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A Formative Assessment with a Confidence-level Indicator for an Intelligent Tutoring System

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Abstract*— An Intelligent Tutoring System (ITS) is a computer program that has intelligence and can provide a learner individualized one-on-one tutoring. An ITS is built on four critical components: the Student, Expert, Tutor, and Interface models. This paper focused on the development of the Student Model, the component that is in charge of assessing what the learner already knows about the topic domain. To this effect, the proponents recognized the importance of incorporating formative assessments to the Student Model such that the ITS may adapt to teaching methodologies that are tailor-fitted to the student's learning process. The developed Student Model is packaged into an Application Programming Interface (API). It employs a formative, multiple-choice type, pre-assessment and could be integrated into an ITS that teaches HTML 5. Traditionally, the result of a multiple-choice test is quantitative. Although this data is invaluable, the proponents recognized that an ITS may further benefit if the result is also qualitative. Therefore, a Confidence-Level Indicator (CLI) is integrated into each test item such that the examiner may also state, together with his answer, his level of confidence to his chosen answer. This improvement may prove to be beneficial to the implementation of other Student Models because it allows active participation of the learner to his learning process.

Keywords— ***Confidence-Level Indicator, Formative Assessment, Intelligent Tutoring System, Student Model.***

I. INTRODUCTION

An Intelligent Tutoring System (ITS) is a computer program that has intelligence and can provide a learner individualized one-on-one tutoring. This definition is anything but simple. The word intelligence in this context would likely spark a heated debate about its meaning. Hence, it is imperative to have a solid grounding on what is the meaning of the word intelligence in ITS. The ITS community announced that there are two critical elements for any tutoring system to be considered intelligent: real-time cognitive diagnosis and adaptive remediation [1]. Real-time cognitive diagnosis is the tutoring system's assessment of what the learner already knows. Adaptive remediation is the intervention that the tutoring system will do to supply what the learner needs to know. These two elements are the key ingredients that make any tutoring system intelligent.

The roots of Intelligent Tutoring System can be traced back to an educational system of instruction commonly referred to as Computer-assisted Instruction (CAI). Interestingly, the earliest CAIs did not run on computers; and, one of the earliest such tools was invented in 1925 by Sidney Pressey. Eventually, CAI moved to a new platform, the computer, but its nature stayed the same. The learning material is presented to the learner, followed by an evaluation of the learner's acquisition of knowledge. If the learner passed the evaluation, the computer-assisted instruction moves forward its natural course. Otherwise, the program invokes remediation, and the earlier learning material is presented to the learner once again, which will be followed by another evaluation. This process may go on until the learner has acquired the desired knowledge such that the computer-assisted instruction may move forward.

The evolution of CAI continued and turned into an Intelligent Computer-assisted Instruction (ICAI). The latter involves the use of Artificial Intelligence (AI) and have far more complex branching than the former. It was in 1982 that the term Intelligent Tutoring System is coined in place of Intelligent Computer-assisted Instruction [2].

During the early evolution of ITS, three essential components were identified as pre-requisites: the Student, Expert, and Tutor models [3]. The first

component, the Student Model, also referred to as the knowledge of the learner, requires that an ITS must be able to assess what the learner already knows. The second component, the Expert Model, also referred to as the knowledge of the domain, requires that after assessing what the learner knows, it must then consider what the learner needs to know. The third and last component, the Tutor Model, also referred to as the knowledge of teaching strategies, requires that an ITS must be able to decide what the next instruction is and how to deliver it to the learner. A fourth component, the Interface Model, was recently added. This component requires that an ITS must be able to communicate with the learner [4][5]. In its most basic form, these are the building blocks of Intelligent Tutoring Systems. With all these in mind, the present study aimed to support the development of an Intelligent Tutoring System that teaches HTML 5 through the development of a Student Model that uses formative assessments.

Every educational institution administers summative assessments to their students after each learning segment. The results of these assessments are for the evaluation of learning outcomes to determine whether the students have acquired sufficient knowledge. In contrast, formative assessments are assessments for learning, which means that they are for monitoring a student's progress such that the teacher may adapt to teaching methodologies that are tailor-fitted to the student's learning process. Furthermore, the administration of formative assessments is before and during a learning activity and is usually not included as part of the final grade of the student.

Formative assessments are invaluable tools that inform an educator on the current learning state of a learner, and, if used accordingly, improves learning outcomes [6][7]. There are numerous ways to administer formative assessments, both formal and informal. One of these is a pre-assessment (pretest). In this regard, the present study's Student Model uses a formative, multiple-choice type, pre-assessment.

Traditionally, the result of a multiple-choice test is quantitative. That is, the result is the accumulated number of correct answers over the total number of test items. Although these data are invaluable, a tutor may also benefit if the result from a multiple-choice test is also qualitative (e.g., which test items are the product of guesswork).

A multiple-choice test item contains two parts. The first part is the question, referred to as the stem. The second part is the list of possible responses, referred to as the alternatives, and is further categorized into two: the distractors (incorrect answers) and the correct answer. An item in a multiple-choice test usually contains four alternatives. In such a case, an examiner has a 25% chance of choosing the correct answer regardless of whether the examiner truly knows the answer or not. In response to this dilemma, the present study aimed to improve the formative pre-assessment by incorporating a Confidence-Level Indicator (CLI) as part of each test item. For example, the examiner may choose an alternative, and append to that alternative a CLI that states that he or she is quite sure of the answer; or a CLI that states that he or she is a little sure of the answer; or even a CLI that states that he or she does not know the answer at all. This improvement may provide a tutor additional insights on the learner's current comprehension of the subject matter. This knowledge, when used properly, may prove invaluable and serve as justification on the different teaching methodologies that the tutor may adopt to tailor-fit the learner's learning process.

II. METHODOLOGY

A. Survey

Educators of private and state-owned Higher-Educational Institutions (HEIs) were the respondents in the conducted convenience sampling in the evaluation of the formative pre-assessment. The use of a questionnaire to this effect evaluated the formative pre-assessment in the following areas: clarity, sentence structure, and alternatives of the test items.

In terms of clarity of the test items, it is imperative that the test items provide clear and concise stems. A definitive test item will provide results that measure key areas in the topic domain. This results, in turn, provides the tutor invaluable insights to the learner's prior knowledge.

Properly structured test questions are also equally important and invaluable. A test question that is ambiguous provides inconclusive result because it is possible that the examiner was unable to choose the correct answer simply because the examiner did not fully understand the question. Therefore, it is imperative that the sentence structure of the stems are properly structured.

The alternatives of the test items are just as important as the stems. The alternatives must not provide unnecessary clues to the correct answer; instead, it should reinforce the learner's thinking skills. Likewise, alternatives in a test item are not meant to confuse the examiner, rather it is meant to train and strengthen the

learner's ability to rationalize. Therefore, care was taken in the construction of alternatives in the test items.

B. Software Development Methodology

The development of an Intelligent Tutoring System is still under the domain of software engineering, and, as such, the guide was a software development methodology. In this regard, the chosen software development methodology was the Prototyping Model and the product is a Student Model packaged into an Application Programming Interface (API).

Prototype development started with gathering the requirements of the proposed Student Model. This includes, among other things, identification of the scope of the topic domain (in this case, HTML 5). When the scope of the topic domain is identified, the construction and validation of the pre-assessment followed.

Three levels of CLI was included in each item of the pre-assessment: Quite Sure of the Answer, Not Sure of the Answer, and Don't Know the Answer. One of these indicators will be appended to the selected answer of an examiner from each test items.

Quick design is carried out after all these activities. The product is a working API prototype of the Student Model. The working prototype was submitted to experts for consultation. Hereto, based on the experts' feedback, the prototype was refined. This cycle of building a prototype and consultation with the experts went on until the prototype was considered satisfactory. Hereafter, the guide for the further development of the Student Model is the iterative waterfall approach.

III. Results and Discussions

There were a total of thirty-nine (39) respondents in the conducted convenience sampling, all of them are faculty members (or affiliates) of the Information Technology Department in their respective institutions. Majority of these respondents have been teaching for more than a decade and have taught web programming subjects in the last five years. Table 1 shows the breakdown of the respondents' profile. It is interesting to note that six (6) respondents indicated that they did not handle any web programming subjects in the last five years and all of those respondents have been teaching for more than ten years. Nonetheless, their ample teaching experience ensures their reliability as evaluators of the formative pre-assessment.

Table I. Profile of the Respondents

PROFILE	FREQUENCY	PERCENTAGE
Teaching Experience		
Less than a year	0	0%
A year but less than five years	12	31%
Five years but less than ten years	9	23%
Ten years or above	18	46%
Faculty Member of Information Technology		
Yes	39	100%
No	0	0%
Handled Web Programming Subject (in the last 5 years)		
Zero	6	15%
One to three times	21	54%
Four to five times	7	18%
More than five times	5	13%

Two indicators were used in the evaluation of the formative pre-assessment's clarity of the test items. In the first indicator, twenty (20) of the respondents strongly agreed, sixteen (16) agreed, two (2) were neutral, and one (1) strongly disagreed that the test items are concise, i.e., each test item provides only a single question or problem. In the second indicator, twenty-one (21) strongly agreed, sixteen (16) agreed, and two (2) were neutral that the questions or problems in the test items are clear and explicitly stated. These indicators evaluated to an average weighted mean of 4.43 which indicates that, in terms of clarity, the pre-assessment is very excellent.

Three indicators were used in the evaluation of the formative pre-assessment's sentence structure of the test items. In the first indicator, twenty-four (24) of the respondents strongly agreed, fourteen (14) agreed, and one (1) was neutral that the questions or problems in the test items are properly structured and contain appropriate vocabularies. In the second indicator, fourteen (14) of the respondents strongly agreed, nineteen (19) agreed, and six (6) are neutral that the negatively stated questions or problems in the test items are used sparingly. In the third indicator, fourteen (14) of the respondents strongly agreed, twenty (20) agreed, four (4) were neutral, and one (1) disagreed that the negative words in a negatively stated question were emphasized using underlines and were capitalized. These three indicators evaluated to an average weighted

mean of 4.34 which indicates that, in terms of sentence structure, the pre-assessment is very excellent.

Four indicators were used in the evaluation of the formative pre-assessment's alternatives (options) of the test items. In the first indicator, sixteen (16) of the respondents strongly agreed, sixteen (16) agreed, six (6) were neutral, and one (disagreed) that the alternatives do not provide unnecessary clues to the correct answer. In the second indicator, fourteen (14) of the respondents strongly agreed, twenty-two (22) agreed, two (2) were neutral, and one (1) disagreed that the alternatives are plausible. In the third indicator, seventeen (17) of the respondents strongly agreed, twenty (20) agreed, and two (2) were neutral that the alternatives are grammatically parallel with each other and are consistent with the question or problem. In the fourth indicator, sixteen (16) of the respondents strongly agreed, nineteen (19) agreed, and four (4) were neutral that the alternatives are presented in a logical order. These four indicators evaluated to an average weighted mean of 4.29 which indicates that, in terms of the alternatives of the test items, the pre-assessment is very excellent.

The overall evaluation of the formative pre-assessment is based on three indicators: clarity, sentence structure, and alternatives of the test items. Based on the preceeding data, the computed average weighted mean of the three indicators is 4.35. This indicates that the formative pre-assessment is evaluated by the respondents as very excellent.

In the case of the CLI, its aim is to improve the interpretation of the result of a multiple-choice test. This is because in a multiple-choice test, as a last resort, an examiner can always depend on mere chance. An experienced human tutor has the ability to gauge a learner's grasp of a particular subject matter by observing how the learner answers the tutor's questions. The same effect may also be attained by simply asking how confident the learner is of the answers. It may be that a computer can mimic this human tutor's ability through the use of sensors or by simply asking how confident the learner is of the answer. The present study's Student Model made use of the latter. Incorporated as part of each test item in the formative pre-assessment, the examiner can state how confident he or she is of the selected answer. For example:

Q: HTML tags are element names surrounded by what?
a) angle brackets
b) curly braces
c) square brackets
d) You DO NOT need to surround it with anything

Immediately after the question, the CLI follows:

Q: How confident are you of your answer?
- I am quite sure
- I am NOT sure
- Actually, I DO NOT know the answer

If an examiner selected *Option A* and the first of the three CLIs, the examiner's answer is then interpreted as *I choose Option A, and I am quite sure of my answer*. Using the CLI, an Intelligent Tutoring System can have a deeper estimation of the learner's knowledge.

IV. Conclusions and Future Scope

The respondents have ample teaching experience and have taught web programming courses several times in the last five years. This is indicative that the respondents are very much qualified to validate the developed formative pre-assessment. With this in mind, based on the data gathered from the survey, it is surmised that the pre-assessment is very excellent based on the following indicators: clarity, sentence structures, and alternatives of the test items. Therefore, the formative pre-assessment integrated in the Student Model is expected to provide reliable assessment of the learner's prior knowledge of the topic domain.

Furthermore, the injection of the Confidence-Level Indicator to each item of the pre-assessment is expected to provide the Intelligent Tutoring System qualitative data that can be used to further enhance the ITS' ability to adapt teaching methodologies that is specific to the learner's needs.

The present study incorporated a formative pre-assessment in its Student Model. The pre-assessment was evaluated using survey questionnaire and it could still improve by undergoing further evaluations such as item analysis. Additionally, the Confidence-Level Indicator that is injected to each test item of the formative pre-assessment may also be applied to other types of examinations and check its applicability.

Lastly, the formative pre-assessment and the CLI is packaged into an API and can be integrated into an Intelligent Tutoring System that teaches HTML 5.

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