

Using Mainstream Game to Teach Technology through an Interest Framework

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ABSTRACT

This study validates a pedagogical framework, which integrates a mainstream game to teach the technology supporting that game. Technologies in learning games can engage students and make the learning contents interesting to them. However, technologies themselves are seldom the subject of learning in the game they support. In addition, learning activities in a gaming context usually engage students temporarily in the subject. As soon as the game is over, students' desire for learning may cease. The framework tries to achieve the transition of students' interests from the initial interest motivated by the game to the later-developed cognitive and personal interests in the subject. Based on the framework, this study designs and experiments a practice to evaluate the proposed framework. Participants' subjective responses show their satisfaction about the practice of learning and developing interest of the subject matter. This study not only provides a dual aspect of game technology adoption for motivating students, but also proposes a pedagogical framework for students' lasting learning. It is expected to provide a new and valuable idea about the use of technologies and games in education.

Keywords

Mainstream game, Interest framework, Game technology, Science teaching

Introduction

Technologies in learning games can engage learners for knowledge exploration, for example, the ultrasonic indoor positioning sensors in the Hunting of the Snark (Price & Rogers, 2004) and the GPS and WLAN in Savannah project (Facer *et al.*, 2004). However, technology and its related science concepts is hardly the subject of learning through the game it supports. That is, playing a game to learn the technology used in the game has never been explored before. This study takes an initial step and attempt integrating a game as a tool to teach the technology supporting that game.

Using a game to teach a related technology topic is intended to raise students' interest in learning. This intention is important for science education. Mounting evidences show a decline of the interest of young people in pursuing science (Osborne *et al.*, 2003; Pintrich, 2003); whereas the science serves as the foundation for the development of engineering and technology which improve human lives. As many technologies are utilized to support games nowadays, using these games to teach these technologies and related scientific concepts could facilitate students' science learning.

From the aspect of interest, the intrinsic appeal of a game makes itself attractive in the classroom; therefore using the game to begin a learning activity seems straightforward. However, if the game is not elaborated in a way to make students be interested in learning the technology, the learning will still be boring as the game ceases. That is, under the gaming context of learning, the aroused interest is mostly a situational one, which will decay as the novelty or excitement of the game does not exist anymore (Schraw *et al.*, 2001). For lasting learning, students' personal interest, which is the internal cognitive desire for a topic, needs to be developed. Little instructional design in science education has been done to deal with this transition issue (Schraw & Lehman, 2001). This study investigates interest transition for lasting students' learning.

Wii is a well-known and interesting game supported by many advanced technologies, such as the IR sensor, the Bluetooth, and the G-sensor. Among the technologies adopted in Wii, this study chooses IR technology for its comprehensibility for students. IR light is a phenomenon of electromagnetic radiation, and can be utilized in various applications such as heating, tracking, and communication. This study hence uses Wii to teach IR. In addition to IR's application, the section of IR in the electromagnetic spectrum is introduced as the scientific concept.

Interest for learning

Interest in learning includes two major types: situational interest and personal (individual) interest. The situational interest refers to a cognitive state from activities and content in a specific situation. The personal interest refers to a relatively enduring inclination toward a particular activity or content, and is a disposition that has developed in the person over time (Pugh & Bergin, 2006). Situational interest is spontaneous, transitory, and environmentally activated, whereas personal interest is enduring personal value, and activated internally (Schraw *et al.*, 2001). Moreover, Kintsch (1980) makes the situational interest finer-grained as emotional and cognitive interest. Emotional interest occurs when the instruction evokes a strong affective response. Cognitive interest occurs when students become engaged in the content which is important to the topic under investigation (Schraw *et al.*, 2001). The classification of interest is summarized in Figure 1.

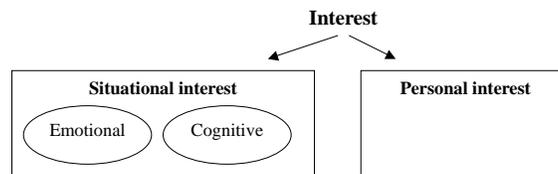


Figure 1. The classification of interest

As to arousing students' interest in learning, using a learning game is a popular teaching technique. However, most learning games only arouse situational interest, and this type of interest may decay along the course of learning (Schraw *et al.*, 2001), especially when the novelty or excitement of the game does not exist as well as more attention and cognitive resource are required for deep learning. In some cases, teachers used interest-catching techniques disconnected from the subject matter (Moyer, 2001). It seems that situational interest is not elaborated well enough to foster the development of personal interest for the subject. Using a game for learning should not only tentatively engage students, but should also develop their personal interest for long-term learning.

Design framework: interest transit

This study proposes an instructional design framework for interest arousing and transitioning. As the pedagogical mission is to use a game to teach a technology, the intrinsic appeal of the game should catch students' attention and arouse their emotional interest. After that, the instruction should engage them in the topic as the cognitive interest. At the end of the game related instructions, students should develop personal interest for lasting learning. In addition to the types of interest, two other aspects of interest are also taken into the proposed framework. The first aspect is the duration of interest. Mitchell (1993) assumed that there are (instructional) conditions triggering students' interest as well as (instructional) conditions ensuring the continuation of interest. Hence, sets of instructional schemes should exist to catch or hold students' attention, and to trigger or ensure students' interest in learning respectively.

The second aspect is the transit of interest, which refers to moving from one interest type to another. In fact, personal and situational interest are not dichotomous phenomena that occur in isolation from each other, but both types of interest can interact and influence each other's development (Hidi, 1990). In this study, this transit aspect of interest means a specific type of interest can be developed from the existing interest type through the proposed pedagogical framework. Among these types of interest, the situational interest often precedes and facilitates the development of personal interest (Krapp *et al.*, 1992). In other words, situational interest triggered by some environmental factors may evoke or contribute to the development of personal interest (Dewey, 1913; Hidi, 1990; Mitchell, 1993; Schraw & Lehman, 2001). Mitchell (1993) also claimed that if a classroom is filled with high situational interest, the environment would change an individual's personal interest level regarding the subject over time. That is, a student's personal interest upon a subject may be increased under an appropriate instruction if his situational interest is already at a high level. These two aspects of interest in learning underpin the framework of interest transit in Figure 2, and the framework is elaborated in the following three phases.

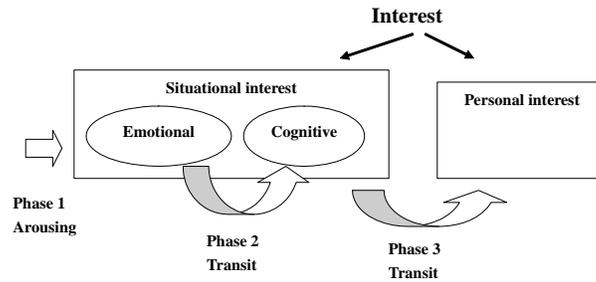


Figure 2. Proposed framework of interest transit

Phase 1: Arousing emotional interest

The first step is to arouse students' emotional interest. The emotional interest can be aroused by novelty and excitement in the game (Malone & Lepper, 1987; Prensky, 2001). A mainstream game presented in a school context is novel and exciting to students. When a game is used in this manner to teach a subject, in Dewey's (1990) terms, the subject is sugar-coated because the activities in the game are used to arouse students' interest in the learning situation but not in the subject itself (Pugh & Bergin, 2006). Hence, the first design phase is to use a game to sugar-coat the subject in order to arouse students' emotional interest.

Phase 2: Transiting from emotional interest to cognitive interest

As students' emotional interest is aroused, they need to be guided to transit their emotional interest to a cognitive one for exploring the subject matter, instead of the game. Schraw *et al.* (2001) asserted that students will develop cognitive interest when the subject matter is important to the issue under the current investigation. In this phase of learning, the issue to be investigated is a game (Wii), and the subject matter is a technology (IR). Hence, the instruction should present how the technology plays a role in relation to the specific game features which arouse students' emotional interest. Because students are attracted by the game, they should be curious about how that technology works and thus their cognitive interest can be developed.

Such instruction can be viewed to psychologize the subject matter in the gaming context to orient students' emotional interest toward the cognitive interest. Psychologizing the subject is to develop meaning in the subject itself through its connection to experience (Dewey, 1990; Pugh & Bergin, 2006). The experience needs to be developed within the range and scope of students' life, and its origin and significance need to be immediate and individual (Dewey, 1990). For this study, the experience refers to the one students gain in their prior game experience as well as the current instructional demonstration of the game.

For reaching the goal of this phase, this study suggests two instructional techniques: 1) augmenting game playing features related to the technology, and 2) disturbing technology support in the game. The first augmenting technique instructionally exaggerates or augments the game features related to the technology topic to be taught. The technique used in the *Hunting for Snark* (Price & Rogers, 2004) is an example. The approaching of the object equipped with sensory device activates the digital animation, which is novel and exciting to students. When the approaching is augmented in slow and re-iterative manner, it should further make students aware of and curious about the sensing technology.

The second technique of disturbing means to cause the malfunction of game playing due to the absence of supporting technology. The students are then aware of the taught technology and how it supports the game. This technique of disturbing echoes Gaver *et al.*'s (2003) proposal of using the uncertainty or the problematic of technology as the design for teaching instead of being treated as a shortcoming. In Schwabe and Göth's (2005) study, the disturbance of GPS-based positioning technology (i.e., the blocking of GPS signal) in a university orientation game is used to facilitate the features of 'map-navigation' and 'hunting and hiding'. As to this study, the disturbing is used as a scheme to pedagogically expose the technology subject in a psychologizing manner. These techniques, instead of

relying on the vantage of a technology, re-appropriate the disadvantage of a technology for a specific instructional purpose.

Phase 3: Transiting from cognitive interest to personal interest

After arousing cognitive interest, the transit to personal interest needs to take place. The success of transit refers to that students can build up an internal initiate of cognitive desire as personal interest for the subject matter, and such desire does not need to be related to the game anymore. As students have developed their personal interest, the subject itself can be attractive even when it is presented in a factual manner (Jones, 1998). For helping students develop this type of interest, providing appropriate information to build up their background knowledge is suggested. Such proposal is based on research indicating the positive relationship between background knowledge and personal interest for learning (Bergin, 1999; Kintsch, 1980).

For providing background information to students, the instruction should be in a progressive manner to keep students engaged in the learning. This is because by presenting knowledge segments in close proximity to one another, this presentation will facilitate the generation of necessary inferences among knowledge segments to reach coherent connections (Schraw *et al.*, 2001). These coherent connections constructed among these knowledge segments can elicit students to cognitively process the meanings of these knowledge segments (Schraw *et al.*, 2001), and support them to construct background knowledge needed for developing personal interest.

Hence, while students hold cognitive interest in exploring how the subject matter of technology relates to the game, the teaching should provide subject matter's information in a progressive manner to engage students and build up their background knowledge. In this phase, the technique is to select and create instructional artifacts which together provide concrete and coherent links between the demonstration in the gaming context and the presentation of subject matter in its factual manner that can still engage students.

Illustration of the design framework

In Wii, participants physically wave the Wii remote to virtually embody the simulated player or avatar in the digital game. Such interactional relationship is known to most students, who, however, do not know the supporting technology behind it. The supporting technology is IR, which is emitted by a sensor bar and then received by the Wii remote for location information. IR is chosen as the teaching subject. As to the scientific concept related to IR, its section in the electromagnetic spectrum is introduced. Based on the proposed three-phase instructional framework, Wii is used to teach IR as a sample practice.

Phase 1: Arousing the emotional interest

The presentation should use the novelty and excitement that a game can bring into the classroom to arouse students' emotional interest. Students are asked questions of what they know about Wii and why Wii is presented. Since Wii is a well-known game for entertainment, it is novel to have it in a classroom. Students should be curious about these questions. In addition, the demonstration of playing Wii's game has exciting multimedia to attract students. These sugar-coating schemes should arouse students' emotional interest.

Phase 2 Transit to the cognitive interest

For transiting students' emotional interest to cognitive one, students need to learn the relationship between the game and IR through the demonstration of how game's novelty and excitement are related to the IR technology. The first augmenting technique employs the operational relationship of the Wii remote, sensor bar, and cursor on the screen to reveal the technical characteristics of IR in terms of its available spatial ranges of distance and angle. The Wii remote is waved to test out the spatial ranges. That is, if the distance or angle between the Wii remote and the sensor bar is out of IR operational range, the cursor on the screen will disappear.

As to the second technique of disturbing, it uses a piece of paper to block the line-of-sight transmission of IR light from the IR emitter (sensor bar) to the Wii remote, so the game operation will be interrupted (i.e., the cursor on the screen will disappear). Students should vividly experience that IR light can be blocked by paper. With these instructions, students should be engaged and able to recognize the existence of IR technology and how it is technically related to the game. Stimulated by the inherited novelty and excitement in the gaming context, students should be willing to explore further IR related knowledge. Then, it can be said that students' interest has been transited from the emotional one to the cognitive one.

Phase 3 Transit from situational interest to the personal interest

For transiting the situational interest to the personal one, the instruction needs to build up students' background knowledge in a progressive manner. The background knowledge is the scientific concept of spectrum, and three artifacts are used. The first artifact is a red candle, which replaces the sensor bar as IR emitter and provides similar IR signal to the Wii remote. The second artifact is a triangular prism. In optics, a triangular prism is used to disperse visible light into spectrum of seven colors. The demonstrated visible light spectrum is then accompanied with the graph of comprehensive wave spectrum (Fig. 3) as the third artifact.

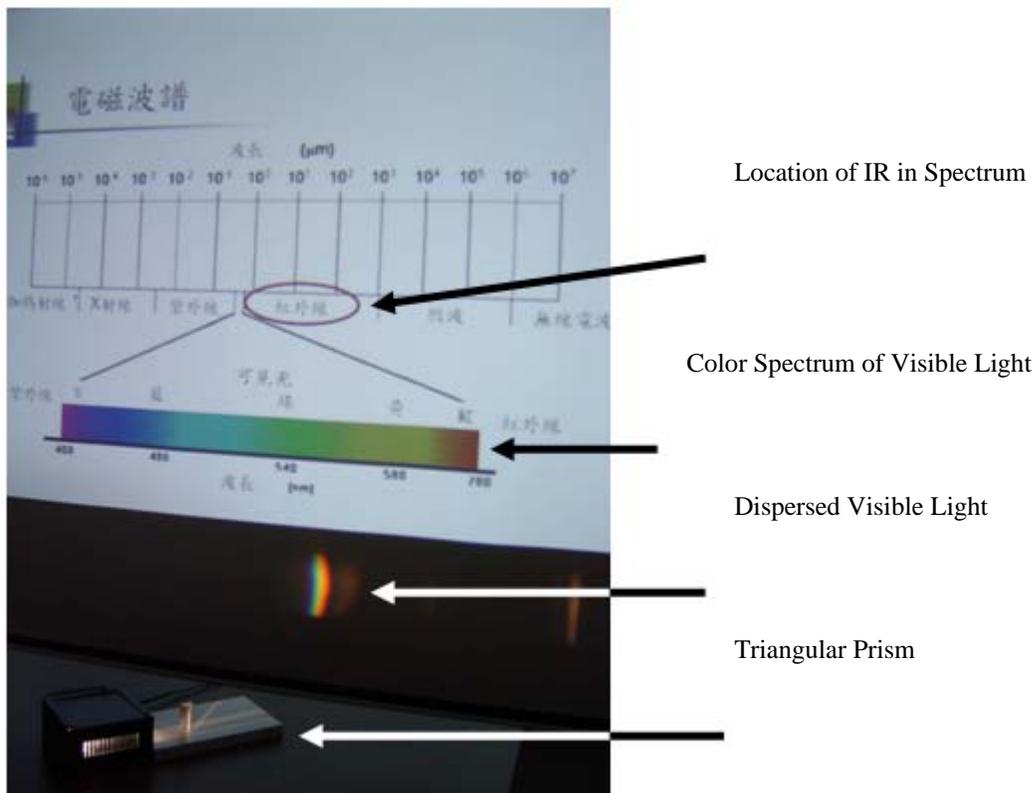


Figure 3. Association of visible light spectrum with the comprehensive electromagnetic spectrum

The red candle is a familiar item for students, and its visible red light provides an inferential connection with IR terminology both in Mandarin Chinese and in English. That is, the flame in the red candle provides semantic association between the artifact and terminology. The presentation informs students that IR in Wii can be replaced by candle's red light, one of the daylight spectrum components dispersed by a triangular prism. As the instruction associates the concrete and vivid daylight spectrum components with the abstract and comprehensive wave spectrum in a progressive manner, students should be able to create rich mental entities that serve as the basis for new concept of spectrum as background knowledge for the IR.

The instruction continues to indicate the location of IR in the spectrum, which is right next to the visible light of red color, to make students realize why the candle can function as the sensor bar of IR emitter. These artifacts connect

the interesting and visible experience of Wii to the ordinary and abstract concept of spectrum as the background knowledge of IR. Students can then learn the new facet of IR associated with the spectrum, which is the factual IR not related to the game. The last presentation regarding IR is its application in night vision, heating, tracing, communications, and meteorology. If students pay their attention toward the presentation of IR applications, it may imply such engagement is a result of interest transit from situational one to the personal one.

Validation of the design framework

Participants for this study are forty-eight students from three vocational high schools joining a winter camp held by a college for building up partnership between the college and high schools. The camp aims at helping the high school students experience specific academic subjects in an enjoyable way. For achieving such goal, the camp uses Wii to teach IR.

Under the activity title of Wii, a three-hour experimental activity is composed of introducing Wii and playing Wii. The Wii introduction includes the console and accessories as well as the technologies of IR, G-sensor, and Bluetooth. Among forty-six slides of power point presentation, twelve slides relate to IR, including five IR applications not related to the game. After the power point presentation, game playing takes place.

Instrument development

In order to investigate students' interest, questionnaires are used as the main data-collection instrument in this study. The pre- and post-activity questionnaires use Likert's scale ranging from 1 (strongly agree) to 5 (strongly disagree). The pre-questionnaire evaluates whether Wii, prior to this study's experiment, is really known and interesting to students. In this way, the current study can assume Wii as a mainstream game to attract students' attention. In addition, the post-questionnaire is used to assess whether the proposed teaching can arouse student's emotional, cognitive, and personal interest.

The students' emotional interest is identified when they show their preference about a type of activity or artifact. In a similar study, Chen *et al.* (2001) analyze students' interest in video viewing of jogging and gymnastic stunts and participatory learning occasions, and evaluate students' emotional interest from aspects of instant enjoyment, novelty, and challenge. Because these instructional activities are similar to Wii in terms of arousing students' emotional interest, these aspects are taken into account in designing questions in this study.

In addition, students' cognitive interest is identified as students show their willingness to explore a topic under a specific instructional stimulation of activity or artifact. Therefore, students need to be asked their preference for science learning, contingent upon a specific instructional stimulation. Among various stimulations, Tuan *et al.* (2005) categorize them as instructional factors of content, teaching methods and context, and also measure students' interest towards science learning under these factors. Moreover, Mitchell (1993) uses detailed instructional stimulations of group work, puzzles, and computers in mathematics to investigate students' cognitive interest in mathematics learning. The questionnaires of these studies are referred because they evaluate students' cognitive interest, which is their interest in the learning content contingent upon a specific instruction. The current study asks students about their preference for these teaching schemes and artifacts of IR technology, and their preference is defined as their cognitive interest in IR.

Finally, the personal interest is identified if students prefer to explore the topic of learning not related to the instructional stimulations. Therefore, students are asked about their preference for learning IR in terms of their intrinsic value of learning or desire to pursue studies in IR. This type of question has been found in Tapia and Marsh's (2004) inventory of attitudes toward mathematics under the category of motivation, which is designed to measure students' interest in mathematics and their desire to pursue studies in mathematics. Pintrich and De Groot (1990) also develop a Motivated Strategies for Learning Questionnaire to measure students' motivational beliefs in a learning activity based on their perceived intrinsic value. Because these measurements relate to assessing students' personal interest in a topic, some of their questions are modified and adopted in the current study to assess students' personal interest in IR.

Experimental result

Since the experiment attempts to justify the proposed framework of interest transit in using Wii to teach IR, the result is listed according to the sequence of activities, in which students' interest has been transited as planned. The survey results list the distribution of participants' selection for each question. The statistic data of mean and standard deviation are also included to provide an overall view of students' response for each question to justify the framework in a broader sense.

Pre-activity survey result

The pre-activity survey asks students about their familiarity with, interest in, and willingness of playing with Wii. The survey results are shown in Table 1. Students' familiarity with Wii is neutral ($M=3.08$, $SD=1.07$), which may be caused by Wii being too expensive to most of these students from neighboring community of low socioeconomic families, and they do not have much chance to get familiar with it. However, all students think that Wii is an interesting game ($M=1.7$, $SD=0.65$). Such result may result from the heated discussion about Wii in the media. These two factors seem to result in the students' high interest to play Wii ($M=2.11$, $SD=0.86$).

Post-activity survey result

The post-activity survey asks students' opinions about Wii, IR, and the overall learning activity, and the survey results are listed in Table 2 to 4 respectively. For these three topics, students' satisfaction, interest, and self-evaluated learning performance are investigated respectively. Regarding the survey result of overall activity, most students are satisfied with it ($M=1.57$, $SD=0.59$), and agree that using Wii to learn IR is interesting ($M=1.59$, $SD=0.63$). They think they can understand the relationship between Wii and IR ($M=1.89$, $SD=0.65$). They also support that using a game to teach a technology is an interesting idea ($M=1.51$, $SD=0.64$).

Table 1. Pre-activity student opinion toward the Wii and IR

Questions rated on a scale of 1-5 (N=37 students) Scale of 1 (strongly agree) to 5 (strongly disagree)	Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree		Mean	SD
	#	(%)	#	%	#	%	#	%	#	%		
I am familiar with Wii.	1	(3)	13	(35)	9	(24)	10	(27)	4	(11)	3.08	1.07
Wii is interesting.	15	(41)	18	(49)	4	(11)	0	(0)	0	(0)	1.7	0.65
I like to play the game in Wii.	10	(27)	15	(41)	10	(27)	2	(5)	0	(0)	2.11	0.86

Table 2. Post-activity student opinion toward the overall presentation

Questions rated on a scale of 1-5 (N=37 students) Scale of 1 (strongly agree) to 5 (strongly disagree)	Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree		Mean	SD
	#	%	#	%	#	%	#	%	#	%		
I am satisfied with the presentation	18	(49)	17	(46)	2	(5)	0	(0)	0	(0)	1.57	0.59
It is interesting to introduce the IR technology by Wii.	18	(49)	16	(43)	3	(8)	0	(0)	0	(0)	1.59	0.63
I can understand the relationship between the Wii and the IR technology.	10	(27)	21	(57)	6	(16)	0	(0)	0	(0)	1.89	0.65
Introducing a technology by a game is an interesting idea.	21	(57)	13	(35)	3	(8)	0	(0)	0	(0)	1.51	0.64

Table 3. Post-activity student opinion toward the Wii

Questions rated on a scale of 1-5 (N=37 students) Scale of 1 (strongly agree) to 5 (strongly disagree)	Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree		Mean	SD
	#	%	#	%	#	%	#	%	#	%		

I am satisfied with the presentation of Wii.	12	(32)	23	(62)	2	(5)	0	(0)	0	(0)	1.73	0.55
Wii is interesting.	23	(62)	12	(32)	2	(5)	0	(0)	0	(0)	1.43	0.59
I have learned the technologies adopted in Wii.	9	(24)	25	(68)	3	(8)	0	(0)	0	(0)	1.84	0.55

Table 4. Post-activity student opinion toward the IR

Questions rated on a scale of 1-5 (N=37 students) Scale of 1 (strongly agree) to 5 (strongly disagree)	Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree		Mean	SD
	#	%	#	%	#	%	#	%	#	%		
I am satisfied with the presentation of the IR technology.	9	(24)	24	(65)	4	(11)	0	(0)	0	(0)	1.86	0.58
<i>Arousing cognitive interest</i>												
Waving the Wii remote and blocking the sensor bar is interesting.	13	(35)	21	(57)	3	(8)	0	(0)	0	(0)	1.73	0.60
Waving the Wii remote and blocking the sensor bar to introduce the IR technology is interesting.	16	(43)	16	(43)	5	(14)	0	(0)	0	(0)	1.70	0.69
I can understand how the IR technology is related to the waving of Wii remote.	10	(27)	23	(62)	3	(8)	1	(3)	0	(0)	1.86	0.66
I can understand how the IR technology is related to the blocking of the sensor bar.	15	(41)	20	(54)	2	(5)	0	(0)	0	(0)	1.65	0.58
<i>Transiting to the personal interest</i>												
<i>Red candle</i>												
Using the red candle to replace the sensor bar in Wii is interesting.	18	(49)	14	(38)	4	(11)	1	(3)	0	(0)	1.68	0.77
Using the red candle to replace the sensor bar in Wii to introduce the IR technology is interesting.	20	(54)	14	(38)	2	(5)	1	(3)	0	(0)	0.57	0.72
I can understand how the IR technology is related to the red candle.	17	(46)	16	(43)	3	(8)	1	(3)	0	(0)	0.68	0.74
<i>Triangular prism & spectrum</i>												
Using the triangular prism to view the spectrum is interesting.	3	(8)	14	(38)	18	(49)	2	(5)	0	(0)	2.51	0.72
Using the triangular prism to view the spectrum to teach the IR is interesting.	6	(16)	16	(43)	15	(41)	0	(0)	0	(0)	2.24	0.71
I can understand how the triangular prism and the spectrum are related to the IR technology.	7	(19)	20	(54)	9	(24)	1	(3)	0	(0)	2.11	0.73
<i>Objective opinion of personal interest</i>												
I will find further information about the IR technology.	16	(43)	17	(46)	4	(11)	0	(0)	0	(0)	1.68	0.66

As to Wii, students are satisfied with the corresponding presentation (M=1.73, SD=0.55). They also agree that Wii is interesting (M=1.43, SD=0.59), which is even higher than their response before the activity (M=1.7, SD=0.65). Under such a highly interesting learning environment, they answer the question of whether they have learned the technologies adopted in Wii with positive responses (M=1.84, SD=0.55).

Regarding the teaching of IR, respondents are satisfied with the presentation (M=1.86, SD=0.58). For surveying opinions about the demonstration of how the game feature relates to the IR technology for building students' cognitive interest, the questions include the scheme of waving (augmentation) and blocking (disturbing). Students not only show high interest in these schemes (M=1.73, SD=0.60), but also agree that adopting these schemes to introduce IR is interesting (M=1.70, SD=0.69). The results show students agree that they can understand how the

game features revealed by the teaching schemes of augmenting and disturbing are related to IR ($M=1.86$, $SD=0.66$; $M=1.65$, $SD=0.58$) respectively.

Three levels of questions ask students about the artifacts of red candle and triangular prisms associated with spectrum for developing students' personal interest. These questions include students' interest in the artifacts, their interest in learning IR through the artifacts, and understanding of the relationship between the artifacts and IR. According to Table 4, the result shows that students are more interested in the red candle than the triangular prism. Such a difference may exist because the candle is more closely related to Wii, and the triangular prism is viewed as a scientific artifact, which is not closely related to the game.

At the end of survey, students show high-willingness of finding further information about IR by highly agreeing with the statement, "I would like to find further information about the IR" with $M=1.68$, $SD=0.66$. According to Jones (1998), when a student has personal interest, he builds up an internal initiate of cognitive desire for the subject matter, and the subject can be attractive to learners when it is presented in a factual manner. Hidi and Renninger (2006) also claim that, when given a choice, if students value the opportunity to re-engage themselves in a topic and will opt to do it, it means they have personal interest for the topic. Therefore, the result indicates the initial development of personal interest because students have cognitive desire for the IR in its factual format, and such desire is not under a situational environment such as a gaming activity. The evidence of students' development of personal interest is also supported by the survey result of the last question: "What are applications of IR -- night vision, heating, tracing, communications, or meteorology?" Of the forty-eight students, only three students do not mark all of these five applications presented in the experiment. This result shows that most students paid attention to and remembered the presentation of IR's applications, which is not related to the game. Paying attention to lectures or explanations is an indicator of interest in learning (Wang & Reeves, 2007), so this study concludes that students developed their personal interest toward IR in this experimental activity.

Discussion

Students' interest

This study uses a game to teach a technology supporting the game. The corresponding practice design is interest-oriented, which arouses and transits students' interest from emotional, to cognitive and then to personal one. According to the survey result, students feel that using Wii in the classroom is interesting, and their emotional interest is aroused. The mainstream game such as Wii is intrinsically attractive to students because students have heard about it or have played it. They feel the novelty and excitement of the game. Therefore, using a mainstream game to sugar-coat the learning content can arouse students' emotional interest in the beginning of teaching.

The result also shows that students' emotional interest has been transited to cognitive interest successfully. Students are interested in the instruction of using Wii to introduce IR. While students are interested in the instruction and understand how IR relates to Wii, they are developing their cognitive interest in IR under the Wii topic. Therefore, the proposed method of psychologizing the subject is successful. This kind of method is also proved in the Savannah project (Facer *et al.*, 2004), which arouses students' emotional interest and then engages them in the subjects to develop students' cognitive interest. In this study, for psychologizing the subject of IR, the techniques of disturbing and augmentation are employed to direct students' attention toward the IR-related game features. That is, students are emotionally engaged in the gaming context because of the game features; meanwhile they are cognitively exploring the subject related to those game features. This study concludes that employing these two techniques can transit students' emotional interest to cognitive one.

Some researchers argue the difficulty to quickly manipulate or build up personal interest during a short-term instruction (Pugh & Bergin, 2006), and assert that situational interest is easier to be manipulated by instructions (Bergin, 1999; Mitchell, 1993; Schraw *et al.*, 2001; Wang & Reeves, 2007). This study goes beyond this instructional scope to develop personal interest for lasting learning. The survey result shows that most students recognize all of the applications presented in the activities. Such result means that they pay attention to IR applications, which are not related to the game during the activity of learning. Students also show their willingness to find further information about IR after the activity of learning. These results show students' interest in learning science, including paying attention to lectures, enthusiasm for searching extra information, and valuing the

opportunity to re-engage in a subject and opting to do it (Hidi & Renninger, 2006; Wang & Reeves, 2007). Hence, students have internal initiate of cognitive desire for the subject matter, and their personal interest is initiated. This success implies that the educational domain of a learning game can be extended. That is, in addition to making learning fun and enjoyable in a gaming context, the design may and should make the learning to be continued when the game ceases.

Sequences of instruction

The proposed framework is an alternative approach to encourage learning science and technology by reversing the presentation sequence of the science discipline, technology, and application. The proposed approach begins with a mainstream game as an interesting application of science and technology. This approach is different from the traditional instruction, whose sequence is from science concept, technology, to application, as the logistics of causal relationship among them. Such causal relationship is typically used for teaching science. This teaching sequence may work for strongly motivated students, but it may not engage students with low motivation. This study result shows students' engagement and their development of interest in the science subject. Hence, it is suggested to reverse the traditional sequence of instruction by beginning the teaching with interesting application to attract low-motivated students, and following the proposed interest framework to make the content more accessible to these students. This study reveals an unprecedented relationship among technology, pedagogy, and learning content. Such relationship echoes researchers' claim that there is a complex web and transactional relationship among technology, pedagogy, and content of learning (Ferdig, 2006; Koehler *et al.*, 2007). Ferdig (2007) delineated a recursive, dynamic creation of technology that supports pedagogy and pedagogy that is fundamentally changed by virtue of its integration with technology.

Balance between design effort and interestingness

The proposed design framework provides a balanced design option between instructor's work and students' interest when it is compared to the methods of combination and fusion mentioned by Umetsu *et al.* (2002). There exists a tradeoff between too much required efforts for an engaging learning game by the method of fusion and less design effort for a less interesting learning game by the method of combination. In this study, regarding instructor's effort, the instructor only needs to understand game features of Wii related to the subject IR, and knows how to present these features. Besides, the instructor can choose artifacts for building up students' background knowledge. With basic understanding of how the technology subject is utilized in the game, realizing those designs as practice of learning should be feasible for most domain instructors, who have neither much game-related knowledge nor game design ability. As to the interestingness of the learning, the mainstream game is intrinsically interesting to students. Hence, the proposal framework achieves a balance between students' interest in learning and the required instructor's game knowledge and design ability.

New role of technology

Finally, the proposed teaching sheds a light on the new role of technology in curriculum and instruction. In many studies, technology has been adopted to facilitate learning. However, discussions about the role of technology seem to focus on the instructional aspect only. The relationship between technology and content is limited to using technology to represent and formulate the content for effective learning, or using technology to make content easy to learn. This study develops technology adoption from the curriculum aspect, based on the causal relationship between science content and technology, to devise a learning practice. Technology adoption in this study also accounts for pedagogy in motivating students. This dual aspect of technology adoption makes technology assume a new role in learning, especially in science education.

Conclusion and future study

Technologies are adopted in learning games to facilitate learning. However, a technology used in the game has seldom been the subject of learning. This study makes the first attempt to investigate this issue. In addition,

although catching students' attention should be the first step of teaching, building personal interest for cognitive engagement in the learning content should then be the primary goal of teaching. For reaching this goal, this study proposed an interest framework. The framework is validated by a sample practice design and experiment. The sample design uses Wii to teach IR, and experiment surveys participants' opinions of this specific learning experience. The results show students hold positive attitudes towards the proposed practice of learning. This study not only provides an additional aspect of design in using a mainstream game to teach science, but also provides a transit view of interest upon learning. This research will hopefully provide a valuable reference for developing similar teaching practices.

Further studies need to ask how much effort should be devoted to sugar-coating and psychologizing the subject matter for developing students' emotional and cognitive interest respectively. Too much sugar will waste treasure class time, and too little will not engage students in learning. This issue may be further investigated and justified quantitatively and qualitatively by taking this study as a platform. Even though a specific practice of using Wii to teach IR validates the proposed framework and pedagogies, how the design framework can be generalized and tested by using mainstream games to teach various subject matters in various classroom settings remains to be investigated.

References

- Bergin, D. A. (1999). Influences on classroom interest. *Educational Psychologist*, 34, 87–98.
- Chen, A., Darst, P. W., & Pangrazi, R. P. (2001). An examination of situational interest and its sources. *British Journal of Educational Psychology*, 71, 383-400.
- Dewey, J. (1913). *Interest and Effort in Education*. Cambridge, MA: Riverside Press.
- Dewey, J. (1990). *The school and society; and, The child and the curriculum*. Chicago: University of Chicago Press.
- Facer, K., Joiner, R., Stanton, D., Reid J., Hull, R. & Kirk, D. (2004). Savannah: mobile gaming and learning? *Journal of Computer Assisted Learning*, 20, 399–409.
- Ferdig, R. E. (2006). Assessing technologies for teaching and learning: understanding the importance of technological pedagogical content knowledge. *British Journal of Educational Technology*, 37, 749-760.
- Gaver, W. W., Beaver, J. & Benford, S. (2003). Ambiguity as a resource for design. *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 233 - 240), CHI 2003, April 5–10, 2003, Ft. Lauderdale, Florida, USA.
- Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research*, 60(4), 549-571.
- Hidi, S. & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, 41(2), 111-127.
- Jones, M. G. (1998). Creating engagement in computer-cased learning environments, ITForum. Retrieved September 19, 2009, from <http://itech1.coe.uga.edu/itforum/paper30/paper30.html>
- Kintsch, W. (1980). Learning from text, levels of comprehension, or: Why anyone would read a story anyway? *Poetics*, 9, 87–98.
- Koehler, M. J., Mishra, P. & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers & Education*, 49, 740-762.
- Krapp, A., Hidi, S. & Renninger, K. A. (1992). Interest, learning and development. In Renninger, K. A., Hidi, S., & Krapp, A. (Eds.), *The role of interest in learning and development* (pp. 3–25). Hillsdale, NJ: Erlbaum.
- Malone, T.W. & Lepper, M.R. (1987). Making learning fun: A taxonomic model of intrinsic motivations for learning. In Snow, R.E. & Farr, M.J. (Eds.) *Aptitude, learning, and instruction: III. Conative and affective process analysis* (pp. 223–253). Hillsdale, NJ: Erlbaum.
- Mitchell, M. (1993). Situational Interest: Its multifaceted structure in the secondary school mathematics classroom. *Journal of Educational Psychology*, 85, 424–436.
- Moyer, P. S. (2001). Are we having fun yet? How teachers use manipulatives to teach mathematics. *Educational Studies in Mathematics*, 47, 175-197.
- Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25, 1049-1079.
- Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology*, 95, 667-686.

- Pintrich, P. R. & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, 82, 33-40.
- Prensky, M. (2001). *Digital game-based learning*. McGraw-Hill, New York.
- Price, S. & Rogers, Y. (2004). Let's get physical: The learning benefits of interacting in digitally augmented physical spaces. *Computers & Education*, 43, 137-151.
- Pugh, K. J. & Bergin, D. A. (2006). Motivational influences on transfer. *Educational Psychologist*, 41, 147-160.
- Schraw, G. & Lehman, S. (2001). Situational interest: A review of the literature and directions for future research. *Educational Psychology Review*, 13, 23-52.
- Schraw, G., Flowerday, T. & Lehman, S. (2001). Increasing situational interest in the classroom. *Educational Psychology Review*, 13, 211-224.
- Schwabe, G. & Göth, C. (2005). Mobile learning with a mobile game: design and motivational effects. *Journal of Computer Assisted Learning*, 21, 204-216.
- Tapia, M. & Marsh, G. E. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly*, 8, 2534-2541. (Retrieved September 19, 2009, from <http://www.rapidintellect.com/AEQweb/cho253441.htm>)
- Tuan, H.-L., Chin, C.-C. & Shieh, S.-H. (2005). The development of a questionnaire to measure students' motivation towards science learning. *International Journal of Science Education*, 27, 639-654.
- Umetsu, T., Hirashima, T., & Takeuchi, A. (2002). Fusion method for designing computer-based learning game. *Proceeding of International Conference on Computers in Education*, 124-128.
- Wang, S.-K. & Reeves, T. C. (2007). The effects of web-based learning environment on student motivation in a high school earth science course. *Educational Technology Research and Development*, 55, 169-192.