material in electronic form, providing communication possibilities, as well as some form of knowledge assessment [6]. However, what such a system lacks is the dimension of personalization.
The need for personalization was defined by M. Nichols: "The integration of technology in learning needs to address the very important issue of enhancing the teaching and learning process, rather than just being seen as a new flexible delivery medium" [35].
While in frontal teaching this aspect of personalization is very difficult to incorporate, namely that teachers would adapt their teaching or pedagogical style to suit the variety of students in the classroom, which actually is the precondition of successful high-quality learning, in WBL systems this can easily be achieved. It is suggested that one of the main problems with e-learning environments is their lack of personalization [7][8]

2.1 Adaptive or adaptable

It is well known that one of the characteristics a Web Based Educational System should have is adaptivity, i.e. the ability to be aware of the user's behavior so that it can take into account the level of knowledge and provide the user with the right kind of documents [9].
In recent years those WBL systems, which have some sort of adaptive qualities, have come more and more into foreground. Systems that allow the user to change certain system parameters and adapt the systems' behavior accordingly are called *adaptable*. Systems that adapt to the users are automatically based on the system's assumptions about the user needs are called *adaptive* [10]
They extend the one-size fits all approach of hypermedia systems by building a model of the users preferences, goals and knowledge and then use this model throughout the interaction with the user.

Mohammad Issack Santally and Alain Senteni [10] described what is traditionally seen as the first attempts at personalization. Although the features describes below did offer some form of personalization, they failed to bring the required results.
The *adaptable* provides the user with complete control over the environment he or she is learning in. As examples we can list that the student is given a choice of the color, font and other related customizations of the learning environments and can freely browse through the environment on their own. However, these are precisely the options that a current web based learning environments contain, and it has proven not to be the optimal solution. On the other end of the scale are the fully adaptive learning environments, which means that the system makes all the decisions deemed ideal for the student based on a stored student model. However, this is only ideal, if the stored user preferences the system operates on are indeed correct, and unfortunately, quite often they are not. Pre-data collected by the system about the user may contain data, which the user has perceived to be true but which may not actually be the case or such data might be valid for only a certain time or under certain conditions that the system is not able to decipher [10].

Adaptivity in hypermedia systems to personalize the user's experience with the system is not a new concept and Brusilovsky [11] describes three main types of adaptation that exists in web-based hypermedia systems namely content, navigation and layout. In adaptive hypermedia literature they are referred respectively as *adaptive presentation* and *adaptive navigation support* [12]. In the project described in this article different form of personalization was used namely, personalization through learning styles, not the adaptive techniques listed above.

From perspective of social constructivism, the function of individual differences on skills, aptitudes and learning preferences could have an impact on the application of technology in classroom settings. Learners' learning styles affect the preferences of information process and prior knowledge affects the propositional network of the long-term memory. Previous studies have confirmed that matching types of instruction with learners' stronger learning styles could enhance learners' information and communication technology (ICT) skills and motivation [13], [14], Kolb also suggested that compensation can help learners overcome weakness in their cognitive styles and develop a more integrated approach to learning [15].

A learning style is defined as the unique collection of individual skills and preferences that affect how a student perceives, and processes learning material [16]. The learning style of a student will affect the potential of the outcome of the learning experience. Cristea [7] highlights the importance of connecting adaptive educational hypermedia with cognitive/learning styles on a higher level of authoring. But before the implementation of the learning styles is considered as one possible "answer to the lack of personalization", it must be mentioned that there are numerous factors which influence the learning process. It is almost impossible to take into consideration each one of them. Thus, at the end of a learning process it is hard to positively determine what did or did not make the learning process successful. This leads to the conclusion that it is very difficult to measure the outcome of different learning styles, too. So far, the psychology of cognitive styles still remains a poorly developed research field. In 2004, at Newcastle University, the researchers, lead by Frank Coffield, found 71 different learning styles. Some of the more well-known styles include those identified by:

- Allinson and Hayes' Cognitive Style Index (CSI)
- Apter's Motivational Style Profile (MSP)
- Dunn and Dunn's model and instruments of learning styles
- Entwistle's Approaches and Study Skills Inventory for Students (ASSIST)
- Gregorc's Mind Styles Model and Style Delineator (GSD)
- Herrmann's Brain Dominance Instrument (HBDI)
- Honey and Mumford's Learning Styles Questionnaire (LSQ)
- Jackson's Learning Styles Profiler (LSP)
- Felder-Silverman's Index of Learning Styles
- Kolb's Learning Style Inventory (LSI)
- Myers-Briggs Type Indicator (MBTI)
- Riding's Cognitive Styles Analysis (CSA)
- Sternberg's Thinking Styles Inventory (TSI)
- Vermunt's Inventory of Learning Styles (ILS)

The section below will present the Felder-Silverman learning style model which can be easily implemented in a DSL with e-curricula.

2.2 The Felder-Silverman Model

According to the model developed by Felder and Silverman (FS) a student's learning style may be defined by the answers to four questions:

1. What type of information does the student preferentially perceive: sensory (sights, sounds, physical sensations) or intuitive (memories, thoughts, insights)? Sensing learners tend to be concrete, practical, methodical, and oriented toward facts and hands-on procedures. Intuitive learners are more comfortable with abstractions (theories, mathematical models) and are more likely to be rapid and innovative problem solvers. This is the sensory-intuitive dimension.
2. What type of sensory information is most effectively perceived: visual (pictures, diagrams, flow charts, demonstrations) or verbal (written and spoken explanations)? This is a Visul-Verbal dimension.
3. How does the student prefer to process information: actively (through engagement in physical activity or discussion) or reflectively (through introspection)? This is the Active-Reflective dimension.
4. How does the student characteristically progress toward understanding: sequentially (in a logical progression of incremental steps) or globally (in large "big picture" jumps)? Sequential learners tend to think in a linear manner and are able to function with only partial understanding of the material they

have been taught. Global learners think in a systems-oriented manner, and may have trouble applying new material until they fully understand it and see how it relates to the material they already know about and understand. Once they grasp the big picture, however, their holistic perspective enables them to see innovative solutions to problems that sequential learners might take much longer to reach, if they get there at all. This is a Sequential-Global dimension.

The Index of learning styles (ILS) is a 44-question instrument designed to assess preferences on the four dimensions as defined based on the 4 types of questions of the FS model.

A brief review of some existing systems follows by [5]:

- TANGOW implements the Felder-Silverman dimensions of learning styles. The system includes low-level authoring patterns such as learning material combination in AND, OR, ANY and XOR relations.
- AHA! is a low level tool with great flexibility based on IF-THEN rules adaptation model. The aim is to investigate how to incorporate high-level specifications deriving from learning styles especially those of field dependent and field-independent styles into the low-level instances and structures as required by the AHA! system.
- Hong & Kinshuk develop a mechanism to fully model student's learning styles and present the matching content, including content (contain), format, media type, etc., to the individual student, based on the Felder-Silverman Learning Style Theory. They use a pre-course questionnaire to determine a student's learning style or the student may choose the default style and he is then provided with material according to his/her style. The efficiency of student learning with the prototype presented is however not yet tested.
- Wolf (2002) proposes iWeaver, an interactive web-based adaptive learning environment. iWeaver uses the Dunn & Dunn learning style model and the Building Excellence Survey as an assessment tool to diagnose a student's learning preferences. Instead of focusing on the student's learning preferences and to offer contents matching only a specific learning style of learners, *iWeaver* offers and encourages the trial of different media representations. It does not however adapt to the changing preferences of the learner.

Unfortunately, the many studies carried out on this subject have been unable to find unambiguous support for the construct 'learning styles' therefore this construct has been under much criticism by researchers. On the other hand, research demonstrates that both low and average achievers earn higher scores on standardized achievement tests and aptitude tests when taught through their learning styles preferences [17]. At the same time, it must be taken into account that no single learning preference is better than any other. Students become more competent learners if they can have preferences for more than one single learning style. This makes them more versatile learners. This reflection can be sustained by the fact that gifted learners prefer kinesthetic instruction but they also have the ability to learn auditorially and visually [18]. Furthermore, underachievers tend to have poor auditory memory. They learn better through graphics and animations rather than text. Low achievers are also said to encounter difficulty to do well in school because of their inability to remember facts through lecture, discussion, or reading where teachers mostly talk and students mostly listen [19].

2.3 Personalization at knowledge assessment

It is important for students to have confident knowledge of the basics in their subject. If they are uncertain about things, for example the meanings of words, they are handicapped in future study. They need, of course, to be able to produce correct answers to a significant part of the relevant questions one might ask, as tested in conventional marking schemes. However, it is equally important, perhaps even more important, that they should be able to identify when they are likely to be getting the answers right and when not. From an assessment point of view, the student's confident belief in answers that are in fact wrong is far worse than their recognition that they simply do not know the correct answer to a particular question.

In the previous DLS system, authors of this paper integrated only true/false and multiply choice knowledge assessments. But if we want a personalized system, we also have to implement some kind of adaptation in this part of application. Here are some reasons for why it is important:

True/false questions present a statement, and prompt the student to choose whether the statement is true. Students typically have a great deal of experience with this type of questions [20].

- Advantages: True/false questions are among the easiest to write, and can be scored electronically.

- Disadvantages: True/false questions are limited in what kinds of student mastery they can assess. They have a relatively high probability of the student guessing the correct answer (50%). True/false also assesses the recognition of information, as opposed to recalling some.

Scores on true-false items tend to be high because of the ease of guessing correct answers when the answer is not known. With only two choices (true or false) the student could expect to guess correctly on half of the items for which correct answers are not known. Thus, if a student knows the correct answers to 10 questions out of 20 and guesses on the other 10, the student could expect a score of 15. If one mark were to be given for a correct response, and zero for an incorrect one, in worst case the final score would be 10/20 or 50% (no lucky guess), which is a pass mark! Clearly, this is undesirable. The problem can be solved by awarding 1 mark for a correct response, and deducting 1 mark for an incorrect response. In this way, a totally prepared candidate will achieve 100%, a totally unprepared candidate 0%, and the other candidates will achieve a percentage score that should be a reflection of their degree of preparation - as far as any test can. This, after all is surely the prime goal of any test. The same thing can be said for the multiply choice quiz, but in this case the students' answers better reflect the real student's knowledge.

To determine the real state of students' knowledge from the course material, in our WBL system we use confidence-based assessment. In this type of assessment beside the student's answer it is also taken into account his/her confidence in to the answer.

In order to measure knowledge one must measure a person's degree of belief. A student with different degrees of belief about a statement that is in fact true, may be said to have one of the following [21]:

- knowledge
- uncertainty
- ignorance
- misconception
- delusion.

The assigned probabilities for the truth of the statement would range from 1 for true knowledge, through 0.5 for acknowledged ignorance to zero for an extreme delusion, i.e. totally confident belief in something that is false.

Experience at University College London (UCL) with medical and biomedical students for several years, with a simple form of Certainty-Based Marking (CBM) has proved popular with students in their study and beneficial to student-teacher interaction [22]. Students need practice to become familiar with the mark scheme, but it rewards realism in a pedagogically sound manner and improves the statistical quality of exam data by marking unconfident answers without penalty but with reduced weight. It avoids two of the cardinal crimes of assessment: rewarding lucky guesses as if they were knowledge, and treating confident misconceptions as no worse than acknowledged ignorance.

The UCL Scheme for Confidence-Based Assessment was devised to satisfy four primary requirements [21]:

- Simplicity: understood easily with little or no practice
- Motivation: students must always benefit by honest reporting of their true confidence in an answer, whether high or low.
- Flexibility: applicable without modification to answers in any format that can be marked definitively as correct or incorrect.
- Validity: maintaining reasonable correspondence to knowledge measures backed by the mathematical theory of information.

The scheme has 3 confidence levels: C=1, C=2 and C=3. If the student's answer is correct, then this is the number of marks awarded (1, 2 or 3) [22]. If the answer is wrong, then the marks awarded at these confidence levels are 0, -2, or -6. For the upper two confidence levels the scheme employs negative marking, but in a graded manner with the relative cost of a wrong answers increasing at higher confidence levels. This gradation is critical, because it ensures that the scoring scheme is properly motivating.

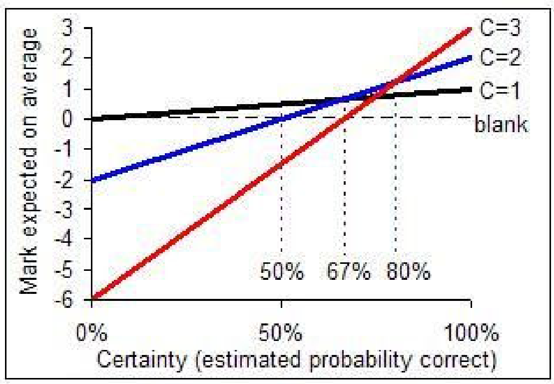

Fig. 1 The UCL scoring scheme

The graph in Fig. 1 shows how for each possible confidence level the average score to be expected on a question depends on the probability of getting it right. If confidence is high (>80%), then C=3 is the best choice. If it is low (<67%) then C=1 is best, and for intermediate estimates of the probability of being correct, C=2 is best. On this scoring scheme it is never best to give no reply, since an answer at C=1 carries the possibility of gaining a mark, with no risk of losing anything. The levels are always described in terms of the marks awarded (C=1,2,3) rather than in language terms such as “very sure”, “uncertain”, etc., which may mean different things to different people.

A crucial feature in confidence-based assessment is the motivating nature of a marking scheme (Fig. 1). Without this, a system that awards higher marks for answers entered at high confidence simply rewards those students who are bold enough or perceptive enough to see that it is never advantageous to enter low confidence. When choosing the marking scheme, it is necessary to pay careful attention to the way it depends on confidence, to ensure proper motivation.

The simplest confidence related self-awareness is the appreciation that one is guessing, or nearly guessing. Discussions often centre round the issue of discouraging students from guessing in exams, because guessing adds random noise to assessment data. Negative marking schemes are often said to discourage guessing, but unless the scheme is motivating it will not be rational for a student to behave in this way [23]. For the purpose of discussion, graphs analogous to Fig. 1 are set out in Fig. 2 for six different marking schemes. Options (including the option to omit an answer) should logically be preferred by a student when the corresponding line is the highest on the graph, for whatever probability corresponds to his/her confidence.

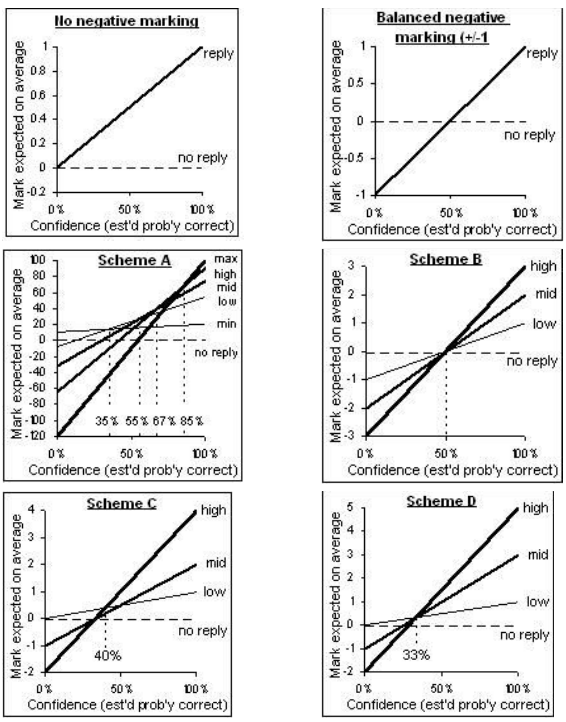

Fig. 2 Marking schemes

With no negative marking (Fig. 2, top left) it is obviously never rational to omit an answer. A simple negative marking scheme, with equal numbers of marks added and subtracted for right and wrong answers, motivates a student to omit a reply when confidence for being marked right is less than 50%. This is valuable for MCQ and open ended answers, but for T/F answers the confidence probability can never be less than 50%, since if it were then a student should prefer the complementary answer. Use of such a scheme for T/F questions is not only irrational but tends to act against the interests of students who follow advice to omit guesses, since even a modest degree of partial knowledge may ensure sufficient bias in favor of correct answers to make the difference between a pass and a fail score. Prejudice against fixed negative marking schemes may stem partly from explicit or implicit realization of this point, though for MCQs with more than 2 options this scheme is preferable to marking without penalty.

2.4 Problems about learning style implementation

When designing the application the initial idea of how will it works and how will it integrate learning styles was the following: in order to use the web application, the students have to register first. They then have to fill in the FS ILS questionnaire which will determine their learning style. By logging in, they will receive a pre-defined learning material which is matched to their learning style. Once the profile is determined the students access the curriculum in whichever formats most suits their preferred learning style.

At this stage, the authors reckon, new problems appear: How well does the determined profile really mirror the student’s profile, and to what extent does the system’s “preferred curriculum” really match the student’s preferences? The first question refer to the case when the student’s answer are not true (reasons for this may be lack of honesty, lack of interest, momentary state of mind, etc) and because of his or her dishonest answers the student was given a different profile. The system always offers an ILS and profile determination, the student only has to initiate these options nonetheless, practice shows that students hardly ever use this option once they have filled in the questionnaire at the beginning. The second question focuses on the phenomenon that the learning style is not an exact parameter; it may change with time and may also depend on the topic. Consequently, the use of adaptivity techniques heavily depends on whether or not the student's profile was correctly detected throughout the entire learning process. This is also true of those system which do not determine the student's behavior using psychological tools, but based on the student's behavior.

Another common mistake must be mention when designing Hypermedia Adaptive Systems: forming the curriculum, processing and presenting it, is strongly connected with the learning style of the assembling expert(s). The authors of this paper feel that it is important to state that a learning material created for a given profile can only be transformed into an e-learning material to the fullest effect by those teachers or instructors who themselves have a similar learning and teaching style. This would lead to the conclusion that the designer team working on project must be definition include experts with different learning and teaching styles to design the learning material according to their styles, as well. Yet it can safely be stated that such complex designer teams are highly unlikely to materialize due to the enormous costs it would involve.

3 Problem Solution

The arising problems have changed the structure and aim of the project. The authors started experimenting with such adaptive systems that where equally adaptable for all parties involved in the education process, teacher and students alike. Two main goals were defined. First, to examine if there is a change in the learning style if the subject to be learned is one of the programming languages, and second, to collect as much information about the presented preferred curriculum as possible. The goal is to use the attained information to determine some form of regularity which can be used to develop similar e-learning contents. The aim is to define some type of methodology for creating learning objects using adaptivity approach to the student's learning style.

For achieving the previously described goals, a web application was developed based on PHP, Apache, MySQL and Linux solutions. The application distributes the e-learning contents and collects information from students. The lessons are pre-composed dynamic html pages. The lessons are created using the structure and presentation style following the guidelines described by the learning style model. Some pages contain somewhat more than the optimal amount of "stuff to be learned" because the lessons are designed to be follow able for all FS profiles.

The application can manage the students' profiles, categorize students by their learning style, distribute the curricula prepared in advanced, track the students' knowledge progress (such as results of tests), and assure asynchronous type of communication (e.g. forum) with the other students. The information collecting part of the application collects data about student's activity in the system, as described in the following example:

1. Information is gathered regarding how satisfied the student is with the presentation and content processing of curriculum and available examples. The external contents are also evaluated. The point is that the student can give a mark to every part of the application. The marks range from 1 to 5 and there is also a possibility to evaluate by textual comments or notes. With this feedback one can measure to what extent the given lesson structure and presentation style is preferred, broken down according to each profile. This information can help to form aspects of how to create e-learning materials.

Also information is gathered about student's activity in the system and within the e-learning material. The following activities are tracked:

- Did the student leave a note, or open some other student's notes?
- Did the student follow the hyperlinks to the examples page and to the external links collection page?
- What is the pathway of visiting the lessons?
- Did the student play the multimedia file on the page (sound, video or flash animation)?
- Did the student ask for printer friendly versions of the lessons?
- What are the time spending statistics on lesson pages and on the example pages?
- Did the student select a bigger picture option on the page?
- How often did the student communicate via the forum?
- Did the student use a glossary?
- Did the student change the color theme of the application?

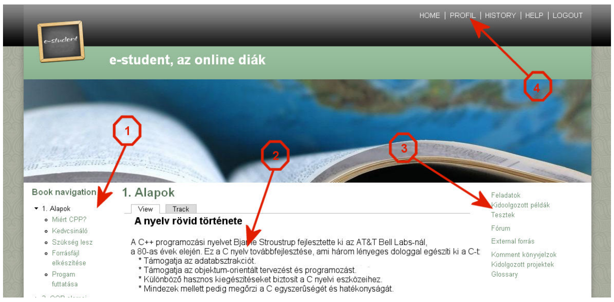

Fig. 3 The main window, (1) links to the lessons, (2) dynamic lesson page, (3) links to the forum, projects etc., (4) profile and system management options

Fig. 4 Bottom of the lesson's page. (1) student's mark to this lesson, (2 and 3) navigation options to chapters, (4) students' comments about this lesson

Fig. 5 (1) this student have done 2 homework and there is 3 to go, (2) student's marks of the available examples

By gathering these information one can learn about the student's special needs, to what extent does the student match the profile determined for him by the system, and did the learning style change during the course.

The goal of this application, beside the information distribution is collecting data. With the feedback from students the authors will be able to build a kind of methodology for developing those e-curricula and learning objects, which adapt to learning styles in the programming languages courses.

3.1 The application so far

This particular application was tested at Subotica Tech in the spring semester of 2009. The students had an obligatory course of C++ programming language consisting of 14 classes in a typical frontal-teaching style. The students were given the option to use the web application as an additional learning tool (with 5 e-lessons). Out of 100 first-year students of informatics, 56 of them had opened accounts in the system. At the end of the semester, a great amount of information was collected. Primarily, this information will be used to perform changes in the application, in a manner that the students indicated. Further, based on the collected information, changes will be applied in presentation styles, lesson structures, and types of examples of the existing as well as the new e-curricula.

In order to attain more relevant information about learning styles in the courses of programming languages, the authors' aim is to develop e-curricula for the Java programming language course to be held in the following semester with the same group of students.

4 Conclusion

This paper presents some problems which may appear in a DLS, when the students learn in an isolated and stand-alone environment, affecting the learning process negatively.

The project implements the next thoughts: The students should benefit from all know learning theories and models as well as learning styles and strategies. We should not be the determinant in fixing the recipe for the students as we do not absolutely know how, when and where students learn.[24]

The current web application was developed in order to detect learning styles and measure the level of satisfaction, so that research would contribute to creating learning objects for teaching programming languages. Also, the data collected from the students can help educators in choosing type of learning activities or in the design of those activities which can suit all types of learner.

Based on the marks and comments, the educator can change the curricula and the system. By taking into consideration the students' views of the curricula, two goals are achieved: firstly, the teacher is no longer the only one who develops the curricula, and secondly, the needs for personalized curricula will be met. Unfortunately these changes will be used only by the next generation of students, and not every student's special need will be fulfilled. Critics may say that the general direction is that of the classical one-size-fit-all approach. It is partially true. But, using the data from the learning style questionnaire, which is a mandatory part of using the DLS, and the data collected by the system about the student's behavior, the educator can detect those students whose needs are more special than the average, and pay them adequate attention, because this course is blended, with majority of lessons happening in frontal teaching style. After all, if the next generation students rate the curricula higher, and leave fewer comments with critics, the authors of the project will consider it a success. If apart from that students will even get better mark at the final exam, his approach can be alternative to the very costly system development which involves the time and energy of numerous experts.

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