Construction and application of an educational game based on the ARCS model

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ABSTRACT: Educational games are growing rapidly, but there are problems when transferring skills from developing the superficial games into developing games with a learning content that would sustain the interest of the users. By analysing the ARCS (attention, relevance, confidence, satisfaction) motivation design model, an appropriate game design is outlined in this article. Strategies are proposed for developing educational games that are stimulating and that sustain and enhance the user's motivation. Educational games lead to the transfer of the knowledge, skills and emotion, which students obtain in the game. The educational game model has been applied to a post-processing project of indoor renderings at a vocational college.

INTRODUCTION

Educational games are such a hot topic in today's educational research that teachers are trying to combine games and education to guide students, heighten the effect of teaching and to improve students' initiative to study. Basic theories and practical exploration are two main aspects of the studies of educational games in China and elsewhere.

Basic theories focus mostly on guiding the construction of educational game. Theories, such as *Multiple Intelligences* by psychology Professor Howard Gardner of Harvard University, Hungarian-American psychology Professor Mihaly Csikszentmihalyi's *Flow: The Psychology of Optimal Experience*, and Malone's *Intrinsic Motivation* provide the fundamental framework for the developing a model of educational games and include design strategies for educational games software, as well as the design and evaluation for playful Web-based learning environments [1-3]. These studies, however, are confined to theory. They are just general discussions lacking conclusions, and reflections after empirical research and concrete application are needed.

In respect of practical exploration, many companies and scientific research institutes in China and elsewhere have been moving into development of educational games supported by substantial funds. But the types of educational game software are so far limited, most of which are used in extracurricular cognitive courses in primary and secondary school but barely in university education. Furthermore, most developers of educational games are companies and enterprises with strong commerciality and their developers are not oriented towards education. As a result, educational games either overemphasise entertainment instead of study, which makes users have problems in moving from external forms of the game to learning content or some are dull and lack operability, which makes it hard to maintain long-term interest and attract students to achieve teaching goals [4].

Based on the problems with research on educational games and using the ARCS (A - attention, R - relevance, C - confidence, S - satisfaction) motivation design model by J.M. Keller, reported in this article is an appropriate game design model for the problem about how to stimulate, maintain and enhance users' learning motivation. In addition, elaborated in this article is how the author designed the educational game *Spot the Differences* and implemented it in a post-processing project of indoor renderings at a vocational college. Educational games make students experience the fun of learning, while transferring the knowledge, skills and emotions outwards towards the course.

ARCS MODEL BASED ON MOTIVATION STRATEGIES

The ARCS (A - attention, R - relevance, C - confidence, S - satisfaction) motivation design model developed by J.M. Keller, elaborates learning motivation and motivation strategies. Four levels correspond to four motivational strategies: attention, relevance, confidence and satisfaction, and each level contains three sub-elements, as shown in Table 1 [5][6].

Table 1: ARCS motivation design and strategies.

Attention	Relevance	Confidence	Satisfaction
A1 Stimulate perception Use appropriate events to stimulate and maintain learning motivation	R1 Well-known content Use well-known content to help learners integrate new knowledge	C1 Learning outcomes Help learners to form an expectation of success	S1 Enhance satisfaction Apply knowledge to achieve learners' fulfilment
A2 Stimulate exploration Encourage search for information	R2 Goal orientation Identify the goals of the task	C2 Expect success Provide different kinds of learning experience	S2 Outside stimulation Reflection and reinforcement
A3 Variability Teaching elements changes	R3 Motivation Match the teaching strategies	C3 Self-control Self-decision, reflection and opportunity	S3 Fairness Evaluation standards

Keller subdivided the ARCS motivational design into ten steps, from learner's analysis to design, as shown in Table 2. Steps 1 and 2 focus on gathering all elements to support the demand analysis in Steps 3 and 4. Step 5 develops the goals and evaluation criteria. Steps 6 and 7 use brainstorming to stimulate motivation design applicable to the current situation. Step 8 is a concrete teaching implementation process. Step 9 involves the selection, modification and development of learning resources. The final step is evaluation and modification.

Table 2: Process of ARCS motivation design.

Step	Content
1. Collect information about the course	Course description, theoretical basis, teacher's information
2. Information about learners	Original skill level, attitude to school and course
3. Analyse learners	Motivational analysis, reason for motivation, factors impacting on any change of motivation
4. Analyse current data	The positive factors stimulating current data, defects, problems and related materials
5. List goals and evaluation standards	Goals of motivation design, learners' behaviours, way to evaluate behaviours
6. List motivation stimulation strategies, which can be used	Using brainstorming to list motivational strategies, including strategies in all teaching components
7. Choose and design motivation stimulation strategies	Choosing motivation stimulation strategies, which are more suitable, including comprehensive methods, integrated methods, sustainability, and so on
8. Integrate with teaching process	Designing the connection with teaching, connection with key points of teaching, modification and improvement
9. Choose and develop resources	Choosing the resources that can be used, appropriate modifications, developing new resources
10. Evaluation and modification	Performance, setting the degree of satisfaction, modifying when necessary

EDUCATIONAL GAMES

Educational games are games that achieve an educational goal. They stimulate participants' competitiveness and expectations of victory through visual displays and internal rules. In addition, the content of educational games is rich in knowledge and stimulates interest. In *Virtual Challenge*, students are required to complete the tasks, during which they acquire relevant educational knowledge. Participants' psychological reactions triggered by the scenes and rules of the game stimulate the motivation to learn.

Games can involve active participation, which is the best way to promote education. Educational games combine the characteristics of both education and gameplay. The game is gameplay, but the information conveyed by the participants' psychological reactions triggered by scenes and the rules of the game stimulate learning. Based on these characteristics, when designing educational games the students' personal characteristics and the applicability of the game to the teaching content need to be considered. Also, the experience of the game must not cause the students to lose interest.

CONSTRUCTING EDUCATIONAL GAMES BASED ON ARCS

Integrate the Design Processes of ARCS Motivation and Educational Game

The ten steps of the ARCS model developed by Keller can be grouped into five sections: gathering information, analysing demands, setting motivation objectives, ways to stimulate motivation and evaluation. The design of an educational game includes the following: a) requirement analysis, including analysing the objectives of the game and

teaching content; b) matching game type to teaching content; c) reviewing the game and teaching to determine the strategies for the development and application of the game; d) game design and implementation; and e) evaluation and feedback.

An educational game is a special learning system, and every step in the process of using the game in teaching must stimulate and sustain the learners' motivation. ARCS is a multi-level systematic process that can be applied to designing educational games. The integration of ARCS with the design of educational games is shown in Figure 1.
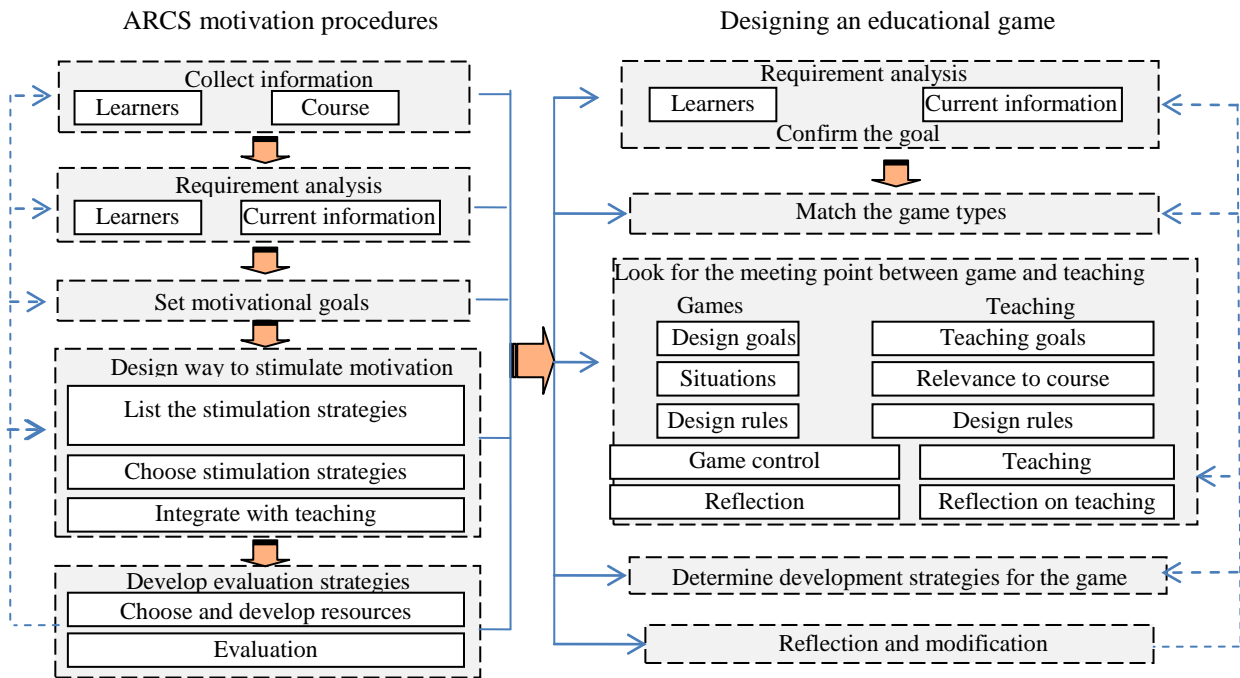
Figure 1: Educational game design model based on ARCS.

Integrating these models establishes the connection between the design processes of ARCS and that of educational games. This connection is not just linear. For example, in the early analysis of an educational system, full consideration needs to be given on to how to inspire and maintain a learner's motivation based on the ARCS model. When designing the game, the functions of the game at each teaching stage should be based upon the ARCS motivation strategies.

Application of ARCS Motivation Strategies in Designing an Educational Game

Attention strategy: the teaching content should reflect users' interest and employ a variety of teaching elements to trigger users' curiosity and stimulate their initial motivation.

Relevance strategy: the relevance of the scenes in the game guides players to transfer knowledge to the teaching content [7]. The information from the game helps to integrate new knowledge by providing users with an expectation of victory.

Confidence and satisfaction strategy: after learning, provide the opportunity for internal reinforcement and external incentives for learners to apply their new knowledge to new situations and, therefore, have a sense of achievement, which ultimately enhances learning motivation, see Figure 2.
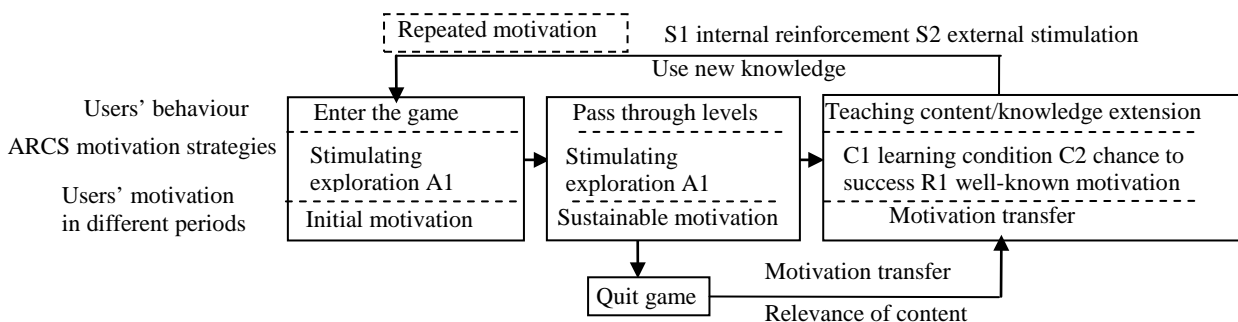
Figure 2: Analysis on different types of motivation strategy for educational games based on ARCS.

Requirements Analysis of the Game

Analysis of students in vocational colleges: generally, students in vocational colleges have poor motivation, interest and perseverance. They are weak at analysing complex problems and are only willing to complete learning tasks step by step instead of having the ability to use knowledge and draw inferences. On the other hand, they are keen on participating in various non-learning club activities and quite a lot are addicted to games [8].

Analysis of teaching content: the course, *Post-Processing of Indoor Renderings*, involves choosing design posters or photos [9]. But students appear to be unmotivated. For example, when teaching post-processing of the living room of a villa, there are difficulties as follows: a) The processing is complex, with many processing steps, such as harmonising overall colour and tone of the indoor renderings, adjusting local materials, adding background and designing lighting effects. Most students psychologically resist the task and shrink back from its difficulties; and b) students are weak at grasping the entire procedure, and only with the guidance of the teacher can they complete the task step-by-step. Students always seem to be pained and frustrated if required to process different types of indoor renderings, even when using the same method.

So in view of this situation, an educational game could be introduced into teaching *Post-Processing of Indoor Renderings* and, hence, eliminate students' psychological resistance and stimulate their interests in learning.

The Game Type

According to surveys, vocational students prefer the on-line game, QQ Games. QQ Games include Chinese Poker, Link Game, Beauties' Difference, Army Chess and QQ Farm, which are all very popular. A single use of one of these games takes little time and is simple to operate.

Players pay more attention to manipulating the scene or characters when using the game product. Therefore, the small, compact mini-game, *Spot the Differences*, was the model for developing the educational game for the post-processing project for the living room of a villa. Students can master it quickly and do not need to spend time becoming familiar with the rules of the game.

Game Development and Design

Stimulate and maintain initial motivation: the game based on *Spot the Differences* supports the post-processing of *the living room of a villa* projects and attract students' attention and arouse curiosity, eliminating psychological resistance to the task and inspiring enthusiasm. In the design, a specific task is the difference between two pictures, and it is displayed on the game's interface.

The difficulty level and the gradual accumulation of pictures on the interface maintain students' motivation for continuing with the game. Once students complete the game, they have also finished the part they are not good at and which they used to resist, i.e. pre-analysis and pre-induction of one task; see Figures 3 and 4.
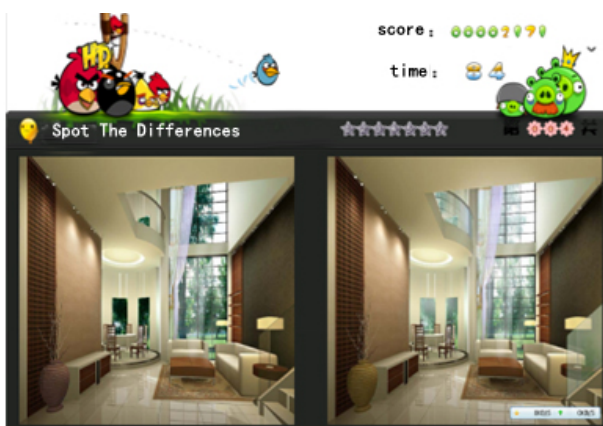

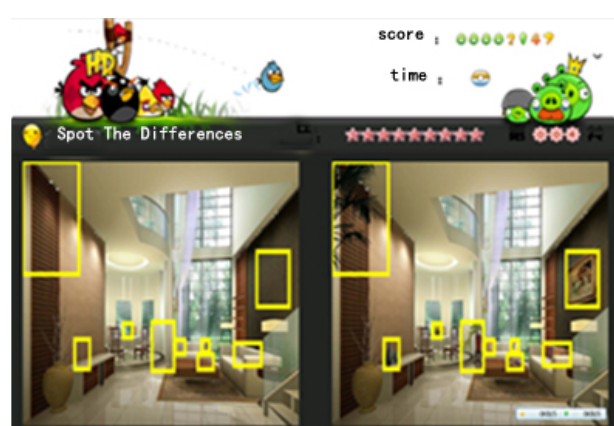Figure 3: Game level design.   Figure 4: Differences in the game level.

Repeat and transfer motivation: after reducing students' psychological fear by using the game, a new interface for the game was developed to import the picture produced in the class so as to stimulate students' motivation to deal with later projects. As a result, students' focus shifts, from playing games to designing game. Learning motivation will be generated to deal with different types of project - see Figure 5.

Figure 5: Generation of the game.

Application Strategies for the Game Class

Induce - draw and hold attention: lead the mini-game *Spot the Differences* into the course and, then, ask students to find differences between two pictures. One is in 3D rendering and the other is post-processed by PS (Photoshop). At every level of the game, the left picture on the interface is unprocessed and the right one is the results picture. Differences between the pictures are the focus of the image processing.

Analyse - build and maintain relevance: after the game is over, students are guided to analyse the game content: What is the setting of the game level? What are the differences between the two pictures? What tools and commands are used in the game when processing the left picture into the right one? Thus, the students' interest is transferred into the project to sum up the general procedure of processing indoor renderings, viz. analysis and planning; harmonising overall colour and tone of the indoor renderings; adjusting local material; adding background; designing lighting effect; and comparing and modifying the whole. The post-processing is further analysed, i.e. the overall tone of the living room is rich, but the colour is a little colder; background outside the window is missing, which appears unreal; there is no indoor decorative display in the room, hence there is a lack of vitality in the interior space.

Practise - build and keep confidence: At this stage, enhance students' learning motivation by making skills mastery rise in a spiral using the cycle, practise - teach - practise. Students practise in advance noting the subtasks set by the game and lectures. The teaching provides the theory, difficulties, and key points involved and critiques students' mistakes. Students' practice improves outcomes and strengthens operating skills.

Exploit - produce and sustain satisfaction: tools are provided to overcome difficulties and allow students to understand key points of the project and, hence, achieve the goal of learning by analogy and to be able to draw inferences about a case from another instance. Students are motivated to complete different types of post-processing image. According to students' personalities, the teacher also assigns two different game designing tasks with different levels of difficulty, viz. post-process the hall of a shopping mall and rooms in a hotel.

Survey on the Effect of the Game Application

The teaching using the educational game was conducted in five experimental classes - Architectural Ornament 0901, 1001, and Architectural Design 1001, 1101, 1201 - and results compared with parallel classes using traditional teaching methods. At the end of the course an investigation was carried out to determine the satisfaction with the game, learning effects and other effects of the educational games on the experimental classes - see Table 3.

Table 3: Investigation into the effects of the educational game.

Category	Investigation item	Point
Satisfaction with the game	General impression	1-10
	Plot	1-10
	Images	1-10
	Music	1-10
Learning effect	How difficult is the level?	1-10
	Do you learn something?	1-10

Presentation mode	Does knowledge present naturally?	1-10
	Do you feel suppressed during the game?	1-10
Interest in game teaching	Does your learning interest increase?	1-10
	Do you like this way to learn?	1-10
	Which subject do you want to apply this learning method to?	1-10

The results show that students speak highly of the implementation of the educational game. They think that addressing the weakness of the normal project process by involving in the game can arouse great interest and overcome the fear of professional courses. By passing through the game levels, students can be very clear about the procedure of post-processing to provide significant help for subsequent image processing. The game level generator can be used to create a new game interface and stimulate interest in building post-renderings of other places, which can make students feel rewarded.

CONCLUSIONS

Based on the four application strategies of the ARCS motivation design model and focusing on the problems of how to stimulate, maintain and enhance user motivation, an appropriate game design model is outlined in this article. A practical development was conducted of an educational game for the post-processing of the living room of a villa. The feasibility and effectiveness of this model was tested through surveys. The author's follow-up studies will concern the development of practical educational games, with a wider range of topics and more teaching content based on the model outlined in this article, and will concentrate on learners' actual interests.

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