An Interactive Multi-touch Teaching Innovation for Preschool Mathematical Skills

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Abstract **-The paper proposes a teaching medium that is suitable for preschool children and teacher to develop basic mathematical skills. The research applies the bases of Multi-touch and Multi-point media technologies to innovate an interactive teaching technique. By utilizing Multi-touch and the connectivity structure of Multi-point to create a technology that facilitates simultaneous interaction from child learners, the teacher can better adjust and adapt the lessons accordingly. The benefit of this innovation is the amalgamation of technology and new idea to supporting teaching media development that permits teachers and students to interact to each other directly, as well as self-learning by themselves.**

Keywords-Multi-touch; Multi-point; preschool mathematical skills; interactive teaching technique.

I. INTRODUCTION

Preschool learning is the first step education that supports child learners in all aspects, e.g., physical, intellectual, professional, and societal knowledge. One of the most urgent and important activity to build their learning is teaching media due to the significant role in disseminating knowledge, experience, and other skills to children. There are numerous teaching media for preschool level, ranging from conventional paper based, transparencies, audio, video, and computer based media. The latter is the principal teaching vehicle which has played an important role owing to its usefulness and convenience. Children can learn by themselves [1, 2] and be independent from classroom environment.

This research aims at using the connectivity of Multi-point technique and Multi-touch approach as the platform and underlying research process to develop proper stimulating media for preschool children to learn basic mathematics. The paper is organized as follows. Section 2 and 3 briefly explain Multi-touch and Multi-point technologies. Section 4 describes the proposed approach, followed by the experiments in Section 5. The results are summarized in Section 6. Section 7 concludes with the benefits and some final thoughts.

II. MULTI-TOUCH

Multi-touch [3] is a technology that supports several inputs at the same time to create interaction between the user and the computer. The system responds to finger movement as commands issued by the user, e.g., select, scroll, zoom or expand, etc. Fig. 1 shows multiple fingers touching on several areas of the screen simultaneously, thereby mimicking interactive reality of learning that stimulates high alert attitude.

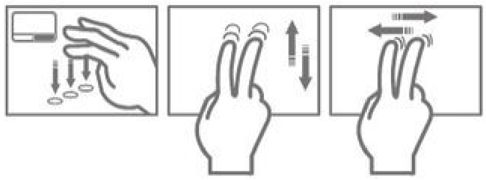

Figure 1. Multi-touch display and finger movement control

III. MULTI-POINT

Multi-point [4, 5] is a multiple computer connection structure developed by Windows [6] for educational institutes or learning centers. It uses one host to support multi-user interface, permitting simultaneous user's responses. The underlying configuration is different from conventional client-server (C-S) model in that communication exchange in C-S takes place between client and server in a pair-wise manner. Any exchange among clients is implicitly routed through the server. On the other hand, Multi-point is a simulcast among peer where everyone can see one another simultaneously and interactively. This is shown in Fig. 2. The result of such connectivity scheme is less expenditure, power consumption, easier to manage which is ideal for classroom environment.

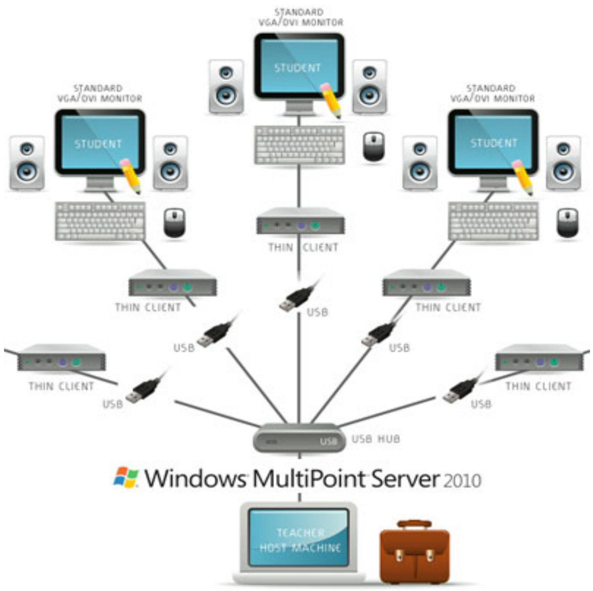

Figure 2. Connectivity of Multi-point scheme

This research applies both technologies by connecting several teaching aids with the help of interactive teaching media. The media in turn facilitate simultaneous teacher's involvement and children's interaction. Teachers can teach and observe the students, while the students can react to the lesson promptly. Thus, lessons and practical exercises can be explained, worked out, and corrected on-the-spot. As such, the teacher can design the lesson and accompanying exercises in an unobtrusive and unbounded by physical means. Conventional preschool teaching employs Computer Assisted Instruction (CAI) [7] which provides media in sentences, images, graphics, charts, graphs, videos, movies, and audio to present the contents, lessons and exercises in the form of banal classroom learning. Teaching by CAI can only create interaction between the learner and the computer. On the other hand, the proposed approach instigates and collects responses from several children. The children collectively learn, collaborate, express individual's opinion, and react as they proceed. This in turn stimulates their interest and thought process for better understand and knowledge acquisition.

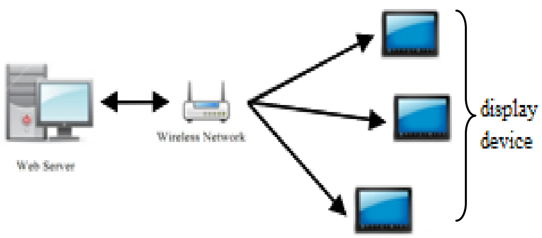

Figure 3. device connection

Fig. 3 shows the inter-connection of electronic devices for basic preschool mathematics which consists of a Web server controlled by the teacher to observe individual child learning. The exercises are designed and broadcasted via duplex wireless means that allow the student-teacher to interact back and forth collectively at the same time.

IV. INTERACTIVE MEDIA TEACHING

Numerous educational media to create learning lessons are prevalent in this digital age. CAI perhaps is a predominant technique being adopted in all levels of teaching. Unfortunately, the-state-of-the-practice falls short of conveying "effective" teaching that inspires learning toward knowledge. The limitations of CAI technology precludes the teacher and students from interacting to one another simultaneously. Thereby spontaneous thinking and feedback can never be motivated and learned systematically. We shall explore the principal functionality of an interactive teaching innovation.

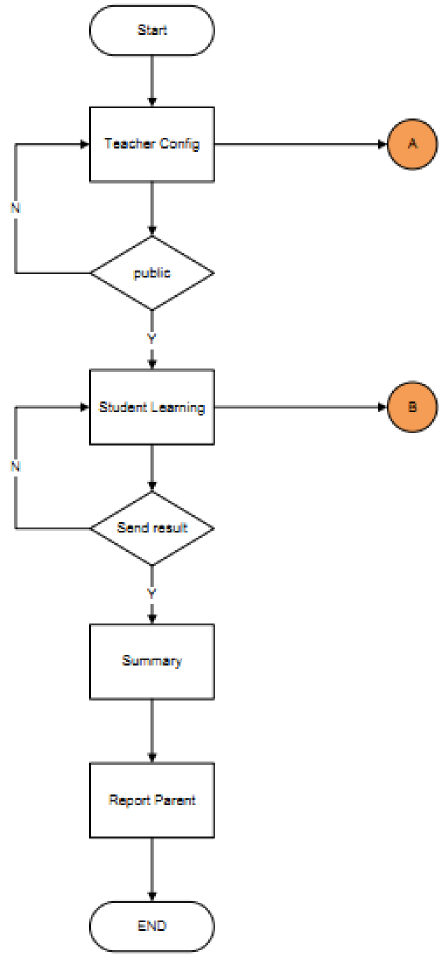

Figure 4. Flow of interactive media teaching

Fig. 4 illustrates the flow of media set up for interactive teaching. We exploit Multi-point principle to attain higher children's interaction through latest electronic devices and Multi-point technology. By strategically creating exercise in the form of interactive game to sense the use of multiple fingers touching, their thought process, while stimulating their interests through game playing, the teacher can observe the children's behavior from their own screen to faster and easier access and respond to the development of each child. Thus, they can promptly monitor, instruct, or sharpen the skill of individual child or the whole group, without having to repeatedly recite the same instruction to every child in the conventional classroom setting.

Some of the benefits precipitated from Multi-point principle are:

1. Instant children and teacher interaction through easily understood media of instructions.
2. Flexibility of creating or enhancing teaching media to motivate children's interests, thereby lessening learning boredom.
3. Strengthen early childhood skills with the help of drawing and graphical illustrations.
4. Increase the speed of cognitive learning in children so as to facilitate subsequent skill development evaluation.

We will elaborate how the proposed scheme works out in the sections that follow.

A. *Teacher Preparation Configuration*

Instructional aids are accomplished via our tool which permits customized display format through simple set up configurations. The teacher can prepare her lessons and companion exercises off-line and upload or post them to the system database. The children will have access to all the materials once upload or posted. Any un-posted instructions, lessons, and exercises will not be accessible by the learners' display device. The process flow is depicted in Fig. 5

B. *Student Learning Process*

The process begins with student's sign-in to identify himself. He then selects the lesson or exercise set to work on. All the activities are monitored from the teacher's console where the results are made available instantly. The process flow is depicted in Fig. 6

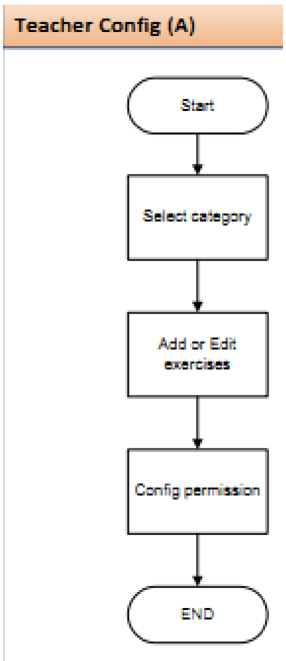

Figure 5. Preparation process of the teacher

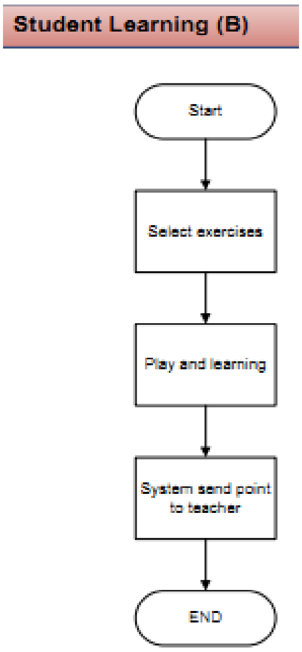

Figure 6. Flow of student learning process

Fig. 5 illustrates the teacher preparation process that proceeds as follows:

1. Select a topic to prepare the lesson.
2. Add or modify the exercises if the exercises are already prepared in the early session.
3. Upload/post the materials in the database.

In the meantime, the teacher can monitor the students' behavior during the lesson as follows:

1. Select the child to be monitored from list.
2. Observe their work.
3. Assess the results to analyze their behavior and development.

C. *Skill test by Bloom's Taxonomy*

Learning evaluation is carried out based on Bloom's Taxonomy [8] in the following aspects:

- Media skills test
- Subject comprehension from doing exercise
- Self practice

The evaluation will adopt three basic indicators given in Table I, namely, Knowledge, Comprehensive and Application to measure the effectiveness of the proposed interactive teaching innovation. This is accomplished via actual preschool class setting by means of CIPP model to be described in the next section.

TABLE I. THREE LEVELS OF EVALUATION BY BLOOM's TAXONOMY.

Level	Evaluate
Knowledge	Able to tell the meaning of positive or negative sign, matching, and shapes.
Comprehension	Know how to complete arithmetic operations
Application	do exercise by themselves

D. *Learning evaluation by CIPP model*

This research makes use of CIPP model [9] to evaluate the class performance with respect to the following criteria: score, learning time, degree of satisfaction, and the ratio of learning per expense. The evaluation is performed in accordance with the CIPP capabilities as follows:

Context: all required class materials from course syllabus are divided into individual topics and subtopics successively. Each subtopic is further broken down into stories so that subject contents can be presented. The corresponding companion exercise are either embedded or added to the end to furnish as many hands-on drills as possible.

Input: the above multimedia lessons are measured to test/monitor the children's skill development, particularly multi-touch drills. The indirect benefits precipitated from this design are duration of work and satisfaction.

Process: a number of evaluations are applied through Multi-point and Multi-touch technologies. For example, the time spent on exercise creation and modification, session evaluation, and cost ratio, etc. In addition, interactive monitoring, collaboration, and assistance, instant results display (upon their availability), and information transfer to/from server, etc. The savings so obtained are the utmost achievement of this innovative approach.

Product: the instantaneous interaction between children and teacher, and the rate of self-learning upon score improvement, result in tremendous skill improvement and experience in new technology. Thus, both score and user's satisfaction improve considerably.

V. EXPERIMENTAL RESULTS

The experiment was run on a Windows-based server that supports two iPad display devices (to be used by a preschool class). The proposed approach focused on a preschool mathematics class, where children learned basic arithmetic operations through interactive visual lesson and exercise. Students retrieved their lesson and corresponding exercises from the Multi-point teaching media system. As the learning progressed, they collaboratively worked on the lessons, exercises, and other activities via the multi-touch system. Their responses were record interactively (including corrections, reworks, etc). The results were instantly processed and made available in the teaching archive. The process is shown in Fig. 7.

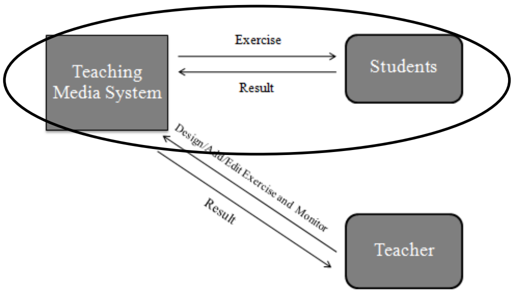

Figure 7. Flow of preschool mathematics exercise

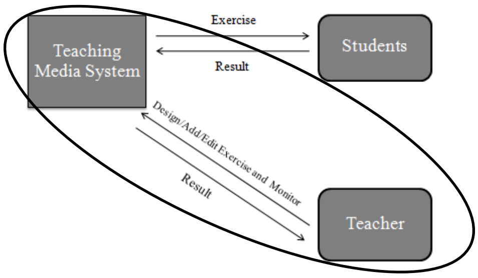

Figure 8. Flow of design, modification, and monitoring exercise

Figure 9. Sample math exercises

Fig. 8 shows the flow of lesson and exercise creation, modification, and monitoring the students' activity interactively through the teaching media system. Individual student's screen can be selectively monitored, assisted to correct errors or when help is needed, and observed and reviewed their performance via summary on score, frequency of attempts, reworks, etc. All of which are supported by Multi-point technique. Fig. 9 illustrates sample mathematics exercises.

We conducted student's performance and teacher's productivity evaluations to measure the accomplishments of both parties under the proposed system in comparison with conventional CAI system. The evaluations measured two instructional media on the same and different lessons. From the students' standpoint, the lesson was designed to observe how students would learn by drawing analogy from the same lesson and accumulate their skills from different lesson. From the teacher's standpoint, this would gauge how productive the teacher performed on the same and different lessons.

Several measures were collected and categorized according to student and teacher, namely, exercise score (D), duration of work (E), and degree of satisfaction (F), as shown in Table II, and time spent on creating exercise (M), time spent on one session evaluation (N), and ratio of learning per expense (P), as shown in Table III. For example, the exercise score obtained from the students learning the same lesson using CAI is 5 out of 10 as oppose to 8 out of 10 problems via Multi-point. In learning different lessons, the exercise score drops to 1 out of 10 from CAI, but still remains decent at 4 out of 10 problems by Multi-point. Similarly, Multi-point outperforms CAI by one hour for the time spent on creating exercise by the teacher in both cases. The same outcomes hold true for learning per expense where more teachers agree on the effectiveness of Multi-point than CAI approach. The corresponding plots are depicted in Fig. 10-13, respectively.

TABLE II. STUDENT PERFORMANCE EVALUATION

Detail	**Same Lesson**		**Different Lessons**	
	CAI	***Multi-Point***	***CAI***	***Multi-Point***
D	5/10	8/10	1/10	4/10
E	20 min	13 min	45 min	30 min
F	9/15	12/15	5/15	9/15

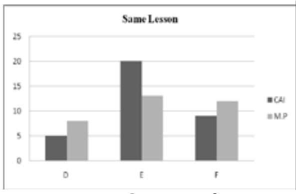

Figure 10. Students' performance on the same lesson

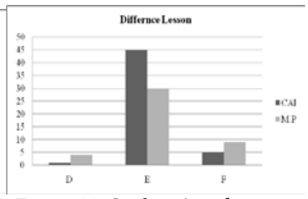

Figure 11. Students' performance on different lessons

Table III. TEACHER PRODUCTIVITY EVALUATION

Detail	**Same Lesson**		**Different Lessons**	
	CAI	***Multi-Point***	***CAI***	***Multi-Point***
M	4 hr.	3 hr.	4 hr.	3 hr.
N	60 min	20 min	85 min	25 min
P	7/15	13/15	4/15	9/15

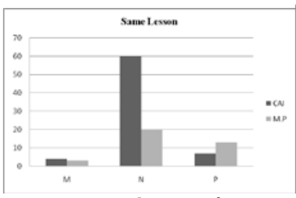

Figure 12. Teacher's performance on the same lesson

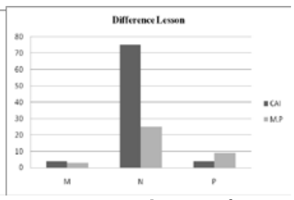

Figure 13. Teacher's performance on different lessons

From the overall comparative evaluation, it is apparent that the use of Multi-point and Multi-touch technologies is more effective than the conventional CAI approach from both student and teacher's standpoint. The obvious initial investment is fully offset by better score, less time, higher satisfaction on the student's part, and more production and cost effective on the teacher's part. The percentage of agreeable opinion on electronic media adoption is illustrated in Fig. 14.

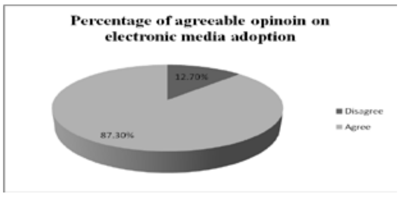

Figure 14 Percentage of electronic teaching media adoption

VI. CONCLUSION

We have proposed an interactive teaching innovation for preschool children to improve their mathematical skills. The contributions are two folds, (1) the teacher can instruct and monitor preschool children's development in real-time, promptly obtaining class evaluation, delivering lessons, and become more economically productive over conventional CAI approach; and (2) preschool children can improve their mathematical skills, or knowledge in general, by interactive means. They will become more enthusiastic to explore new ideas, express themselves, and gain confident and self-esteem as they progress. The proposed approach is simple and straightforward to realize. The underlying configuration exploits Multi-point to simultaneously connect students with the teacher, while interactively furnishes spontaneous communications among them. In the meantime, students can collaboratively work on the exercise to enhance their learning skill via Multi-touch technology. The resulting amalgamation is an innovative scheme which is subsequently implemented as a teaching tool.

We targeted at developing their mathematical skills to gauge how the overall configuration will work out. The comparative summaries with conventional CAI turned out to be superior and satisfactory in many regards.

We envision that the proposed system can be further extended to operate on larger network scale, whereby wider student audience can be reached.

ACKNOWLEDGMENTS

We would like to express our special appreciation to teachers and students of Samsen Nok School and Phacharard Kindergarten School for their courteous cooperation and invaluable time for this research.

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