PAPER

A Practical System for Instant 3D Games Using Quizzes

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SUMMARY This paper presents a practical system which allows instructors to easily introduce 3D games utilizing smartphones in a classroom. The system consists of a PC server, a big screen and smartphone clients. The server provides 3D models, so no 3D authoring is needed when using this system. For an instructor, preparing slides of quiz-questions with the correct answers is all that is required when designing 3D games. According to a quiz specified by an instructor, this system constructs a corresponding 3D game scene. The answers students provide on their smartphones will be used to play this game. Everyone in the classroom can see this 3D game in real time on a big screen. The game illustrates how every student has reacted to a quiz. This system also introduces specialized queues for mobile interactions; a queue for commands from an instructor and a queue for data from students. The command queue has higher priority than the data queue; so that an instructor can control this system by sending commands with clicks on a smartphone. Previous studies have mostly provided specially designed teaching materials to instructors, often treating them as passive consultants. However, by using slides, already familiar to instructors, this system enables instructors to combine their own teaching materials with 3D games in the classroom. Moreover, 3D games are expected to further motivate students to actively participate in classroom activities. This system is evaluated in this paper.
key words: *instant 3D game, mobile interface, student response system, prioritized queue processing*

1. Introduction

Today, mobile devices are emerging as effective learning tools in the classroom [1]. There have been many studies on how mobile devices can enhance learning in the classroom. Electronic voting systems using infrared [2], [3] or radio-frequency systems [4] have been used by students to anonymously respond to quizzes and have evolved into student response systems using smartphones or tablets [5], [6]. Also, special coursework utilizing smartphones [7], augmented books with handheld devices [8], and wireless classroom management systems [9] have been suggested to enhance classroom learning.

Game technologies have influenced education in many areas. A lot of effort has been put into developing game-based learning; this has led to the creation of serious games [10]. Games have been shown to increase student motivation [11], [12]. Mobile serious games (MSGs) have been studied by researchers in various disciplines to study their potential benefits in supporting collaborative learning in schools [13], [14].

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Fig. 1 Three components of instant 3D games.

Previous research has demonstrated that games and mobile devices can improve classroom interactivity, motivate students, and encourage students to perform better than in traditional learning environments. However, previous research has focused on effective learning for students in specific subjects [6]–[8], [11]–[16]. System experts have carefully designed and provided games or coursework, which unfortunately often left instructors as passive consultants. It has been reported that games can provide a more effective learning environment when instructors use them to complement their teaching [17].

Therefore, this paper presents a practical system which will enable instructors to easily integrate 3D games using smartphones into conventional classrooms. As described in Fig. 1, an instant 3D game is based on three components: 3D models, slides of quizzes, and smartphone inputs. The system hardware includes smartphones and a router connected to a PC server as shown in Fig. 2. Instructors provide slides of quizzes only. No 3D authoring is required. Depending on the quiz and participating students, a 3D game scene is instantly constructed utilizing 3D models provided by this system. Students' responses on their smartphones will be used to play the instant 3D game. This game simulates the situation of solving a quiz.

As a result, this system helps instructors combine 3D games with their conventional lectures. For example, suppose that an instructor has PPT slides for a lecture, as shown in Fig. 3. Then the instructor can lead the class as usual

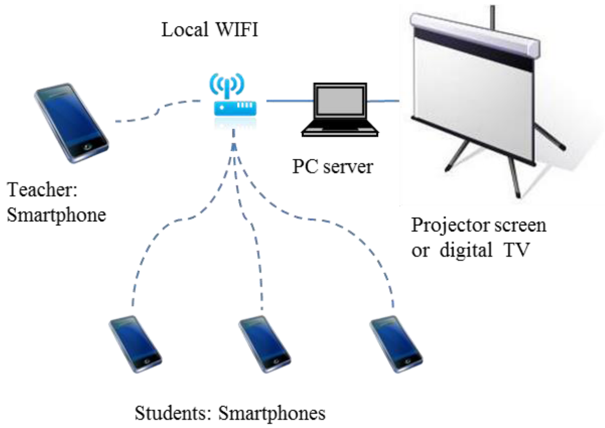


Fig. 2 Hardware configuration.

with the first three slides. Later, instant 3D games can be presented with quizzes in the last slide. Instant 3D games are expected to encourage students to participate more actively in classroom activities with real-time visualization of their interactions. The system has been evaluated in various classrooms, and the results are presented in this paper.

2. Related Work

A lot of research has been conducted on how to take advantage of mobile devices and game technologies in classroom learning [1], [18].

2.1 Mobile Devices in the Classroom

Student response systems have been presented to facilitate the use of mobile devices in the classroom [2]–[6]. Electronic voting clickers using infrared signals [2], [3] or radio frequency [4] have been used for real-time interactions between an instructor and students in a classroom. Multiple choice or true/false questions were prepared by the instructor. Students used voting clickers to answer the quiz-questions. The aggregated results from these anonymous voting systems were displayed by a projector on a screen in the classroom providing real-time feedback. These systems demonstrated significant improvements in classroom interactivity. But anonymity could not induce serious participation of every student because voting results could not be referred to later. Also, managing clickers created additional work for instructors [2], [3]. Smartphones and tablets have been introduced for identified interactions [5] and freeform inputs from students, such as equations or diagrams [6]. To facilitate identified interactions, logging processes and databases were introduced in the server. Instructors and students used their smartphones for quizzes and the results were sent back to the corresponding smartphones [5]. For freeform inputs, real-time feedback was not possible, since the instructor had to see and confirm the data inputs later [6]. Also, it is not convenient for instructors to enter quizzes on mobile devices and grade student replies later.

Other studies on how to utilize mobile devices more actively in the classroom have been suggested. Mobile devices were used as computing platforms for a specific network design course for students in an Engineering college [7]. Augmented reality (AR) experiences have been provided and evaluated for some elementary to high school students [8]. When using AR books, a handheld mobile device displayed the virtual 3D content overlaid on real book pages. This system required instructors to learn to use special authoring tools to create their own 3D contents [8]. The interactions of two groups of students in an elementary school were compared: one group used mobile devices and the other did not use them [9]. This comparison showed a significant improvement when learning in a classroom using mobile devices [9]. In these studies [7]–[9], instructors were required to learn how to use special authoring or monitoring tools, provided by experts, to prepare teaching materials or to observe students.

2.2 Games in the Classroom

Serious games have been employed in many areas [10]. Various attempts using serious games have been shown to further motivate students to participate more actively in the learning process [11]–[16].

Using games in the Computer Science curriculum, at universities, helped to attract more applicants and reduced failure rates over the first year. This has been achieved through connecting game development to the computing concept [11], [12]. However, this research is hard to apply to general classrooms, since the games were designed for a specific curriculum.

Mobile serious games (MSGs) monitor the mobility of the player in the game, using the speed of a player's reaction, changes in the environment, or accelerations. These monitoring systems require more sensors. MSGs have been provided to elementary and middle school students [13], [14]. Personal digital assistants (PDAs) and attached GPS units were also given to the students. They were asked to survive as lions in a virtual African Savannah, moving around a specified playing field [13]. Three other MSGs were also played by 4 students in 8th grade. They were asked to visit a zoo and a museum to learn about the evolution of the species [14]. The above MSGs contributed to the development of collaborative learning and the problem solving skills of the participating students. However, MSGs are based on the mobility of the player so they cannot appropriately be applied to traditional classroom environments. In these studies, the role of the instructors was limited to monitor or consultant for student players.

For a 3D game, making appropriate 3D models is essential. Instructors have been required to learn how to use 3D authoring tools [8], [15]. However, it is hard for instructors to build 3D models and games for their lectures, and usually experts provided 3D games for specific topics [16]. Also, most games have been provided in single-player mode [11]–[13], [16], [17].

2.3 Instructors in the Classroom

Instructors play a critical role in the successful introduction of new technologies in the classroom [2]. Due to the increasing demand for mobile and game technologies, instructors have been forced to adjust to meet the ever changing demands of the learning environment [18], [19]. In previous student response systems using smartphones [5], [20], [21], instructors have to prepare quizzes by themselves. Moreover, instructors are required to enter the questions and correct answers on their smartphones. Quizzes are saved in databases in the server, and then later sent to the smartphones of students. Therefore, in those systems, due to transmission time, battery power, and memory requirements on smartphones, instructors were forced to follow specific formats for quizzes and text-oriented questions are preferred.

Generally, it is difficult for instructors to design and integrate a particular game into the curriculum and achieve the best results under given time constraints [18]. Researchers have provided instructors with special games, leaving instructors as passive consultants. A survey reported that games can be used more effectively in learning if instructors combine them with their lectures [17].

Therefore, this system is designed to allow instructors to complement their teaching with instant 3D games. Most instructors usually present slides on a shared big screen in a classroom for their lectures. Figure 3 shows an example of slides for a lecture. An instructor can use the first 3 slides for a lecture as usual. Quizzes on the last slide can be used to play instant 3D games, using this system.

2.4 Contribution

This paper presents a practical system, which simulates a quiz session in a class as an instant 3D game. No 3D authoring is required in this system. An instructor only prepares slides for quizzes. Based on a quiz and the participating students with smartphones, a 3D game is instantly generated using built-in 3D models, and is displayed on a big screen in the classroom. Simple web-based interfaces and prioritized queues for smartphone interactions are also introduced in this system. As a result, this system enables instructors to combine 3D games and smartphones with their conventional lectures. This system has been evaluated in several classes and the results are also presented in this paper.

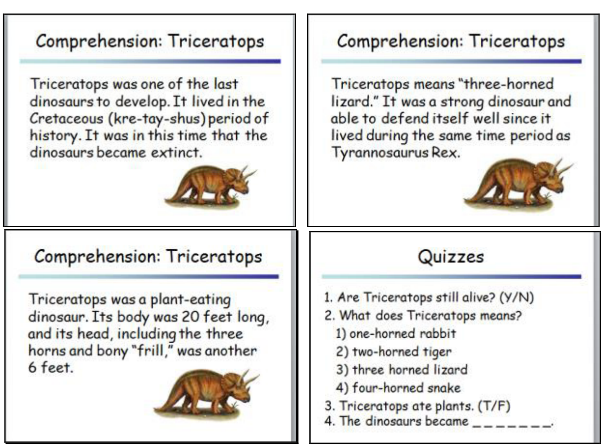


Fig. 3 An example of PPT slides for a lecture.

3. Instant 3D Games with Smartphones

Games capture students' attention and motivate students with virtual rewards and peer recognition. The positive effect of games in various learning environments has already been demonstrated, by previous research [11]–[16]. However, instructors could not create 3D games or customize them for their class by themselves utilizing previous systems. Also, previous student response systems using mobile devices have usually focused on presenting individualized quizzes and results so it has been hard to share the results with others.

This paper presents a practical system which will enable instructors to easily introduce 3D games with smartphones into the classroom. This system visualizes solving a quiz as a 3D game, and allows everyone to see their relative and individual status in the results of a quiz. As depicted in Fig. 1, instant 3D games are based on three elements: 3D models, slides of quizzes, and smartphone inputs.

3.1 3D Models

This system is designed to minimize additional work for an instructor. For example, no 3D authoring is required. This system provides 3D models for background scenes and player characters. The examples of 3D background scenes and player character models are shown in Fig. 4 and Fig. 5. Each scene has special models of flags. Flags containing

Fig. 4 Examples of 3D models for background scenes.

Fig. 5 Examples of 3D models for player characters.

digits represent multiple choice answers. Flags containing "O" and "X" indicate true/false, right/wrong, or yes/no answers, based on the quiz. Also, each background has invisible markers indicating the starting position of the player characters. For a participating student, a character model is selected and placed on a marked position. Each character has simple animations such as walking, rotating, and jumping.

The assignment of a scene and player models for a game can be designed in various ways. Since class time is limited, class time should be saved. To construct a 3D game instantly, this system is designed to randomly assign a background, player characters, and the initial position of each player in a background. It takes about 9 seconds on average to construct and load a game in this system, as illustrated in Table 1 and Table 2.

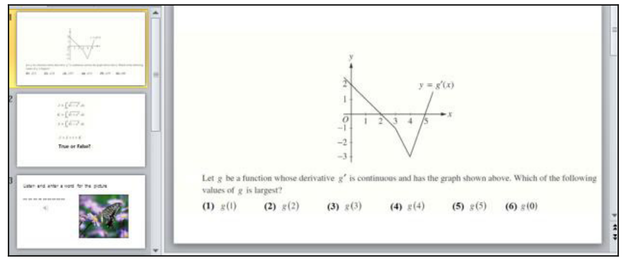
Eight background models and 50 player characters are included in this system, so that a class of up to 50 students may participate. When a student logs in, a randomly assigned player character can be displayed on the big screen, so that every student can identify his or her own character.

3.2 Slides of Quizzes with Corresponding Answers

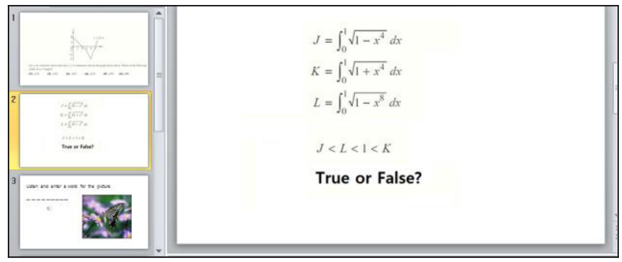
Most instructors already know how to make and use PPT slides in the classroom, as shown in Fig. 3. This system allows instructors to use PPT slides for quizzes with corresponding correct answers for an instant 3D game.

Slides of quizzes will also be presented on a big screen in the classroom. An additional tool or a separate database to save and transmit quizzes to smartphones is not required in this system. Not only text-oriented quiz questions but also various questions with images, sounds, or mathematical expressions can be prepared and displayed by an instructor, using PowerPoint as usual.

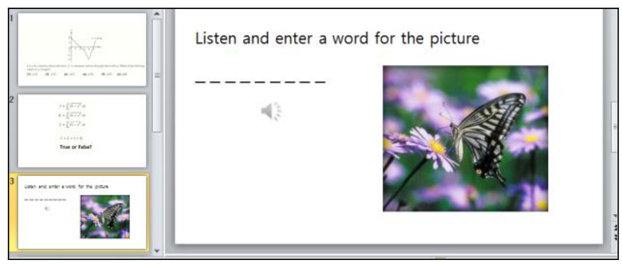
In this system, for real time evaluation, a quiz question can be one of the following types: true/false, yes/no, multiple choice, or short answer. The length of a quiz question should be limited to one slide, as illustrated in Fig. 6 (a) to Fig. 6 (c). The corresponding correct answers should be saved in a table in the last slide sequentially. The number of cells in the table should be equal to or greater than the number of slides for quiz-questions, since each slide has a



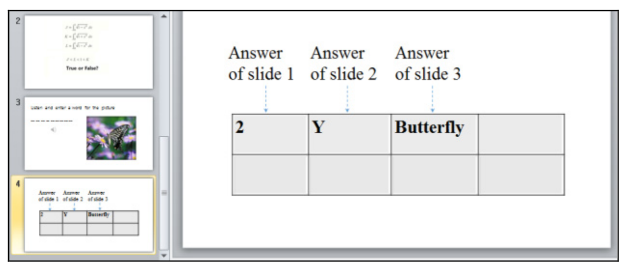
(a) Slide 1: a multiple choice question



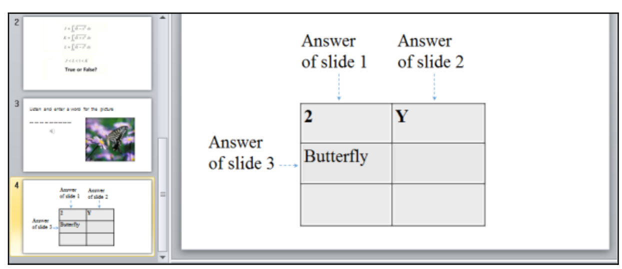
(b) Slide 2: a true or false question



(c) Slide 3: a short answer question



(d) Example of last slide 4: correct answers in a table



(e) Example of last slide 4: correct answers in a table

Fig. 6 Examples of quiz slides with correct answers.

quiz question, as shown in Fig. 6 (d) or Fig. 6 (e). The row major numbering is applied to access the correct answers in the table. For example, the correct answer of a quiz in slide 1 should be saved in cell# (1, 1) of the table, as shown in Fig. 6 (d) or Fig. 6 (e). The answer of a quiz in slide 3

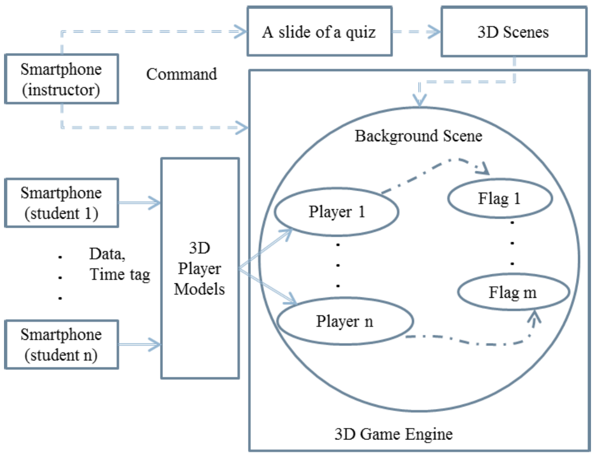


Fig. 7 Smartphones are used to control and play an instant 3D game.

should be entered in cell# (1, 3) of the table in Fig. 6 (d) or in cell# (2, 1) of the table in Fig. 6 (e).

This system considers a given quiz as a scenario for an instant 3D game. After a background scene is selected, flags in a background are then determined by the type of quiz. Each flag can be a target for a player to reach. One of the flags will represent a correct answer. The last slide will be used to evaluate students and show the results of a quiz in a game.

3.3 Two Kinds of Smartphone Clients

This system is designed to use smartphones to control and play an instant 3D game in the classroom. Two kinds of smartphone clients are introduced in this system, for an instructor and students respectively, as depicted in Fig. 7, Fig. 8, and Fig. 9.

An instructor will use a smartphone as a remote controller of the system. Using a smartphone, the instructor will control a PPT slideshow, start an instant 3D game, allow students to play, and finish the game. Students will enter their answers for a quiz on their smartphones as directed by the instructor. Therefore the smartphone client of an instructor sends commands only, while the client of a student sends data only. These commands or data are sent to the PC server. To process messages separately from two clients, this system proposes to use two separate queues in the server, as illustrated in Fig. 8. The queue for commands has higher priority than the queue for data, so that an instructor can have complete control over students' smartphone inputs. For example, an instructor can allow students to enter their answers for 2 minutes only. After a given time, an instructor can move to the next quiz slide, forcing the system to ignore students input to the previous question.

3.4 Playing an Instant 3D Game

In this system, an instant 3D game is created with 3D models, quiz slides, and students' smartphone inputs, as illustrated in Fig. 7. In a classroom, when an instructor starts

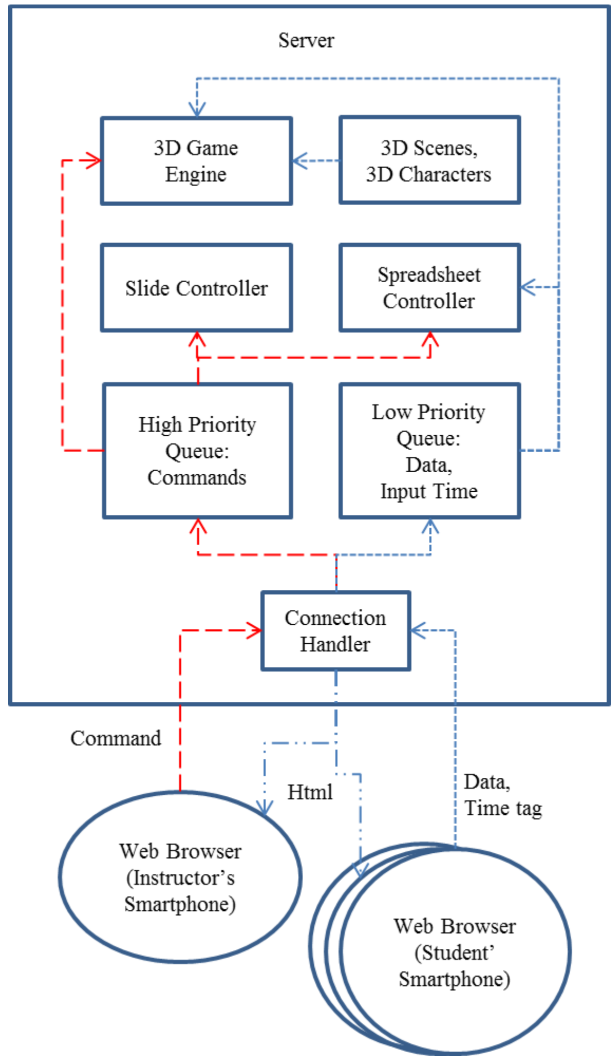
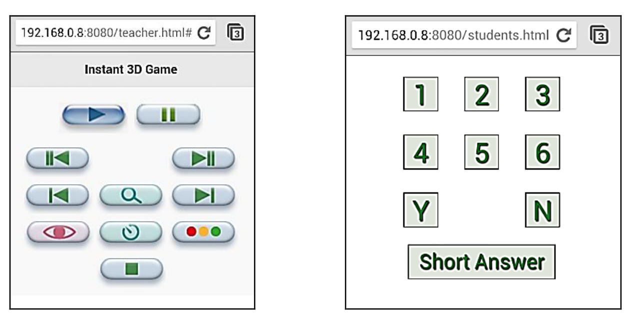


Fig. 8 Program components and prioritized queue processing in this system. An instructor can initiate the system using a smartphone, sending commands in red to the server. Student data with time tags in blue will be used to play the game under the control of an instructor.



(a) Instructor's smartphone (b) Students' smartphone

Fig. 9 Screenshots of smartphone interfaces for an instructor in (a) and students in (b).

a slideshow of a quiz, the scene is first constructed with a background and selected flags, determined by the type of quiz. When a student logs into the system, a player character will be added to the scene, representing each student in the classroom. When each student enters an answer for a quiz on his or her smartphone, the instructor can start the game. The player characters can stay, move quickly, or slowly approach the corresponding flags in the game, according to students' inputs with time tags. Each input value is used to set a target flag for each player in the game. Time tags will determine the speed of each player in the game. A group of balloons will illustrate a correct answer for the quiz. As a result, as shown in Fig. 10 and Fig. 11, the 3D game illustrates what each student enters, who did not enter an answer, how fast each student reacts, who is correct or not, and how many students are right or wrong. Except for the time required for students to solve a quiz, the time required to play a game for a quiz takes about 7 seconds, so an instant 3D game consumes about 15 seconds on average, as shown in Table 1 and Table 2.

4. Implementation

This system is designed as a localized client-server system. As specified in Fig. 2, smartphones of an instructor and students are clients. A router is used to connect clients to a PC server through a local WIFI network. Slideshows and 3D games are displayed on a shared big screen in the classroom.

4.1 Smartphone Clients

Smartphones have relatively limited system resources; such as low battery power, slow CPU speed, and lower memory capacity than a PC. Downloading multimedia data on smartphones consumes a lot of resources and network bandwidth. Since this system utilizes a localized architecture, slides and instant 3D games will be presented on a shared big screen in the classroom. Therefore, downloading them onto the smartphones of every student in the classroom can be avoided.

For each smartphone client, this system introduces simple web-based interfaces. HTML and JavaScript are used to implement client interfaces. No separate app is necessary, since smartphones already have built-in web browsers. Any mobile device with a web browser can be used as a client to this system. As shown in Fig. 9, the user interfaces of clients are composed of simple buttons, representing commands or data.

An instructor can send commands to the server with clicks on buttons, illustrated in Fig. 9 (a). Each button represents commands such as play the game, pause the game, go to the first quiz slide, go to the last quiz slide, go to the previous quiz slide, go to the next quiz slide, find a quiz slide, show real-time student input, set the timer, show results, and stop.

Students will send their answers to the server using buttons, illustrated in Fig. 9 (b). Each button represents a value; numbers are for a multiple choice quiz. Y and N are for a true/false or yes/no quiz. A button for short answers will display an additional input box for students to enter short answers.

During the class, an instructor and students can log into the server, using the web browser on their smartphones. An icon can be added on the screen of a smartphone, using a menu such as "Add to Home Screen". Later, connecting to the server will be easier and faster than the first time, by using the icon as a shortcut. It is advised that students use their real names as their ID, since smartphone inputs are identified, evaluated, and saved with their corresponding ID.

After HTML-based interfaces are downloaded to smartphones, only commands or data will be transmitted between the server and smartphone clients.

4.2 A PC Server

A PC server controls slideshows and 3D games, through communicating with two separate kinds of smartphone clients. The programs in the server have been implemented in C++ and C#. The following components are included in the server, as shown in Fig. 8:

- Connection handler
- Message Queues for Commands and Data
- Slide Controller
- Spreadsheet Controller
- 3D scenes and characters
- 3D Game Engine

The *Connection Handler* is programmed to provide the communication between a server and smartphone clients. When messages from smartphone clients are received, the *Connection Handler* distributes them to the corresponding queues. Messages from an instructor's smartphone are pushed into the *Queue for Commands*, while messages from students are placed in the *Queue for Data* as shown in Fig. 8. To provide an instructor with complete control, the instructor's commands should be processed over students' data. Therefore the *Queue for Commands* has higher priority than the *Queue for Data* in this system.

Slideshows are directed with the *Slide Controller to* show slides of quiz-questions on a shared big screen.

Anonymous voting may induce playful responses from students [2], [3]. To avoid disrespectful inputs, every input is recorded with a student ID. The results for each quiz will be automatically saved in an Excel spreadsheet using the *Spreadsheet Controller*. The instructor can show the spreadsheet to the class in real-time or keep it for later reference. The *Slide Controller* and *Spreadsheet Controller* are collections of function calls to MS Office library such as; go to the next or the previous slide, or save an input value in a specific cell in a worksheet of an Excel file.

Finally, an open source *3D Game Engine* [22] is included with *3D models* to create and play instant 3D games under the complete control of an instructor.

4.3 Examples

In this system, any smartphone can be a client, since a smartphone usually has a built-in web browser. Any other mobile device with a web browser such as tablets can also be a client. The server is installed on a notebook PC with i7 CPU 2.2GHz and 8GB memory. A low-cost router is used to create an 802.11b/g Wi-Fi network.

Figure 10 shows an example of an instant 3D game for a multiple choice quiz in Fig. 6 (a). The summarized statistics are listed in a signal on the top right corner of the screen. For example, the 6 students indicated on the green light, have answered correctly, the 4 students shown on the red light have answered incorrectly, and the students listed (0) on the yellow light are hesitant to give an answer to the question. There are a total of 10 participating students, as indicated on the sky-blue light. Everyone can see the correct answer is 2, visualized with a group of balloons over a flag marked with “2”. Also everyone can see that Mike, Clara, Eric, Phil, Jenny, and Tyler responded correctly. Sarah, John, Amy, and Sunny gave incorrect answers to the quiz question; Sarah entered 3, Amy entered 4, John entered 5, and Sunny entered 6.

Other examples of 3D instant games are also displayed in Fig. 11. Various background models with quiz slides in Fig. 6 (a) and Fig. 6 (b) are used to create these games.

Processing times for an instant 3D game have been measured and presented in Table 1 and Table 2. The same background model as the one in Fig. 10 is selected in this instant 3D game. The number of player characters is dependent upon the number of participating students. For a multiple choice quiz, illustrated in Fig. 6 (a), the processing time for loading and playing with students inputs are listed in Table 1. Table 2 shows the processing time for a true/false quiz in Fig. 6 (b). Time for students’ inputs is excluded, since an instructor will specify an appropriate time for students to solve and enter their answers on smartphones according to the quiz. Each time in Table 1 and Table 2 is an average time of 5 trials on a tested notebook PC server. It takes about 8.5 seconds on average, to construct a game scene with up to 40 players. Playing a game for a multiple choice quiz consumes a little more time than for a true/false quiz. Due to random start positions for players in a game, it may take more time for players to move to their targets. So the play time with fewer players can be longer than with more players, as shown in play times for 20 players in Table 1 and for 30 players in Table 2. On average, an instant 3D game only requires about 15 seconds for each question.

Actually, smartphone inputs to this instant 3D game system can be replaced with previously used clickers as described in Sect. 2.1. However, previous research has already indicated the main disadvantages of using clickers. They are as follows [2], [3], [19]: frequent malfunctioning of clickers, playful inputs, the noisy sounds of clicking, and the limitation of quiz types. The instructors also have to carry, distribute, and collect clickers before and after class. Additionally, instructors should check the power level of the batteries and also if clickers have been lost. Therefore, to reduce the additional responsibilities of instructors, smartphones or tablets, owned and managed by students, are preferred in

(a) A group of balloons on a flag, 2, shows the correct answer (2).

(b) Mike and Eric reacted with a correct answer faster than others.

(c) Sarah, Amy, John, and Sunny entered wrong answers.

(d) Tyler is the last one to enter a correct answer.

Fig. 10 Captured images of an instant 3D game for a multiple choice quiz in Fig. 6 (a) with a correct answer of 2.

Table 1 Processing times for a multiple choice quiz in Fig. 6 (a)

Number of players	Loading Time (seconds)	Play Time (seconds)	Total Time (seconds)
10 players	8.1	5.6	13.7
20 players	8.7	8.0	16.7
30 players	8.9	7.1	16.0
40 players	8.4	6.0	14.3
Average	8.5	6.7	15.2

(a) (b) (c) (d)

Fig. 11 Captured images of instant 3D games with various backgrounds.

Table 2 Processing times for a true/false quiz in Fig. 6 (b)

Number of players	Loading Time (seconds)	Play Time (seconds)	Total Time (seconds)
10 players	8.1	5.0	13.1
20 players	8.7	5.7	14.4
30 players	8.9	7.3	16.2
40 players	8.4	5.8	14.2
Average	8.5	6.0	14.5

this system.

5. System Evaluation

The instant 3D game, presented in this paper, provides quiz games in multi-player mode in the classroom. An instructor should actively lead and control the students in the classroom when using this system. Therefore, this system should be not only easy to use but also beneficial to both instructors and students, so that they want to use it in their classes. The system has been evaluated considering the satisfaction level of instructors and students and the effectiveness of the system.

A quick user study and several demos have been completed with 19 teachers in an elementary school and 9 teachers in a middle school. This system has been tested with students in 2nd and 5th grade in an elementary school and 8th graders in a middle school. This system can be applicable to any level, if the class subject can be presented on PPT slides containing simple quizzes. A volunteer teacher in an elementary school has used this system in her computer classes for 2nd and 5th graders over a week. In a girls' middle school, another teacher has used this system for her English class, for a week. In a computer programming class, in an Engineering College, this system was tested with sophomores for 2 weeks. The number of students in each class ranged from 20 to 40 students. Students could easily identify their player characters on a big screen.

Teachers and students were surveyed after demo classes. The following survey questionnaires were given to teachers in an elementary and girls' middle school:

1) Do you want to use this system in your class?
2) Do you think this system helps students concentrate on the class?
3) Do you think this system helps students understand the lesson?

The following survey questionnaires have been given to students, except 2nd graders:

1) Do you like the class with this system?
2) Do you think this system helped you focus on the class?
3) Do you think this system helped you understand the subject better?

The following survey questionnaires have been given to 2nd graders:

1) Do you like the class with this system?
2) Do you think you can study better with this system?

Additionally, teachers and students were asked to write down the advantages of, and their recommendations for improving this system.

The majority of teachers and students were satisfied with this system. Teachers were content due to the fact that the system allowed for the utilization of smartphones and 3D games in the classroom, without requiring additional 3D authoring. Most teachers already have their own quizzes

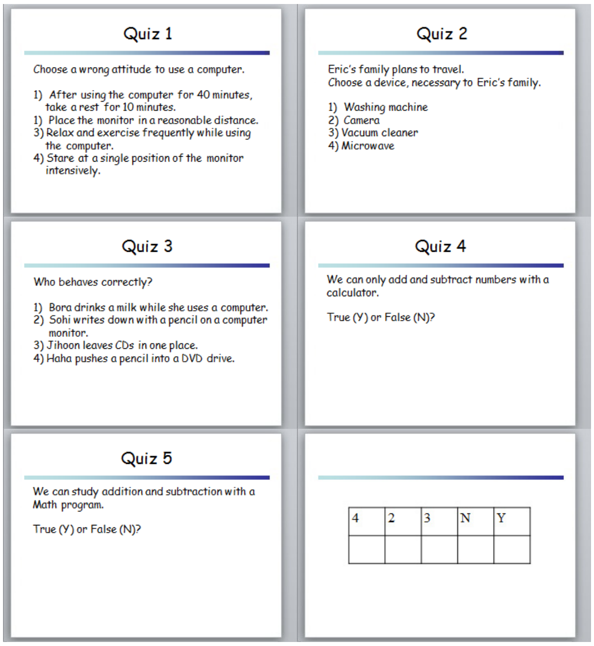


Fig. 12 Examples of quiz slides used in a class of 2nd graders.

Table 3 Responses of teachers in an elementary school

Response	1^{st} Quest.	2^{nd} Quest.	3rd^{h} Quest.
Highly Positive	7	8	4
Positive	9	10	9
Medium	3	1	6
Low	0	0	0
Negative	0	0	0
Total	19	19	19

Table 4 Responses of teachers in a middle school

Response	1^{st} Quest.	2^{nd} Quest.	3rd^{h} Quest.
Highly Positive	1	1	1
Positive	6	6	6
Medium	2	2	2
Low	0	0	0
Negative	0	0	0
Total	9	9	9

for their lectures, so quiz slides could easily be adapted to the system. Their previous teaching materials could be used while saving about 10-15 minutes for quizzes with this system. Volunteer teachers generally used this system at the start and/or the end of their lectures, with about 5 quiz questions. Examples of quiz slides, used in a class of 2^{nd} graders, are listed in Fig. 12.

As shown in Table 3, Table 4, and Table 9, most teachers surveyed were positive, 81% on average, about using this system in their classes. Notice that there are no low or negative responses from teachers. Most teachers also mentioned that this system encourages students to participate more actively in classroom activities using 3D characters. Teachers also liked the option of seeing the status or the responses of every student during a quiz in real time. Teachers even suggested the idea of sharing captured videos of instant 3D games with absent students.

As illustrated in Table 5 to Table 8, students were also

Table 5 Responses of 2^{nd} graders

Response	1^{st} Quest.	2^{nd} Quest.
Positive	83	71
Medium	3	18
Negative	3	0
Total	89	89

Table 6 Responses of 5^{th} graders

Response	1^{st} Quest.	2^{nd} Quest.	3rd^{h} Quest.
Highly Positive	50	45	49
Positive	13	12	8
Medium	9	15	13
Low	4	2	5
Negative	2	4	3
Total	78	78	78

Table 7 Responses of 8^{th} graders

Response	1^{st} Quest.	2^{nd} Quest.	3rd^{h} Quest.
Highly Positive	7	10	3
Positive	9	12	11
Medium	7	1	9
Low	0	0	0
Negative	0	0	0
Total	23	23	23

Table 8 Responses of sophomore in a college

Response	1^{st} Quest.	2^{nd} Quest.	3rd^{h} Quest.
Highly Positive	17	24	13
Positive	37	29	34
Medium	12	12	18
Low	4	3	5
Negative	0	2	0
Total	70	70	70

Table 9 Response summary of teachers for 1^{st} question

Response	Elementary Teachers.	Middle school Teachers	Average
Positive	84%	78%	81%
Medium	16%	22%	19%
Negative	0%	0%	0%

Table 10 Response summary of students for 1^{st} question

Response	2^{nd} graders	5^{th} graders	8^{th} graders	sophomores	Average
Positive	93%	81%	70%	77%	80%
Medium	3%	12%	30%	17%	16%
Negative	3%	8%	0%	6%	4%

motivated by instant 3D games and participated actively in the class. Students mostly stated that the class was more amusing and enjoyable. Quizzes based on 3D games were preferred to paper tests. Every student was forced to participate in the class, due to visualized players in the game. Moreover, students liked playing the game with other students in their class. Some students said that they liked it, since they could feel and see that they were really participating in class activities, rather than just sitting quietly in the class. A few students responded negatively because they thought the sound of students enjoying the game may disturb the class. This can be easily controlled by instructors. Notice, that there is no equivalent negative response in a girls' middle school, with quieter classes.

As a result, the evaluation results demonstrated that this system would enable teachers to integrate 3D games and smartphones into their lectures. It also showed that the system motivated students to more actively participate in class activities, since all students could be seen by their peers in the class as players in a 3D game.

This system is a unique system, which provides 3D games for all subjects in multi-player mode for the classroom. For software engineering education, game-based learning systems have been actively introduced. A survey indicated that the evaluations of previous games for software engineering education were mostly based on subjective questionnaires [17]. Most previous game-based systems have been provided in single-player mode for specific subjects so those systems concentrated on surveying the satisfaction level of students only. In Table 9 and Table 10, the results show that 81% of teachers and 80% of students are satisfied with this instant 3D game system. The level of satisfaction of students with this system can be considered as similar to previous 3D game-based systems [16]. Further studies to formally measure different game's impact are needed [17].

6. Conclusion and Future Work

Previous research has already demonstrated that games and smartphones are effective in motivating students in the classroom. However, in most previous studies, system experts provided special teaching materials or games to instructors and students. Therefore, this paper presents a new practical system to allow an instructor to integrate 3D games using quizzes into conventional classrooms.

An instant 3D game simulates a quiz session in a classroom. Templates of 3D models are included in this system. Slides of quizzes are the only material that an instructor should prepare. According to a quiz and the number of students participating, this system constructs an instant 3D game with randomly assigned 3D models.

An instructor can control this system by sending commands with clicks on a smartphone. Students' replies to a quiz, on their smartphones, are used to play this instant 3D game. Displaying slides and 3D games on a shared big screen will avoid excessive transmission of slides, images, or 3D games to smartphones. Therefore, in this system, simple web-based interfaces are implemented for smartphone clients. Other mobile devices with a web browser can also be used as a client.

This system has been designed to allow for no additional 3D authoring, and uses PPT slides and spreadsheets as data files for instructors. Random assignment of built-in 3D models will also save limited class time. As a result, this system enables an instructor to combine 3D games with their previous lectures while minimizing additional work for instructors.

Future research includes an intensive user study. Also, how to further support group activities will be studied to extend this system. Additional research on open architecture for 3D games will be conducted to improve the visualization in group activities and to include different game styles such as adventure or survival games.

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