Participatory Simulation System to Support Learning Computer Science

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Abstract: In this paper, we propose a SPS (Scaffolding Participatory Simulation) framework using the fundamental concepts in scaffolding. Making use of this framework, a mobile system is developed to support students to understand the concept of computer science easier and clearer. Besides it improves the interactive communication, increases the motivation and enthusiasm of the learners. Using the SPS-based system, the teacher can assign tasks to his learner and ask them to do the task. Learners receive these tasks, collaborate together and exchange their physical positions according to the task assigned. The system will check the result and provide feedback to the learner. Learners can understand the concept (or rule) through their trial and errors. The SPS helps the learner to deeply understand the feature of the concept (or rule). This framework is the basic for creating the ALGOS System to help learn sorting-algorithm.

Keywords: Participatory Simulation, Scaffolding, Authentic Learning, MCSCL, SPS.

Introduction

The poor communication between students and teacher is one of the major problems in mass lectures. However, mobile devices can reduce this problem and by improving the interactive communication help to increase the motivation of the students [10]. Mobile devices (e.g., PDA's or notebooks) provide different services aiming at the improvement of interactivity and creating additional, computer-moderated channels of communication between the learners and the teacher [10]. Further, mobile handhelds can easily be used in any classroom or field site; hence they can be used more often than computer labs [15]. Using mobile devices for supported collaborative learning is known as MCSCL (Mobile-Computer Supported Collaborative Learning). Nowadays, there are more and more supported learning researches about MCSCL in order to enhance learning and teaching [8,2]. Many studies have examined the use of wireless mobile devices in learning. According to [9], "90% of teachers in a study of 100 palm-equipped classrooms reported that handheld was an effective instructional tools with the potential to impact learner learning positively across curricular topics and instructional activities." The MCSCL is classified as follow [9]:

(1) Classroom response systems: This is a system where learners can answer the teacher's question immediately with a mobile device, and the system will then display the total result. According to this result, the teacher can grasp the understanding condition of each learner about the course content. The system turns every learner into an active learner. For instance, "ClassTalk" [http://www.bedu.com] is a classroom response system that shows teachers the statistics of learners' answers in the classroom immediately.

(2) Collaborative data gathering: The mobile learning environment changes the monotonous way of teaching in the classroom whereby the learners are only listeners. It lets the learners gain experience from real life, and deeply understand what they have learned.

The learner touches and feels the actual object. For example, the Bird Watching Assistance System [2] was developed for this purpose to support the learning environment.

(3) Participatory simulations: This is to let the learner understanding the course content better through the participation/practice. The learner uses a mobile device to take part in a common participatory simulation. Through this active participation, the learner can discuss and get the correct answer, consequently understand what they have learned better. For example, the Virus Game was developed by the MIT [14] to explain the process of how virus is spread.

(4) Others applications: As like other researches, the system is being developed in the university, which uses PDA to support the study activity. For example, in Tokushima University, we have a project called BSUL (Basic Support for Ubiquitous Learning) [7] to aid study activity.

In this paper, we use the scaffolding technique to design a participatory simulation framework to support collaborative learning, called SPS (Scaffolding Participatory Simulation). Based on the SPS framework, we have implemented a system support to learning sorting algorithm called ALGOS (PDA-based Learning Algorithms System) to help learners to learn sorting-algorithm. This system was then implemented and evaluated.

There are 3 important keywords in most CSCL papers and researches, authenticity, scaffolding and reflection. SPS framework uses the participatory simulations method to realize authenticity, and this framework was designed using the scaffolding technique, and in the framework, history records are then used to realize reflection. In the following sections, we describe how scaffolding technique is used to design the SPS framework and the characteristics of the SPS framework, and how the SPS framework uses participatory simulation for algorithm learning. Finally, we will describe the implementation and evaluation of ALGOS and the plan for the future works.

1. Participatory Simulation

During the past ten years, computers have been used increasingly as simulation machines. The widespread popularity of game software like SimCity and SimEarth give a clear indication of the extent to which simulation has permeated popular culture [14]. Participatory simulations grew out of an age-old tradition of using role-playing to help people develop personally meaningful understandings of complex or nuances situations [14]. Students engaged in participatory simulations act out the roles of individual system elements and then see how the behaviour of the system as a whole can emerge from these individual behaviors [15]. Participatory simulations are learning games where players play an active role in the simulation of a system or process. Simulations of this type have recently come to the attention of educators through the work of Colella [3].

The SPS framework focuses on the participatory simulation that is to learn the concept (or rule) through doing it. Using SPS-based system, the teacher can assign tasks to his learner and ask them to do the task, and learners receive these tasks, collaborate together to do the task. The system supports the learner to do the task step by step, the system will check every step and feedback the learner, learners can understand the concept (or rule) through their trial and errors, when the learner masters the concept (or rule) on a certain level, the system will reduce the help function gradually and more responsibility is shifted to the learner. As mentioned above, the SPS framework is used to build the ALGOS system. In this system, all the learners stand in a line with PDA, and the teacher can assign tasks to his learner and ask them to do the task by using the system, and learners receive these tasks, collaborate together and exchange their physical positions according to the algorithm. This system helps the learner to deeply understand the feature of the sorting algorithms.

This research is advocated by pedagogical theories such as hands-on learning and authentic learning. Brown, Collins, and Duguid [1] define authentic learning as coherent, meaningful, and purposeful activities. When classroom activities are related to the real world, learners receive great academic rewards. There are four types of learning to ensure authentic learning: action learning, situated learning, incidental learning, and experimental learning [6]. SPS framework employs two forms of authentic learning; action learning and experimental learning based on face-to-face communication. SPS framework brings the learners to learn in the 'real world'. The SPS framework also employs interactive learning. Interactive learning involves interactions, either with other learners, teachers, the environment, or the learning material.

2. SPS Framework

The SPS framework comes from the traditional education was and can be seen as an extension of the traditional education. In the traditional education system, teachers give priority to the learners, and learners are normally very passive. For example, in learning computer science theory, when the teacher teaches some complicated concept or algorithms, they only explain literally but it is difficult to make it clear to the learners. So making use of this framework, a mobile system to assistant teachers to explain the concept and algorithms easier and clearer is developed. Besides, it improves the interactive communication, and increases the motivation and enthusiasm of the learners.

2.1. What is the scaffolding?

Before moving on to the SPS framework, we would like to explain the term 'scaffolding'. The term 'scaffolding' comes from the works of Wood, Bruner and Ross [14]. It can be explained better with the following sample. For example, earning to ride a bicycle gives children a wonderful sense of accomplishment. Many of us can recall running alongside a child, holding the bike steadily as the youngster gained speed and then wobbled off independently, unaware that he or she was pedalling without support [5]. Scaffolding, as provided by human tutors, has been well established as an effective means of supporting learning [11].

The timing of the scaffolding is very important. When the children are just learning to ride bicycle, it is necessary to hold the bike steady for giving s/he wonderful sense, when s/he can pedal without support, if we still hold the bicycle, it will hinder s/he to achieve more speed. Now we should begin the process of "fading", or the gradual removal of the scaffolding, which allows the learner to work independently.

2.2 Design of SPSF with scaffolding technique

The design of SPS framework is divided into four sequential parts (see figure 1), the first one is the initial process, the second one is the system-driven part, which is the process of scaffolding to support task execution, and the third is the learner-driven part, which is the process of "fading" to train the learners to think by themselves and the last part is the reflection part.

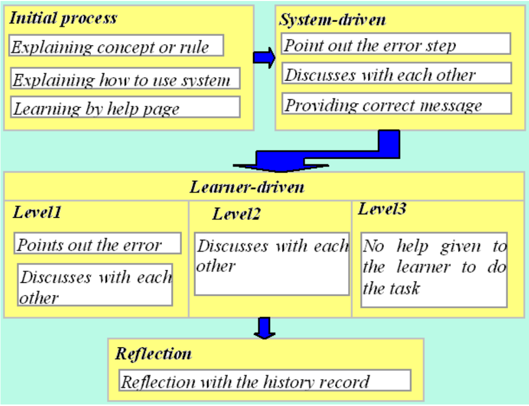

Figure 1 Design of SPS

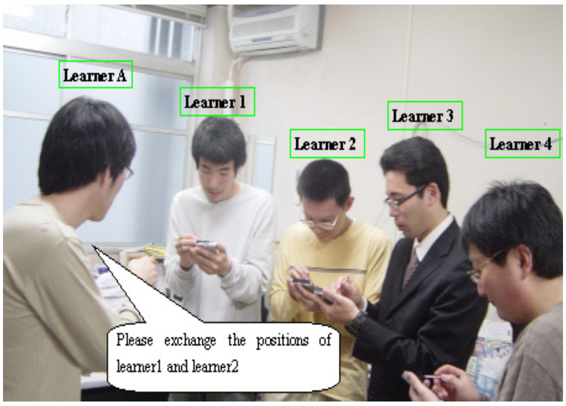

Figure 2 overview of Level3

2.2.1 Initial process. The teacher explains the concept (or rule), and point out the major emphasis, and then explain to learners how to use the system, at the end explanation will be conducted using the examples in help page. This is very useful to help learners to understand.

2.2.2. System-driven part. In the system-driven part, the system guides the learner to do the task step by step. The system-driven acts like a bridge used to enable learner to master the concept (or rule). All the learners do the task using PDAs. The system will give guide them on how to do the task. The learner could discuss and compare with his other learners by indication, before exchanging the position. Here, mistakes are expected from the learners, but the system will provide the learners with some information, which points out if the position is incorrect and how to correct them for the learners to be able to achieve the task. The learner comprehends through participation in the discussion and help from the system to understand the feature of this concept (or rule). There are three characteristics to support learners in system-driven:

1. Discussion and help with each other.
2. Pointing out the error position.
3. Providing messages to correct the error.

2.2.3. Learner- driven part. The learners use the learner-driven system to practice doing the task by themselves. When the learner masters the concept (or rule) on a certain level, the process of fading begins. The teacher will judge according to the level of understanding of the learners and reduce the system's help function gradually.

We design the learner-driven into three levels depending on the process of fading as in Figure1:

Level 1 only points out the error, but the method on how to correct it must be completed by the learners, and they can discuss and compare with his neighbouring learner, before exchanging the data.

Level 2 does not point out the error, and the learners have to correct it by themselves. They can discuss and compare with their neighbouring learner before exchanging the data.

Level 3 (see Figure 2) lets everyone do the task with the PDA. For example, there are 5 learners with PDAs named A, 1, 2, 3 and 4. Learner 1, learner 2, learner 3 and learner 4 each one represents a number and Learner A will have to rearrange the numbers according to the task. Learner A stands before them indicating how to do switch positions and do the task. Facing the other learners, leaner A orders them to exchange their position without discussion. If Learner A passes the third level, we can say s/he can complete doing the task independently.

2.2.4. Reflection. Every step is stored in the history record, after finishing the task, the learners can see the history of the each step, which points out the wrong positions for the learners and its corrections. With the history record learner can reflect the algorithm.

3. ALGOS

We use the SPS framework to develop the ALGOS system, which was modeled following the standard specifications of Java 2 Platform, Standard Edition (J2SE), and using Apache Struts, which used the MVC (Model-View-Controller) architecture scheme.

3.1 Architecture

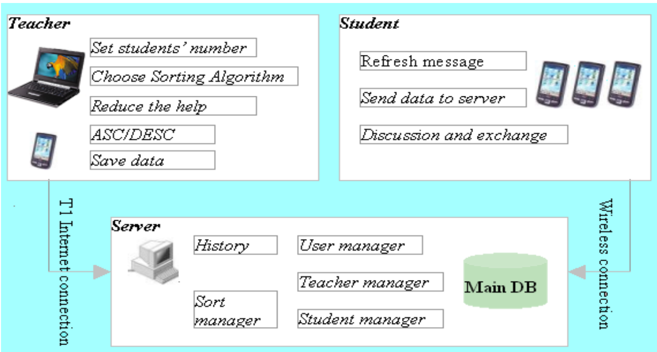

Figure 3.Architecture

There are 6 sorting algorithms in this system. They are bubble-sort, insertion-sort, selection-sort, quick-sort, heap-sort, and shell-sort. We set the number of students between 3 and 10 in the same time. There are three modules in system (see Figure 3).

1. Server module: The server will send messages to the teacher or the student. Each time after sorting, the server will accept data records from the student module and the server will save these data records automatically. With these records, the server will validate the sorting whether it is correct or not, and send messages to the students or teacher.

2. Teacher module: Teacher select the sorting algorithm, and set the number of the students, then choose either ascending or descending sort.

3. Student module: The students will get the data to be arranged from the server according to the ID of the students. Then the students have to analyze, compare, discuss, and swap the obtained data. The result will then be sent to the server and the server will make a comparison of the correctness of the result.

3.2. User Interface

We have designed the system as a central server, with two interfaces, the first one is a student interface, and the second one is a teacher interface.

Teacher Interface. As shown in figure 4 (A), there are three check options in this interface, one for error checking, the second one is the help message to correct the error and the third one is to choose either ascending or descending sort. Here the teacher can select the sorting algorithms and set the number of the learners and choose either ascending or descending sort. When the error checking option and help message option is on, it is in the system-driven mode, if one or all of them are off, this system is in the learner-driven mode.

Student Interface. As shown in figure 4 (B), it is the 'Student' window. There are also messages from server and the position of each number. The learner will change his physical location and the number position according to the sorting algorithm. The 'upload' button is used to send the result to the server every step. Students can also review the sorting algorithm here and also the number of loops for the algorithm.

(A) Teacher (B) Student

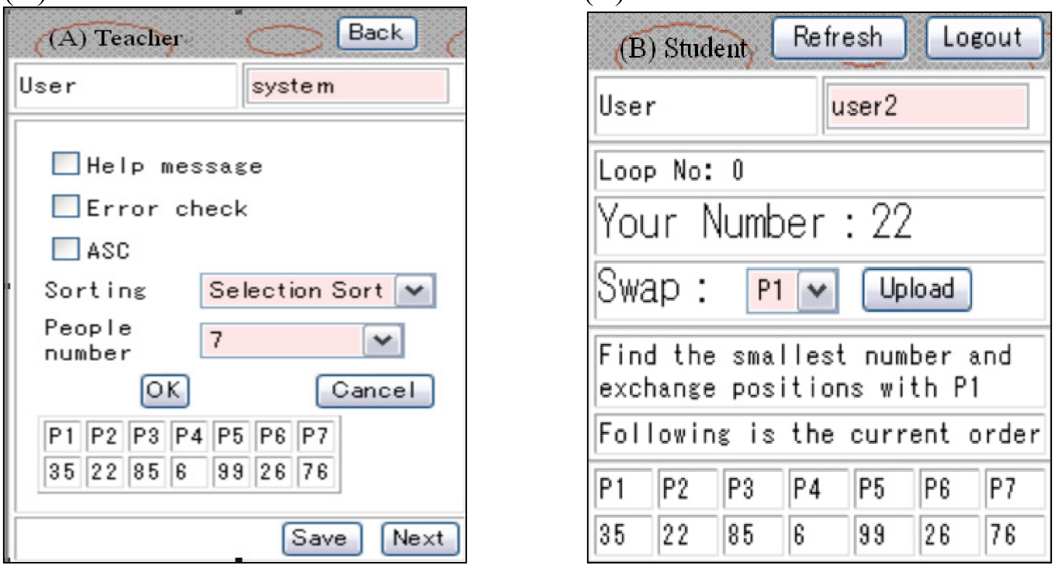

Figure 4. Interface

4. Experimentation

Figure 5. The scene of groups learning

For the experiment, we asked 30 learners to evaluate the system and divided them into 3 groups. Figure 5 shows a scene of different groups learning. And we divided the learner into 3 groups and named them A, B, and C.

After completing the experimentation, a system evaluation questionnaire was given out. The learners evaluated the system by grading each of 10 questions, which is given from point one being the lowest to five being the highest (1: totally disagree, 2: partially disagree, 3: Neither agree nor disagree, 4: partially agree, 5: totally agree). The average of the points was 4.0. Table 1 shows the results of the evaluations by the questionnaires.

According to Question (1), the system is helpful for learning algorithm. Question (2), the system checks each step and gives helpful information, the result was not as good because they said there are some message not point out the error position. Question (3), the evaluation was not as good because this was the first evaluation and the interface of system were not user-friendly enough. After that, we did some modifications on the interface the result of the evaluation improved. Modifications will be made gradually from time to time to improve the user-friendliness of the system. We also need more explanation for the learners how to use it. Question (4) shows they like using this kind of system to help learning.

From the results of question (5), they can understand the algorithm better after making mistakes. Question (6,7) show in this way, they can help each other well. Question (8, 9) shows that they can understand the algorithm deeply and was enlightened by the discussion. Thus, we are also thinking about how to enlighten and help to improve the understanding of learners learning sorting algorithms. In the discussion, they can tell each other what they comprehended. And they like the way of studying by discussion. Question (10) uses this history record to reflect the process of the sorting; they can reflect the process again. Some learner commented that by the history record they can know the whole process, and they can ponder and reflect the algorithm by the history records.

Most of learners commented that they could learn how to sort algorithm using this system, and it is a good way to explain the algorithm by the participatory simulation. This system gives the opportunity to the learners to see in practical how the sorting algorithms are done. But the system is not easy to used.

From the evaluation, we can observe that the students were able to learn better and enjoy the learning process in such group settings. Each group would compete with each other to be the fastest to sort the algorithm.

Table 1 Results of questionnaire.

	Questionnaire	AVG
1	Do you think this system is helpful for learning algorithm?	4.0
2	The system checks each step and gives helpful information; do you think it is helpful?	3.5
3	Do you think this system is easy to use?	3.2
4	Do you want to keep using this kind of system to help learning?	3.9
5	Can understand the algorithm better after making mistakes?	3.9
6	Can you understand deeply when you get help from the other learners?	3.7
7	Can you explain well when you help some else?	4.1
8	Do you understand deeply and enlightened by the discussion?	3.5
9	Do you think it is interesting to study while discussing with other learners?	4.2
10	How about using this history record to reflect the process of the sorting?	4.0

6. Conclusion and Future works

This paper describes the SPS framework, which was designed using scaffolding technique, SPS framework uses the participatory simulations method to realize authenticity, and in the framework, history records are then used to realize reflection. Based on SPS framework, the ALGOS system was implemented and evaluated. The teacher can use this system to help the learner to understand the algorithm deeply. We found that it was very easy for learners to understand and the main goal is achieved, whereby each learner understood the algorithm deeply. A major advantage of participatory simulations is the fact that learners learn to see patterns and understand coherences much easier. The communication and discussion is always an essential part of the learning process. The emerging field of mobile interactive services and participatory simulations improve learning especially in the case of complex problems.

This system is still not that user-friendly. Thus, we are planning to improve the interface and ease of usability, which will be a new topic to be explored in the future. We will have more evaluation of this system in the class to get feedback from the learners in order to test and improve it perfectly to achieve the goal of using it in class.

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