Participatory simulation framework to support learning computer science

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Abstract: This paper proposes a participatory simulation framework using the fundamental concepts in scaffolding and fading to support computer science learning called Learning Computer Science using Participatory Simulation (LCSPS). As an implementation, this framework is the basic for creating the Algorithms for Optimisation and Simulation (ALGOS) (PDA-based Learning Algorithms System) system to support learning sorting algorithm. Using ALGOS, the teacher can assign tasks to learners and ask them to do the task. Learners receive these tasks, collaborate together and exchange their physical positions according to the task assigned. The main purpose of ALGOS is to help the learners to deeply understand the feature of the algorithms.

Keywords: authentic learning; LCSPS framework; Mobile–Computer Supported Collaborative Learning; MCSCL; participatory simulation; scaffolding and fading.

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1 Introduction

Recently, with the evolution of improved wireless telecommunications capabilities, open networks, continued increases in computing power, battery technology, and the emergence of flexible software architectures, these technologies can be commonly used in mobile learning. The world becomes more fluid, networked, and complex, organisations will continue to be more mobile than ever before (Liebowitz, 2007). Mobile technology is associated with any device that is designed to provide access to information in any location, or while on the move. Specifically, this includes, but not limited to: wireless notebooks, tablet computers, mobile phones, and Personal Digital Assistants (PDA). One important field where mobile technology can make significant contributions is education (Barak, Harward and Lerman, 2007). Mobile computing offers potential opportunities for students' learning. It is important to have an operational understanding of the context in developing a user interface that is both useful and flexible (Uden, 2007). Mobile devices have become indispensable tools these days, the use of technologies for mobile applications is confined to those technologies that are faster and take small footprint in memory (Davidrajuh, 2007). Mobile devices (e.g. PDA's or notebooks) provide different services aiming at the improvement of interactivity and creating additional, computer-moderated channels for communication between the learners and the teacher. Further, mobile handhelds can easily be used in any classroom or field site; hence, they can be used more often than computer labs (Vahey and Crawford, 2002).

Using mobile devices for supporting collaborative learning are known as Mobile–Computer Supported Collaborative Learning (MCSCL). There are many projects using MCSCL in Tokushima University, such as CLUE (Ogata and Yano, 2003a,b), JAPELAS (Yin, Ogata and Yano, 2004). CLUE is a prototype system for embedding KA map, and facilitates to share individual knowledge and to learn through collaboration. JAPELAS is to support foreigners to learn the Japanese polite expression using PDA, anywhere at anytime.

Nowadays, there are more and more supported learning researches about MCSCL in order to enhance learning and teaching (Chen et al., 2002; Okada et al., 2003). Many studies have examined the use of wireless mobile devices in learning. According to (Roschelle, 2003), "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's learning positively across curricular topics and instructional activities".

MCSCL can be classified as follows:

1 *Classroom response system*. This is a system where learners can answer the teacher's questions immediately with a mobile device, and the system will then display the total result. According to this result, the teacher can grasp the level of understanding of each learner on 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 helps the learners to gain experience from real life, and deeply understand what they have learnt. The learner touches and feels the actual object. For example, the Bird Watching Assistance System (Chen et al., 2002) was developed for this purpose to support the learning environment.

3 *Participatory simulations*. This is to support the learners to understand the course content better through participation/practice. The learners use mobile devices to take part in a common participatory simulation. Through this active participation, the learners can discuss and get the correct answers, consequently understand better what they have learnt. For example, the Virus Game was developed by the Massachusetts Institute of Technology (MIT) (Colella et al., 1998) to explain the process of how a virus is spread. Another project, JAPELAS (Yin, Ogata and Yano, 2004) allows participatory simulation where learners play roles in different kinds of social situations.

4 *Others applications*. As like with other researches, systems are being developed in universities using mobile device such as the PDA to support study activity. For example, in Tokushima University, we have a project called BSUL (Basic Support for Ubiquitous Learning; Saito, et al., 2005) to aid study activity. Another project called Perkam (El-Bishouty, Ogata and Yano, 2006) allows the learners to seek for and share knowledge, interact, collaborate, and exchange individual experiences. The Perkam system recommends the appropriate educational materials and peer helpers.

In traditional education, only one way communication exists. The teacher teaches and the students listen. Traditional education is passive, lacks interaction, and sometimes complicated contents are hard to be taught and understood. Poor communication between students and teacher is one of the major problems in mass lectures. However, mobile devices can aid in reducing this problem and improve interactive communication help to increase the motivation of the students (Kopf et al., 2005). Innovative educational projects are evolving in response to the new opportunities that are becoming available by integrating advanced technologies (Barak, Harward and Lerman, 2007).

In this paper, we propose a participatory simulation framework to support collaborative learning, called Learning Computer Science using Participatory Simulation (LCSPS). Participatory role-playing activities have been commonly used in social studies classrooms, and have been infrequently used in science and mathematics classrooms (Wilensky and Stroup, 2000). Our focus is primarily on learning complicated computer science topics such as compression algorithm and graph theory. Making use of the LCSPS framework, the learner plays the role as a data in the simulation of logic to visualise the data flow of computers in the real world. This framework encourages more active participation and interaction among the learners.

LCSPS was designed using the scaffolding and fading concept, so the framework will give the right advice at the right time to the students. In the area of educational research, the term 'scaffolding' has been used to describe various instructional techniques for supporting learning activities that reflect authentic task situations. Scaffolding enables the learners to engage in out-of-reach activities; having a 'knowledgeable other' or 'more capable peer' to support the learners and 'share the cognitive load' (Jackson et al., 1996). The scaffolding concept has also been used in other researches such as the Bird Watching Assistance System (BWAS) (Chen et al., 2002) for collaborative data gathering to support the learning environment. This system offers a mobile learning system which supports the learners learning through scaffolding. The BWAS system contains a testing subsystem that evaluates each learner's level of learning. It has a structured-assistance learning system; more assistance is given for beginners, and as they become more proficient, less assistance is given. Learners in the system use mobile learning devices to acquire and learn through a wireless transmission tool anytime at anywhere. Evaluation from their experiences was undertaken and showed that the learners benefited substantially even though the scaffolding support was gradually withdrawn. It was also found that the learners who used the bird watching system improved their learning, above and beyond what would normally be expected they would learn.

As every step will be saved, the system can be restarted at any stage they want to do. Using the history record in this framework, reflection can be realised for better understanding.

Based on the LCSPS framework, we have implemented a sample system called Algorithms for Optimisation and Simulation (ALGOS) (PDA-based Learning Algorithms System) to help learners learn sorting algorithm. This system was then implemented and evaluated. In the following sections, we describe how scaffolding concept is used to design the LCSPS framework and how the LCSPS framework uses participatory simulation for computer science learning. Finally, we will describe the implementation and evaluation of ALGOS and our plan for future works.

2 Participatory simulation

During the past decade, 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, 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 (Vanessa et al., 2002). Learners 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 behaviours (Wilensky, 1999).

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 caught the attention of educators through the work of Colella (2000). Participatory simulation is an approach to improve the learning success and the motivation of students (Kopf et al., 2005). A major idea of participatory simulation is the concept of learning through doing. Learners participate in an active way, analyse information, make decisions, and see the outcome of their actions. This increases their motivation and the learning success improves (Papert, 1991). Thus, the LCSPS framework helps to improve interactive communication, and increases the motivation and enthusiasm of the learners.

Using LCSPS-based system, the teacher can assign tasks to the learners for them to execute. After the learners receive these tasks, they will collaborate together to do the tasks. The system supports the learners to do the tasks step by step, checks every step and gives feedback to the learners. This way, the learners can understand the logic or theory being taught through discussions, trial and errors, and when the learners master the logic on a certain level, the system will gradually reduce the help functions and more responsibility is shifted to the learners.

As mentioned above, we used the LCSPS framework to build the ALGOS system. When using this system, each learner holds a PDA and they will stand in a line. The teacher then assigns an array of numbers to them to sort according to a certain algorithm. The learners will solve the tasks by collaborating together and exchange their physical positions according to the algorithm. Each time when they exchange their positions, the new position of each step is sent to the server. The system will check it and feedback to the learners with the positions of the numbers if there is a mistake. The learners will correct the number positions and send the new corrected position again to the server. Through discussions, trial and errors, learners will have a better understanding of the sorting algorithm.

This research is advocated by pedagogical theories such as hands-on learning and authentic learning. Brown, Collins and Duguid (1989) define authentic learning as coherent, meaningful, and purposeful activities. When classroom activities are related to the real world, learners' understanding increases. There are four types of learning to ensure authentic learning: action learning, situated learning, incidental learning, and experimental learning (Ogata and Yano, 2004; Yin, Ogata and Yano, 2005). The LCSPS framework employs two forms of authentic learning; action learning, and experimental learning based on face-to-face communication. LCSPS framework brings the learners to learn in the 'real world'. The LCSPS framework also employs interactive learning. Interactive learning involves interactions, either with other learners, teachers, the environment, or the learning material.

3 Design of the LCSPS framework

We designed the LCSPS framework using scaffolding and fading. Here, we want to use the scaffolding concept to help learners to learn complex computer science theory step by step, and then reduce the help gradually until the learners can master the whole concept.

The LCSPS framework originates from traditional education 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 concepts or algorithms, they will normally only explain it literally and it is difficult to make it clear to the learners. To solve this problem, we used the scaffolding and fading concept to develop a mobile system as an extension of the traditional education to support learning.

3.1 What is scaffolding and fading?

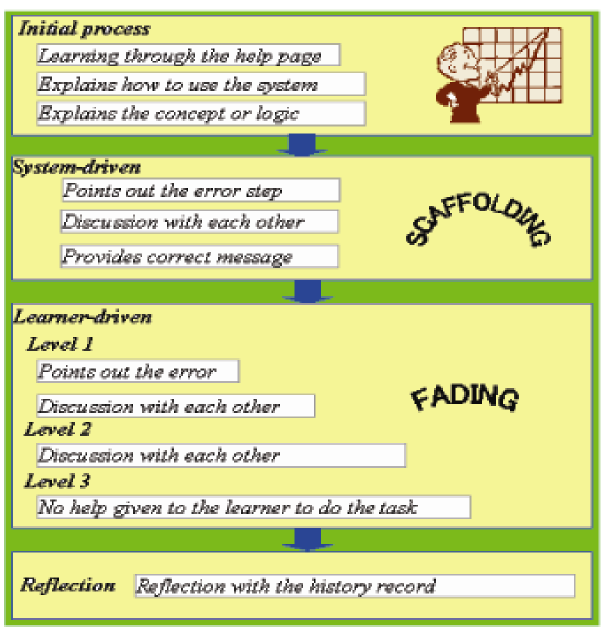
Before moving on to the framework, we would like to explain the term 'scaffolding'. The term 'scaffolding' comes from the works of Wood, Bruner and Ross (1976). It can be explained better with the following sample: Learning to ride a bicycle gives children a wonderful sense of accomplishment. A normal situation is of an adult running alongside a child, holding the bicycle steadily as the child gained speed and then let him or her wobble off independently, unaware that he or she was pedalling without support (Feldman, 2003). Scaffolding, as provided by human tutors, has been well established as an effective means of supporting learning (Soloway et al., 2001).

The timing of the scaffolding is very important. As the example above, when the child is just learning to ride a bicycle, it is necessary to hold the bicycle steadily to give him/her a wonderful sense of riding in the initial scaffolding process. But when he/she can pedal the bicycle without support but if we still hold on to the bicycle, it will hinder her/him to achieve more speed. Next, the gradual removal of the scaffold by letting go of the bicycle is necessary and thus begins the fading process. This fading process is important to allow learners to work independently.

3.2 Design of LCSPS framework with scaffolding and fading technique

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

Figure 1 Design of LCSPS framework



During the initial process of learning and problem solving, the teacher will provide general ideas, concepts, rules, and examples to the learners to guide them and to make sure the learners have a basic idea of what has to be learnt. Following that, the system-driven component will assist the learners by providing some instructions, the learner will gain experience from the aid and help messages to tackle the problems presented in the PDA. After some practices using the PDA to solve problems, the learners will gradually learn and understand the methods and techniques to solve the problem and when the learners become more experienced with the logic, the fading process is started where the learners use the learner-driven component to practice independently.

On the other hand, when the fading process begins, the system will reduce the help messages gradually and more responsibility is shifted to the learners. Finally, the learners will be able to solve the problems by themselves without the help of the system. At the end learners can reflect with the history records during the learning process.

3.2.1 Initial process

The teacher explains the logic, points out the major concepts and then explains to the learners how to use the system. Explanation will be conducted using the examples in the help pages to help learners to understand the system better.

3.2.2 System-driven

The system-driven uses the scaffolding concept to guide the learners to do the task step by step. This system acts like a bridge to enable learners to master the logic. PDA is used to execute the task. The system will guide them on how to do the task. The learners could discuss and compare with other learners before exchanging positions. Here, mistakes are expected from the learners, but the system will provide the learners with some information, which points out the position if it is incorrect and how to correct them during task solving. The learners comprehend the feature of the logic through participation in the discussion and help from the system. Three characteristics in system-driven to support learners:

- discussion and helping each other
- pointing out the error position
- providing messages to correct the error.

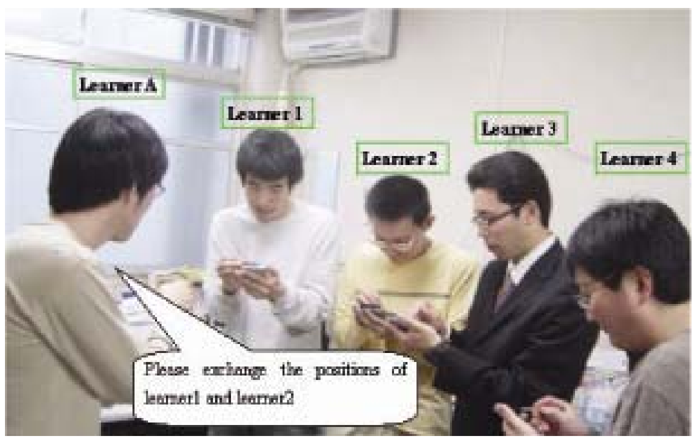
3.2.3 Learner-driven

When the learners become more experienced, the fading process is started in the learner-driven system. The learners use the learner-driven system to practice doing the task by themselves. When the learners master the logic 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 system into three levels depending upon the process of fading as in Figure 1:

- *Level 1* only points out the error and the correction that must be done and the learners can discuss and compare with their neighbouring learners, 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 learners before exchanging the data.
- *Level 3* (see Figure 2) everyone will complete the task by himself or herself in this level. For example, there are five learners with PDAs, namely, 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 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 that he/she is able to complete the task independently.

Figure 2 Overview of level 3



3.2.4 Reflection

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

3.3 Characteristics of the LCSPS framework

There are three main characteristics in this framework:

- The framework uses participatory simulation, and enables students to dive in a simulation just like in a game. Active participations and discussions in the system also help to increase their motivation to learn.

- The framework was designed using the scaffolding concept, providing the right advice at the right time to the students.
- Using the history record in this framework, reflection can be realised for better understanding. Also, every step will be saved allowing the system to be restarted at any stage.

4 ALGOS

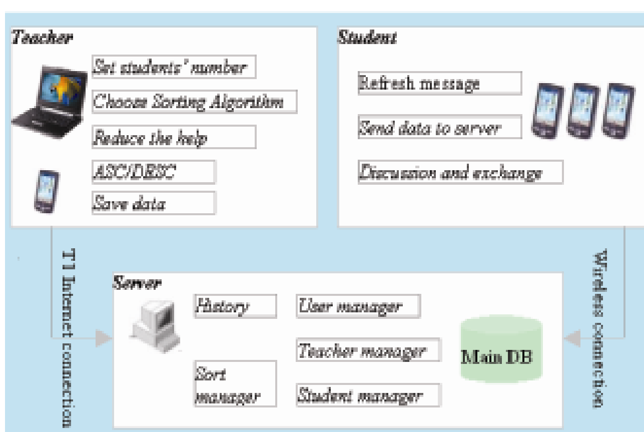
We use the LCSPS framework to develop the ALGOS system, which was modelled following the standard specifications of Java 2 Platform, Standard Edition (J2SE), and using Apache Struts, which uses the MVC (Model-View-Controller) architecture scheme. We chose this architecture because of its reusability components and the previous experience in developing web applications under this specification (Ayala and Saito, 2003). Apache Struts is based on the structure of MVC (Model-View-Control). Struts-config.xml is an important partial disposition file of control, which defines alternations between the pages, and works like the event mechanic for the user's interface.

An exciting aspect of wireless mobile technologies for education, as described in the literature today, is that tools that first existed only on expensive desktop machines are now being made available on inexpensive handheld units (Soloway et al., 2001). We used wireless LAN (IEEE 802.11b), Tomcat 5.0 as the server and runs it on the desktop computer. On the other hand, learners run this system on a Pocket PC2003 with an Access database. We have finished the development of the system and are described as follows:

4.1 Architecture

There are six sorting algorithms in this PDA participatory simulation system. They are Bubble Sort, Insertion Sort, Selection Sort, Quick Sort, Heap Sort, and Shell Sort. We can set the number of learners between 3 and 10 to learn at the same time. There are three modules in the architecture of system (see Figure 3).

Figure 3 Architecture of system



4.1.1 Server module

The server will send messages to the teacher or the learners. Every time after sorting, the server will receive data records from the learner module and the server will save these data records automatically. With these records, the server will validate the sorting whether it is correct, and send messages to the learners or teacher.

4.1.2 Teacher module

The main job of the teacher module is to select the sorting algorithm and set the number learners. After the random data is generated, the teacher sends this data to the learners. The teacher can use a desktop personal computer or a PDA for this purpose.

4.1.3 Student module

The learners will get the data to be arranged from the server according to the ID of the learners. Then the learners have to analyse, 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. At the same time, the teacher can view the result and also measure the understanding of the learners and revise any new ways to explain the compilation of data.

4.2 User interface

We have designed the system as a central server and as in Figure 4; interfaces (A) and (B) are for the teacher while (C) and (D) are for the learners. The teacher will do the settings as in (A) and then will confirm the settings as in (B). The system on the learner side starts with an initialisation page as in (C) followed by a page for sorting with help messages in (D).

4.2.1 Teacher interface

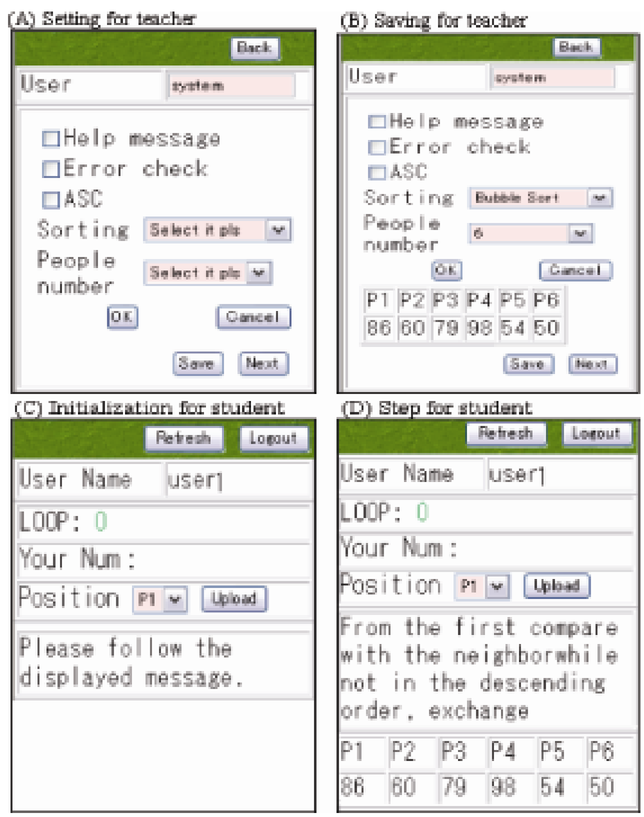
As shown in Figure 4(A), there are three checkboxes in this interface, for error checking, a help message to correct the error and a choice for either ascending or descending sort. When the error checking option and help message option is on, it is in the system-driven mode, if one or all of them are off, this system is in the learner-driven mode.

The teacher logins as a teacher user, the teacher's window will appear as shown in (A). In 'Setting for teacher' window, the teacher can select the sorting algorithms and set the number of the learners. After the selection, the numbers and first-time position will appear as in (B). In the 'Saving for teacher' window, the system will generate a list of random of numbers and send this list and the position number to the learners. P1, P2, P3, …, PN are the positions of the numbers and this data will be saved in the database, these are all the settings for the teacher. Then, when the teacher clicks 'next' the sorting will be started. The system will assign one number in this list to each learner. The system also will assign one number in this list to each PDA.

4.2.2 Student interface

As shown in Figure 4, when learners login with the user ID, the (C) 'Initialisation for learner' window will be shown. When it is refreshed, the number of the users will appear as in the (D) 'Step for learner' window. There are also messages from the server and the position of each number. The learner will change his/her location and the number position according to the sorting algorithm. The 'upload' button is used to send the result to the server after every step. Learners can also review the sorting algorithm here and also the number of loops for the algorithm.

Figure 4 Interface of system



4.3 Scenario

This is a scenario of using the system of learning algorithm with ALGOS. Figure 5 is a sample of the bubble sort algorithm. In each loop, circled numbers are correct and fixed while the underlined numbers indicate that these positions require changes in next loops. In the evaluation conducted in a sorting algorithm class, there were altogether 21 students and a teacher. The students were divided into three groups and were instructed to use this system at the same time. In this case, the teacher has chosen the bubble-sorting algorithm.

The system generates the data randomly and sends them to the learners. In the example shown, the array list "84, 94, 43, 93, 96, 83, 14" will be sorted descending. Learners will stand in a line with a PDA, which displays their numbers and positions.

Figure 5 Bubble sort

	P1	P2	P3	P4	P5	P6	P7
Start	<u>84</u>	94	<u>43</u>	93	96	83	14
Loop1	94	<u>84</u>	93	96	83	43	14
Loop2	94	<u>93</u>	96	84	83	43	14
...	<u>94</u>	96	93	84	83	43	14
End	96	94	93	84	83	43	14

Before using the system, the teacher explains the concept of the sorting algorithms and how to use the system, and then the learners will read the help instructions in the system.

At first the teacher chooses the option with error checking and help message, so it is in the system-driven mode. The system will give hints and instruction to solve the problem. In loop 1, a help message like this will appear initially: "The first person (in this case P1) compares and changes his position with the neighbour if it is not in descending order". After discussion and comparison, the new position is uploaded to the server. The students will also change their physical standing position in the line. The server will evaluate the change of positions and send an error message if the change was done incorrectly. In case of mistake in the change of positions, the message will then point out the error position and ask the learners to correct it such as: " Numbers 84 and 94 are not in descending order, please change your positions". Conversely, if the positions were changed correctly, the server will generate a message like this: "P2 and P3, please compare your order and upload the new positions". As in the case of P1 and P2, if the change was incorrect, the server will generate a message to aid the learners again and vice versa if the change was correct. This process is also carried out for the other learners until P7.

As we move on to Loop 2, each learner will discuss and compare with his neighbour learners according to the messages from server as in Loop 1 and this process goes on for a few loops depending upon the problem until the whole array is sorted.

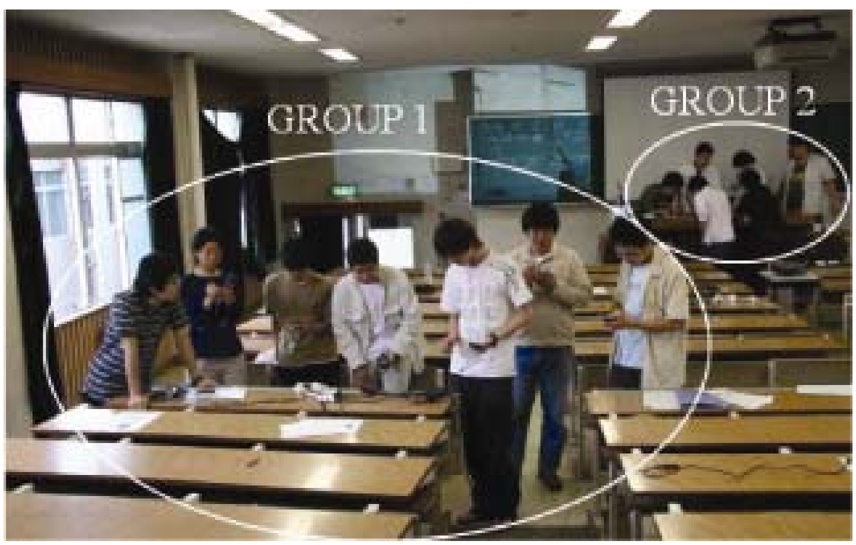
When the learner masters the bubble-sorting algorithm on a certain level, the teacher will turn off the help message option, now it is in the level 1 of the learner-driven mode. The system only points out the error position and the learners can discuss with each other to solve the problem. Then, the teacher will turn off the help message option and error checking option, thus changing it now to the level 2 of the learner-driven mode, the learners discuss with each other to solve the problem. In the end at level 3, one student stands before another student to instruct them how to switch positions and do the task.

5 Evaluation and experimental results

In order to verify the effectiveness and evaluate the usability, we got some feedbacks from the users of this system. We have evaluated this system using two methods. In the first method, every group was given the same set of data to be sorted using one sorting algorithm, while the second method of evaluation is that every group was given the same data to be sorted but with various sorting algorithm to solve the problem. Using the first method, as we know of human nature, learners will be motivated to compete with other groups to solve the problem in the quickest time. This creates a healthy competition and helps to increase the interest of learners while learning. As for the second method, students are using different sorting algorithms and this can help them to understand which sorting algorithm is faster or more effective for sorting.

We asked master students who have learnt the sorting algorithm about three years ago when they were undergraduate students to use the system. Most of them have not used sorting algorithm for a long time so they have forgotten the rule of the sorting algorithm. We are proposing that they can use the system to review the algorithm again. We chose learners who have not used sorting algorithm for a long time to get their feedback and the efficiency of relearning the sorting algorithm using the system. Figure 6 shows a scene of using ALGOS.

Figure 6 A scene of using ALGOS



5.1 First method – same sorting algorithm

In the first method, every group was given the same set of data to be sorted using one sorting algorithm. We asked 21 students to evaluate the system. Twenty-one PDAs were used in this system. We divided the students into three groups. 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. After completing the experiment, we obtained some comments such as "Our group tried our best to beat the other three groups to solve the problem as fast as possible to show that we can understand the algorithm better". So we can conclude that this framework helps to improve interactive communication while increases the motivation and enthusiasm of the learners.

5.2 Second method – different sorting algorithm

In the second method, every group tried to sort the data with different algorithms. We also asked 21 learners to evaluate the system and divided them into three groups. We can observe that the time used varies among the groups. After completing the experiment, we obtained some comments about the different algorithms used and most of them concluded that the quick sorting algorithm gives the shortest time for sorting.

5.3 Questionnaire

Every time after the experiment is completed, a system evaluation questionnaire was given out. The learners evaluated the system by grading each of the 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 and 5: totally agree). Table 1 shows the results of the evaluations by the questionnaires.

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 some information; is it 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 someone 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 and video to reflect the process of the sorting?	4.0

According to Question (1), the system is helpful for learning algorithm. Question (2), the system checks each step and gives helpful information, but some messages did not point out the error position clearly. Question (3), the evaluation was not as good because in the first evaluation the interface of system was not user-friendly enough. After that, we did some modifications on the interface and 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 to add more explanations for the learners to use the system. 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. Questions (6 and 7) using this method, they can help each other well. Questions (8 and 9) show 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 while learning sorting algorithms. In the discussion, they can tell each other what they have comprehended. And they like the way of studying by discussion. Question (10) uses this history record and video to reflect the process of the sorting; they can reflect the process again. Some learners commented that through the history record and video, they understand the whole process, ponder and reflect on the algorithm.

We obtained some comments as in Table 2. Most of the learners commented that they could learn about sorting 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. The system is similar to play games in class. It is more interesting than just by learning using teaching material. The only disadvantage was that the system is still not user-friendly enough.

Table 2 Comments

	What do you think about this learning method?
1	It is very easy to be understood using this way of teaching algorithm.
2	We can exchange our views on the solution of the algorithm and get the best way to solve the problem.
3	In this way, I can get help from the other learners.
4	Studying in this way is just like studying in games.
5	Learning from using the system is more interesting than learning from teaching material in a normal class setting.
6	We can do revision on the algorithm learnt in class with this system.
7	Please improve the interface.

6 Conclusion and future works

In this paper, we have proposed the LCSPS framework, which was designed using scaffolding and fading technique. The LCSPS framework uses the participatory simulations method to realise authenticity, and in the framework, history records are then used to realise reflection. In normal classes, students only listen and read. Using the system based on the LCSPS, students not only listen and read but also study through discussion with each other and doing practical tasks. Making use of the LCSPS framework, the learner plays the role as a data in the simulation of concept (or rule) to visualise the data flow of computers in the real world.

Based on this LCSPS framework, as a sample system, the ALGOS was implemented and then evaluated. From the evaluation, we conclude that by using the ALGOS, learners can understand the algorithm deeply through their discussions, trial and errors, and the system is useful for learning algorithms. The communication and discussion is always an essential part of the learning process. Most of the learners commented that they could learn how to sort algorithm using this system, and it is a good and interesting way to explain the algorithm by the participatory simulation. We can conclude that the LCSPS was a good framework to help learners to understand the complicated computer science deeply, and it can also improves the interactive communication, increases the motivation and enthusiasm of the learners. 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 use this system in the class to get more in-depth feedback from the students in order to test and improve it to achieve the goal of using it in class.

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