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The Effects of Adaptive Hinting Framework Using Animated Pedagogical Agent

[1]Mohd Fadli Ahdon and [2]Mohd Noor Arif Bin Abdullah

[1,2]Unit Teknologi Komputer, Kolej Komuniti Arau, Perlis, Malaysia.

[1]fadlie187@gmail.com, [2]arifsyukran_lillah@yahoo.com.sg

Abstract. Hinting is a useful and common pedagogical tactic in one-on-one tutoring when a student has difficulty in solving a problem or answering a question. Incorporating hinting strategies in MOOCS and learning management system (LMS) can promote interactions between the student and the system, thus, increasing the student awareness and alertness. This paper study the effectiveness of adaptive hinting model for delivering hinting in MOOCS using animated pedagogical agent that can offers interactivity and adaptability. From the descriptive analysis, we find that the mean of posttest of the students from the treatment group learned SSK2013 Web Development course at Kolej Komuniti Arau through MOOCs by using animated pedagogical agent is higher than the mean of posttest of the students from the control group that learned SSK2013 Web Development course through MOOCs without using animated pedagogical agent. Animated pedagogical agent is an animated character that acts like cyber tutor to provide the users with a higher level of interaction in computer-based learning environments.

Keywords: Animated Pedagogical Agent, Hinting and MOOCS.

INTRODUCTION

Hints are useful and common pedagogical tactic, particularly in one-on-one tutoring sessions. Hints can activate otherwise inert knowledge making possible its recall, or to stimulate the inferences required to complete a task using knowledge thought to be available to the student (Hume, 1996). Hints can either explicitly convey information to the student or they point to information presumed to be available to the student. More specifically, Hume (1996) defined a hint as a rhetorical device that is intended to either to provide the student with a piece of information that the tutor hopes will stimulate the student's recall of the facts needed to answer a question and to provide a piece of information that can facilitate the student's making an inference that is needed to arrive at an answer to a question or the prediction of system behaviour.

Massive open online courses (MOOCs) are a relatively new phenomenon sweeping higher education (Bonk, 2015). From the literature, we can distinguish two types of MOOCs: xMOOCs and cMOOCs. The xMOOCs take the traditional model of a portable approach by considering the teacher as an expert tutor and students as knowledge consumers. The cMOOCs are based on a connectivity approach, which views knowledge as being shared by the different participants, and learning as the process of generating those

networks using online and social tools (Daradoumis et al., 2013). Bendou et al., (2017) have identified four limitations of traditional MOOCs:

- MOOCs teach to a certain percentage of the learners
- Students needs assistance and immediate feedback
- Students wants a great adaptive instruction
- Students needs continuous presence

In addition, in the classroom system, a learner can easily get a teacher's attention to solve problems and provide assistance such as hints. However, this assistance is only possible during class time. One suggested solution involves the use of a virtual teacher. The virtual teacher was not a teacher at all but an autonomous, intelligent agent. The learner is able to get their learning at exactly the time they need it. Therefore, the primary objective of this research is to develop a MOOCS system model that provides adaptive and interactive hinting using animated pedagogical agent. Animated pedagogical agent is an animated character that facilitates interactive learning in computer-based learning environments. The primary function is to support human in accordance with the application pedagogical theory within learning environments. The use of animated pedagogical agents can make the learning process more lively and appealing (Stoilescu, 2009). Our prototype system focused on the exercise part of SSK1013 Basic Programming course covering selection, looping and database topics.

LITERATURE REVIEW

Intelligent agent is a new class of software or 'SOFT ROBOT' that acts on behalf of the user by performing special task such as filtering email, negotiating for services, automating complex tasks, scheduling appointments, finding and filtering information and making travel arrangements. Although intelligent agents can embody any combination of these characteristics, they frequently have very limited and discrete functions. The high level of intelligence and autonomy attributed to some agents is the synthesis of aggregate activities of many types of agents actively exchanging knowledge (Govindasamy, 2014).

One of the most promising research areas for intelligent agent is education and training. Such an agent can be used specifically to support and guide the interaction between the student and the system. This agent is referred to as pedagogical agent. Pedagogical agent is an autonomous agent that acts as virtual tutors or teacher to create rich, face-to-face learning interactions. The primary function is to support student in accordance with the application of pedagogical theory within learning environments. It can also serve as a pedagogical expert where it can monitor and evaluate the timing and implementation of teaching intervention such as giving help, feedback and hint. It will act upon the environment and interact with the student in ways that will facilitate learning, while dynamically responding to spontaneously occurring opportunities for instruction and personalized tutoring. This is possible because the agent monitors the progress and current knowledge of the student in each task. The agent has knowledge of the skills that are needed for the task, as a human tutor would demonstrate them. It then compares this knowledge with the student's performance of the same skill. When provided with a suitably rich

interface, multi-modal dialog can be added to the interaction in order to ensure instructional effectiveness.

Furthermore, pedagogical agent can also be represented in educational system as animated characters to make the learning process more lively and appealing. Animated pedagogical agents offer great promise for broadening the bandwidth of communication between the system and user, and increasing the ability of the system to engage and motivate student (Schroeder et al., 2017).

RELATED WORKS AND APPROACH

There are several tutoring systems that used hints as a tutoring tactic. Andes (Gertner et al., 1998) generates individual hints using a Bayesian network based student model to establish follow-up hints, and deliver them using an associated sequence of hint templates for each goal and fact in its knowledge base.

The Lisp Tutor (Anderson et al., 1995) also generates hints from a sequence of hint templates. It used model tracing techniques to detect whether a student is following the correct solution path or not. Sherlock II (Lesgold et al., 1992) generates a paragraph after the conclusion of the tutoring session that sometimes contains a hint. CIRCSIM-Tutor (Zhou et al., 1999) used heuristic rules to choose a hinting strategy based on the category of student's answer, the tutorial plan, and the tutoring history. The content is determined by searching the domain knowledge base to instantiate strategy.

In our MOOCS system, the central issue of hinting is to help a student to recall the related domain rules using animated pedagogical agent. This agent will guide, help and support the student in accordance with the application of pedagogical theory within learning environment. This can be made since the agent monitors the progress and the current knowledge of the student in each questioned. The agent has the knowledge of the skills that are needed for the question, as a human tutor would help them. It then compares this knowledge with the student’s performance of the same skill and provides a hint that the student’s need to answer the question.

Furthermore, we have classified hints to two categories which are CI-Hints and PT-Hints. It is being categorized by the manner that students are prompted with the information they need to proceed with their problem solving (Hume, 1996). Some hints directly convey information to the students (CI-Hints). Other hints point to pertinent information but do not explicitly convey information to the student (PT-Hints).

The rules for hinting in our approach are based on the behaviour of a student. There are two conditions when the agent will provide hinting which are the student must have exhibited some deficiency or error and the student is likely to respond positively to the hint. Based on the human tutoring transcripts, a set of hinting strategies were abstracted, as described before. Then, a hinting algorithm is developed for each category of student answer. Each answer category is associated with a predefined list of strategies. Some of the algorithms are quite simple, such as, if the student gives a near miss answer, the agent

responds with a leading question that points to an intermediate link from the near miss to the correct answer. However, some of the algorithms can be more complex, for example, if the student's answer is incorrect, there are several available strategies. If the tutor is tutoring a causal link in the forward direction, most hinting strategies focus on evoking terms related to the variable already mentioned or on giving an intermediate link in the forward direction. The following are some hinting strategies that are being integrated with animated pedagogical agent adopted from Zhou *et al*. (1999) analysis of human tutoring transcripts as shown in Table 1.

TABLE 1: Hinting Strategies

Hinting Strategies	**Descriptions**
Refer to an Object	Occasionally the system may point to an object to help student concentrates on the analogy of the term in Data Structure and Algorithm Analysis subject if the student is unable to answer a question. This kind of hint is useful when the student has problem in finding the first variable of the answer for the question given by the agent.
Give an Intermediate Causal Link	The agent offers a small piece of information relating the variable in question to the desired answer. As an example, in Data Structure and Algorithm Analysis subject, suppose there are several causally related physiological variables such as A that affects X and affects B. Usually the tutor will teach the relationship between A and B only, ignoring intermediate steps like X. The pedagogical expectation is that the student will think along these lines and find the desired answer.
Give Evoking Terms or Synonyms	In order to teach some facts and concepts, most of the time a tutor use a specific set of computer terms. With the intention of encouraging the student to use the same terms, the tutor sometimes chooses more evocative phrases. For example, in data structure course the tutor often use “object queue” as a synonym for “First in First Out” and evoking images of student queuing entering a bus or vehicles queuing to get a toll ticket.
Linguistic Hint	Since human tutors use natural language, they sometimes give subtle linguistic hints which include very little domain information. These hints are intended to help the student to think more actively. A typical example occurs when the agent is expecting several parameters from the student and the student gives only some of them. The agent may simply reply with “And?”" to indicate that more information is expected.

The mentioned strategies are the most frequently used. However, some other strategies are used only in special tutoring situations, such as, pointing out the function of a term, using capital letters to indicate a core variable, giving a definition, pointing out the problem solving context, and referring to an equation. The prototype system will be tested by a group of student taking SSK1013 Basic Programming at Kolej Komuniti Arau Perlis. The results will be evaluated to see the effectiveness of hinting strategies for different categories of student response using animated pedagogical agent.

RESULTS

Figure 1 shows the proposed model of the prototype system consisting of the animated pedagogical agent and web-based tutoring component that are located on the server side. The proposed model of the prototype system consists of four main components namely, Pedagogical Module, Student Model, Exercise Module and Hints Module. The Pedagogical Module manages the interaction between the student and the system by retrieving the information and knowledge from the Student Model, Exercise Module and the Hints Module. The lecturer can retrieve and update information from Student Model as well as Question Bank.

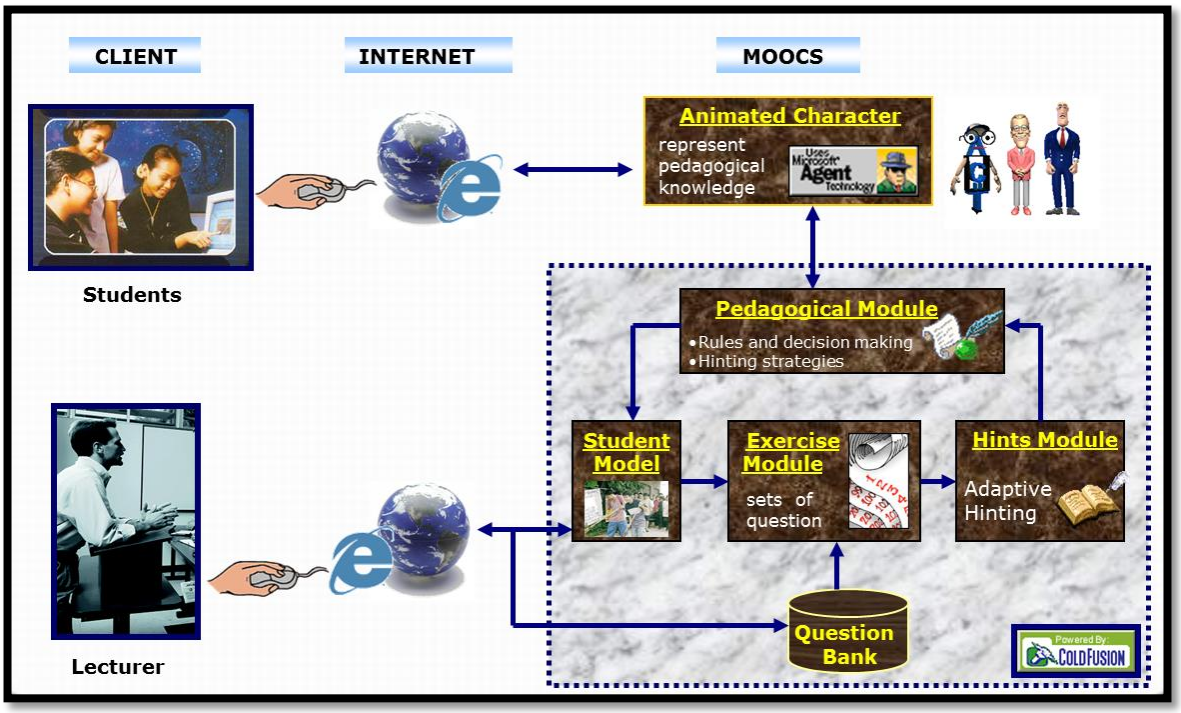

FIGURE 1: Proposed Prototype Model

The proposed model consists of the following components as shown in Table 2.

TABLE 2: Component for Proposed Model

Component	Descriptions
Student Model	Contains information about the student understanding of the Exercise Module by having a model of student's answering style and using diagnostic tools contained within the Pedagogical Module to extract learner's state of understanding about the given question.
Pedagogical Module	Contains rules or other decision making tools that allow it to judge the student's understanding of a subject domain (as represented by the Student Model) and matches it with the actual knowledge structure (as represented by Hints Module).

Hints Module	Contains information about the hints knowledge domain, such as, facts and concepts, and the processes needed to complete the problems within the system.
Exercise Module	Contains questions and quizzes that will be updated by the lecturer and used by the Hints Module during the learning process.

This research used a quasi-experimental research design control group, pretest-posttest design as shown in Table 3.

TABLE 3: Nonrandomized Control Group, Pretest-Posttest Design

Groups	Pretest	Treatment	Posttest
Treatment Group	A1	X	A2
Control Group	A1	-	A2

X=Animated Pedagogical Agent

The samples of this study have been selected using a cluster-random sampling technique. Two classes of Sijil Sistem Komputer dan Rangkaian (SSK) students have been selected from Unit Teknologi Komputer, Kolej Komuniti Arau. Both The treatment group consists of 20 students from SSK1A class while the control group consists of 20 students from SSK1B class. Students from the treatment group learned SSK1013 Basic Programming course through MOOCs by using animated pedagogical agent while students from the control group learned SSK1013 Basic Programming course through MOOCs without using animated pedagogical agent.

Two types of instrumentations have been used in these studies which are performance tests (pretest and posttest) and interviews. Data from the pretest and posttest have been analyzed using WEKA 3.9. Analysis of Variance (ANOVA) has been used to analyze the data to find out whether there is a significant difference between the performance of students in the treatment group and the control group. Besides that, data from the interviews have been analyzed qualitatively to find out which parts of animated pedagogical agent that really helps the students in learning Basic Programming. Result from the ANOVA analysis has shown that there is a significant difference between the posttest of students from the treatment group and students from the control group ($p = 0.001$) at $\alpha = 0.05$. From the descriptive analysis, it also shows that the mean of posttest of the students from the treatment group is higher than the mean of posttest of the students from the control group. With reference to Table 4, the mean of posttest of the treatment group is 79.79 while the mean of the posttest of the control group is 75.59.

TABLE 4: Result of Descriptive Analysis

Groups	Mean	Standard Deviation	N
Control	75.59	5.30	20
Treatment	79.79	7.71	20
Total	77.67	6.90	40

DISCUSSIONS

Integrating pedagogical agent in MOOCS is currently a hot issue in research. By incorporating hinting strategies with animated pedagogical agent, the MOOCS can be more interactive and adaptive. Furthermore, animated pedagogical agents introduce a new paradigm for instruction that is based on concept of shared abilities and cooperative learning between humans and computers. Apart from difficulties in actually constructing animated pedagogical agents for education, exploring the development of artificially animated pedagogical agent is a worthy task in enhancing our understanding.

CONCLUSIONS

A literature study of hints has been initiated. Integrating hinting in MOOCS can promote interactive between a student and the system as well as increasing student awareness and alertness. The implementation of hinting strategy using animated pedagogical agent offers more interactivity and adaptability. A difference type of hints can be presented to different types of student considering their level of understanding, as stated by the pedagogy theory. The animated pedagogical agent behaviours and expressions can be also deliberately designed in order to appear lifelike and thus creating a friendlier teaching and learning environment. However, it is still necessary for these agents to have a rich representation of task domain knowledge to support a wide range of pedagogical capabilities.

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