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Construction of the e-PAYA for Technology-enhanced Learning in Kindergarten

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Abstract

This paper presents an experimental study on young children's off-task behaviors with and without the designed system called e-PAYA (PA for pat, YA for yell) which comprises learning devices, a sensory input device, a wireless local network and RFID software. We demonstrate the impacts on learning by applying e-PAYA in storytelling. The research methods include observation, questionnaire survey, interviewing and experiment. Sixty 4-year-old children were selected from a private preschool in Taipei City. Half of them were arranged in an experimental group with e-PAYA, with the others in a control group without e-PAYA. The proposed framework was designed, implemented and validated through a prototype system. The results show that there are significant differences in regard to group and gender. With e-PAYA, frequency analysis shows that on-task performance is significantly greater than that in the control group (p=.001).

Keywords

On-task Performance; RFID; Interactive Device; Technology-enhanced Learning

Introduction

Digital learning has already been applied in primary schools; however, there is a lack of related studies on the impacts of technology in preschools. Preschool teachers are used to tell stories by using a picture book that is too small to attract all of the children's attention. Children were easily distracted, which caused off-task behaviors. This phenomenon is the rationale for this study. To avoid the phenomenon, the authors aimed to determine whether interactive technology was a possible solution to the loss of attention on the part of young learners. It was required that a proposed framework be designed, implemented and validated through a prototype system entitled e-PAYA. This study is the first to develop the e-PAYA for preschool children, by employing sensors, RFID tag and reader, and a database. Secondly, this study aimed to assess the impact on learners' on-task performance after implementing e-PAYA in storytelling activities. To achieve the desired purpose, an experiment was conducted in a preschool, and its effectiveness was evaluated. In summary, the purpose of the study is listed below.

1) To explore which part of the e-PAYA that preschool children prefer after the development of the e-PAYA.

2) To analyze the advantages of e-PAYA for preschool children.

3) To examine task-off behaviors during the storytelling process between groups.

4) To examine learning effectiveness between groups and the gender after the storytelling.

Related Research

A large body of the research focuses on how computers and technologies can support collaborative learning through communication, primarily through verbal interaction and social negotiation (Taciana, & Sara, 2009). Multimedia tangible technology has been demonstrated to benefit disability groups (Garzotto, & Bordogna, 2010). Related research supports the view that teachers of young children can apply computers to facilitate the development and learning of their students. Specifically, technology helps teachers to select and use software and hardware that are developmentally appropriate for children. Also, it promotes important learning outcomes. Surveys of teachers found that 49% rated the level of importance of computers and technology for the development of young children as high, and 33% rated the level of importance as somewhat high for the educational development of young children (Barbuto et al., 2003). With respect of age differences and technology, Al-Mousawi and Alsumait (2012) applied iPad for storytelling and found that 4-year-old children were

more interactive than 5-year-olds; however, there was no gender difference in improving their communication skills by iPad. Also, Read (2012) measured the experience of children with technology and found that some of the differences in the way children of different ages use the Fun Toolkit. Research on gender differences in behavior toward computers has increased in the past 20 years. Girls performed better in animation and boys did better in broadcasting (Hale, 2005).

Instructional Media

Instructional media allows children to become immersed in creative learning activities (Mayesky, 2002). Conventionally, instructional media include: videotapes and movies, photos, cassette tape recorders, overhead projectors, compact discs and disc players, etc. Most of these are employed as individual entities; and there is a lack of integration, interaction, database, and so on. Practitioners employed media in teaching without reflection about how children can take the initiative in interaction with the media. However, practitioners considering the use of multi-media should ask themselves, "How do I expect the multi-media to make learning fun and effective?" (FSU, 2010) How can practitioners know whether children have learned? In this research, e-PAYA was designed to attest effective teaching through instant feedback of children's learning instances. In particular, children were expected to have fun due to the connection between multi-media (audio and graphics shown on screen) and activities via the e-PAYA.

Interactive Technology

With regard to how interactive technology, such as in augmented environments, can be best exploited to support learning, research told us that, in general, augmented sound/narrative may have a powerful effect on children's information acquisition (Hinske et al., 2010). One of the earliest studies in the field made direct comparisons between digitally augmented and non-augmented equivalent environments (Mitsuhara et al., 2007). Predictably, the findings indicated that interactive technology encouraged children to immerse themselves in the learning situation and helped them to maintain their attention. This result is important from the viewpoint of learning because it is necessary for children to be motivated and to maintain their learning motivation when dealing with difficult learning topics. However, they did not examine what learning effectiveness these interactions can provide. In this study, an analysis was conducted on learning effectiveness.

There are related researches on interactive technology, such as a complete teaching tabletop interaction system, comprising wireless object tracking technology with a graphical display and audio feedback (Khandelwal, & Mazalek, 2007). As there is no database available in such a teaching table, learning effectiveness is limited to just 'one time learning'. In this paper, the e-PAYA was designed with a database so that teachers can obtain children's learning profiles for self-comparison and norm-comparison.

Accordingly, the research hypotheses are summarized based on the purpose of the study after literature review.

1.1) Experimental group of children was attracted by the luminance and sound feedback, the appearance of a representative face on screen, instant learning feedback after children had touched the e-PAYA.

1.2) The e-PAYA enhances children attention.

1.3) The e-PAYA made learning fun.

2.1) Experimental group children felt that e-PAYA activity was fun, and enhanced their interest in learning.

2.2) The e-PAYA facilitates teaching efficiency.

2.3) The e-PAYA creates learning portfolio for comparison between the individual child and children.

3) There is no significant difference between groups on the off-task behaviors.

3.1) Learning effectiveness of the control group was better.

3.2) Girls answered correctly better than the boys did.

Experiment

The e-PAYA is based on the function of identification, and a synchronous feedback system. The client-server interactive mode integrates the server unit, including host, database and display device. This system allows users to access information in the learning database and to promptly obtain feedback.

Methodology

Time sampling was applied in this study. For young children, observation is the most appropriate method. The underlying methodology is that young children are unable to describe their experience in detail. Observation does not rely on the children's ability to express.

themselves through speaking or writing, What you see is what young child is. In addition, an experimental method was also applied that e-PAYA was an

experimental treatment.

Participants

The usefulness of the e-PAYA was evaluated by task-off behavior observation and learning effectiveness between groups assigned, as depicted in Table 1 and Figure 2. In total, the subjects were 60 4-year-old children in a private preschool in Taipei City. Learning sheets were given to the control group for feedback after the storytelling.

TABLE 1 SAMPLES DISTRIBUTION BETWEEN GROUPS

	5-6 years		4-5 years		Total
	Boy	Girl	Boy	Girl	
Exp. Group	11	4	7	8	30
Subtotal	15		15		
Control Group	6	9	5	10	30
Subtotal	15		15		

FIG. 1 EXPERIMENTAL GROUP WITH E-PAYA (RIGHT) VS. CONTROL GROUP WITHOUT E-PAYA (LEFT)

System Overview

The prototype system was implemented in a Processing Program for reading RFID Tag data from Arduino, and sending to Flash. It works on a standard PC whose operating system is Windows XP. An RFID reader and an LCD projector are connected to the PC. The demonstration and system infrastructure are given in Figures 1 and 2.

Figure 2 shows a work of fiction entitled *The Adventure of Christine*, consisting of five scenes. Five devices of e-PAYA, along with the story, are ready for children to learn and react.

FIG. 2 DEMOSTRATION OF E-PAYA

As shown in Figure 3, there are two sides of e-PAYA. One is the computer with database for the teacher to get learning feedback from the children; while the other is the e-PAYA to be played by children wearing gloves with RFID tags.

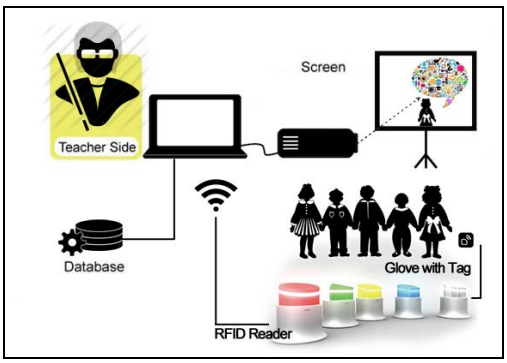

FIG. 3 SYSTEM INFRASTURCTURE OF E-PAYA

Scale of the Learning Effectiveness

The narrative of the *Adventure of Christine* story is connected to the events, presented to children in a sequence of animation. Five questions representing five narratives were developed to examine the learning effectiveness.

Q1 Which one is the food for the train? a). soft drink, b) mild, c) bone, d) oil.

Q2 Which one is good for Christine's growth? a). soft drink, candy, b) chocolate, apple pie, c) milk, sandwich, d) cake, lollipop.

Q3 How can Christine make up the broken bridge? a). figure A, b) figure B, c) figure C, d) figure D.

Q4 Which direction is the right track toward the destination? a). Route A, b) Route B, c) Route C, d) Route D.

Q5 Which one is the food for the robot? a). candy, b) cookie, c) bone, d) battery.

The above five qestions corresponded to the content of learning materials. These five flash animations were individually given after e-PAYA learning activity was over.

Reliability and Validity Analysis

The Cronbach's alpha was used for internal consistency estimate of reliability of test scores. The test comprised five questions regarding the knowledge of *The Adventure of Christine.* The value of alpha is 0.70, indicating that the internal consistency is good. The result of the construct validity analysis shows that the value of discriminant validity is insignificant (t=4.517, p=.139).

Procedure

The procedure for the experimental group is as

follows:

1) Children are grouped into five.
2) Children play with the e-PAYA, group by group.
3) The teacher guides children on how to operate the device.
4) Children wear the gloves with the tags inside.
5) The teacher manipulates the e-story, and children listen and reflect on the questions.
6) The e-PAYA simultaneously displays children's answers on the screen.
7) When all the questions are dealt with, the e-story telling ends, lasting for 10 minutes around each e-PAYA learning activity.

TABLE 2 PROCEEDING PROGRAM FOR READING RFID TAG FROM ARDUINO AND SENDING THEM TO FLASH

```
void serialEvent(Serial _p) {
  pname = _p.toString();
  // read RFID data from Arduino
  String s = _p.readStringUntil(LF);
  if (s!=null) {
    s = trim(s);
    s1 = getMyName(s);
    chid = int(s1)-1;
    // check RFID serial Number and Flash
// Object ID Mapping
    for(int i=0; i<5; i++){
      if(pname.indexOf(portid[i])!=-1){
        pid = i;
      }
    }
    if(act<5){
      // send RFID data to Flash
rfidcc();
    }
  }
}
void rfidcc(){
  if(w1.indexOf(s1)==-1){
    w1 += ";"+s1;
    rex[act][chid] = pid;
    recnt[pid]++;
    myServer.write(chid+","+pid);
            myServer.write(zero);
          }
```

The procedure for the control group is presented below:

1) The teacher prepares the same story content with the same pictures derived from the e-story telling content.
2) The teacher prepares the learning sheets for each question to be answered.
3) The teacher tells the story.
4) After the storytelling, the teacher gives the learning sheets to the children.
5) The teacher collects the learning sheets.

Result and Discussion

Development of the e-PAYA

To achieve the first purpose of the study, a processing program was applied for reading RFID tag data from Arduino and sent to Flash for preschool children, by employing sensors, RFID tag and reader, and database.

An ordinary combination algorithm was proposed as above. The algorithm directs the tag signal to the host and then presents the flash animation on the screen. Meanwhile, right or wrong answers will be recorded in the database.

Impacts of e-PAYA on Off-Task Behaviors

The second purpose of this study was to assess the impact on learners' performance after implementing e-PAYA in storytelling activities. To examine the impacts of e-PAYA on on-task performance, time-sampling observation and recording were applied. In regard to the video-taping of children's task-off behaviors, the results are shown in Table 3 and Figure 4.

TABLE 3 OFF-TASK FREQUENCY DISTRIBUTION

	5-6 years	4-5 years	Total
Experimental Group	18	15	33
Control Group	15	15	30
Total	33	30	63

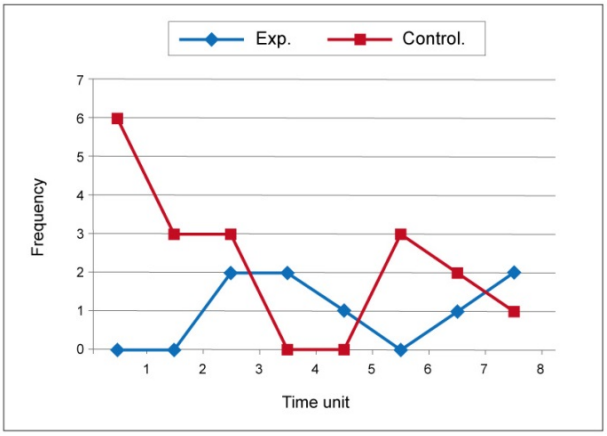

FIG. 4 TASK-OFF BEHAVIOR ANALYSIS BETWEEN GROUPS

Figure 4 indicates that children pay much more attention in learning activities with e-PAYA. In the beginning, the experimental group of children was so attracted by the flash animation that they paid great attention to the storytelling. In the control group, children were distracted at the beginning, such as chatting with one others. During the storytelling

process, the experimental group of children exhibited more task-off behaviors for the following reasons.

1) Children played with the gloves with tags inside.
2) Children were disturbed by the noise outside of the classroom.
3) Children were disturbed by the teacher's intervention while Flash animation was carried on.

After the experiment, the teacher discussed with the children about how they felt. Three questions were inquired as follows:

1) Is it fun to learn through e-PAYA? Why?
2) Which part of the e-PAYA do you prefer? Why?
3) Which part of the e-PAYA do you dislike?

The findings indicated that children in the experimental group were attracted by the luminance and sound feedback, the appearance of a representative face on screen, instant learning feedback after children have touched the e-PAYA, and the learning portfolio comparison of the individual child and between children. e-PAYA made children feel that the activity was fun, and their interest was enhanced in learning.

According to the in-depth interview, the teacher thought that the e-PAYA not only facilitated teaching efficiency, but also increased the children's learning interest. E-PAYA made learning fun because multi-media presentation attracted children's attention and enhanced their memory.

Meanwhile, a Chi-Square test was administered for age difference of off-task behaviors. The results are given in Table 4.

TABLE 4 SUMMARY OF CHI-SQ ANALYSIS ON OFF-TASK BEHAVIORS BETWEEN GROUPS

	5-6 years	4-5 years	Total
Experiment Group	18	15	33
	17.29	15.71	
	0.030	0.032	
Control group	15	15	30
	15.71	14.29	
	0.032	0.036	
Total	33	30	63

Chi-Sq = 0.130, DF = 1, P-Value = 0.718

Table 4 indicates the expected counts and counts of off-task behaviours have been pbserved. The age difference is insignificant.

Impacts of e-PAYA on Learning Effectiveness

In order to examine learning effectiveness, five questions were given between groups after the storytelling. Results of descriptive analysis are summarized in Table 2.

Table 5 indicated that the learning effectiveness of the control group is better. In the control group, the teacher looked at children's facial expressions and made a decision as to whether further explanation was needed, while the experimental group of children was easily distracted by pop-up characters that attracted their attention. As a result, they might forget previous questions shown on the screen.

TABLE 5 DESCRIPTIVE ANALYSIS BETWEEN GROUPS

Group	N	Mean	SD
Exp.	30	80	22.89
Control	30	96.67	7.58

Table 6 indicates that girls answer correctly better than the boys did. Girls paid much more attention to the learning tasks.

TABLE 6 DESCRIPTIVE ANALYSIS BETWEEN GENDERS

Gender	N	Mean	SD
Boy	29	83.45	23.95
Girl	31	92.9	11.01

TABLE 7 DESCRIPTIVE ANALYSIS BETWEEN AGES

Ages	N	Mean	SD
5-6 years	30	90	15.54
4-5 years	30	86.67	21.87

It was also shown that 5-6-year-old children answered correctly more often than the 4-5-year-old children did. T-tests for differences between groups, gender and ages were administered by Minitab, and the results are summarized in Table 8.

TABLE 8 T-TEST OF DIFFERENCES BETWEEN GROUPS, GENDER AND AGES

	Freedom	T-value	P-value
Group	35	-3.79	0.001
Gender	38	-1.94	0.06
Age	52	0.68	0.5

Table 8 indicates extremely significant difference between groups. Without e-PAYA, children perform significantly better (P-value=0.001). It was demonstrated that children are used to filling out a learning sheet. Unfamiliarity of interactive devices is the cause for the better learning effectiveness in the control group.

Table 9 depicts that the interrelationship is significantly different between group and gender ($p=0.001 < 0.05$). Regarding the learning effectiveness, children in the control group outperformed the experimental group children did and girls answered correctly better than the boys did.

TABLE 9 ANOVA ANALYSIS ON DIFFERENT AGE AND GENDER

Source	df	Seq SS	Adj SS	Adj MS	F	P
Age	1	166.7	456.1	456.1	1.71	0.197
Gender	1	1544.6	726.6	726.6	2.72	0.105
Group	1	3233.2	3403.9	3403.9	12.73	0.001
Age × Gender	1	377.6	144	144	0.54	0.466
Age × Group	1	274.9	527	527	1.97	0.166
Gender ×Group	1	1268.8	1268.8	1268.8	4.75	0.034
Error	53	14167.6	14167.6	267.3		
Total	59	21033.3				

S = 16.3497 R-Sq = 32.64% R-Sq(adj) = 25.02%

Conclusion and Implications

This experiment revealed that using interactive media technology can attract children's attention, and that the e-PAYA plays a significant role in interactive learning. E-PAYA provides a friendly voice and visual feedback and clues on the screen, which is fun for children to get instant feedback under such a synchronized mechanism; thus attention are paid. The findings indicated many impacts of the e-PAYA, including: increased on-task performance, self-efficacy, learning motivation and interest, fun, taking initiative in learning, learning efficiency, interaction between peers and with the e-PAYA itself.

Regarding implications for practice, e-PAYA can feasibly be applied in other areas, such as science, mathematics, creative development, and so on. The elderly and special children are groups of interest for follow-up studies.

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