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Determination Of The Features Of Instructional Computer Games

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1. Introduction And Background

The ultimate goal of computer based education is to design an education-application which interactively presents all the relevant information in the best possible way. Imagine an expert system with all the advanced capabilities presents the information by using all sorts of different media, including virtual reality, accesses a rich knowledgebase, and interacts with students as an expert in the field. This kind of a system would provide the knowledge and experience of the best teacher to a large group of people.

Today, the use of computers in education is generally an effort to imitate the conventional education by using the computer. But it may be necessary to adapt a totally different approach in order to fully utilize the capabilities of a computer. One of the best ways to utilize the power of the computers in education may be to present the instructional material in the form of an instructional computer game. Computer games can enhance learning while affecting the motivation and retention of knowledge and skills positively. In the context of this paper, learning is defined as enhancing the learning outcomes proposed by Gagné (1985). A game becomes an intentional education tool when the rules which govern the play of the game demand the development and use of educationally valuable skills, the acquisition of important knowledge, or exploration of a worthwhile world of experience.

1.1. Problem Statement

Numerous instructional computer games are being released but they can not always maximize the learning outcomes. Some games are ineffective in terms of enhancing the outcomes although they are very entertaining and motivating. On the other hand, other games are useless in terms of their instructional content because they lack the interesting and entertaining aspects which are essential for the student's motivation. In order to design a balanced instructional computer game which entertains and motivates a student while enhancing the learning outcomes, the essential features of the instructional computer games (ICG) should be identified.

1.2. Research Objectives

The objective of this paper is to propose an integrated framework which unifies and complements the existing approaches to the identification of the key features of ICG by analyzing the features of ICG that enhance the instructional quality, features that enhance motivation, and the relationship among these features. Some research questions to be answered are; Are these two sets of features separate? Is there a conflict between these two sets of features? What is the optimum combination of features with the ultimate goal of enhancing the learning outcomes?

1.3. The Underlying Theory

The proposed work is based on the instructional design theory (Kemp, 1971; Moore and Anderson, 1969) which is itself based on general systems theory, communications theory, theories of learning (Atkinson and Shiffrin, 1968), and instruction theory (Bruner, 1966; Gagné, 1985). Motivation theories (Thorndike, 1911; Hull, 1943; Skinner, 1953; Csikzsentmihalyi,1975, 1979 Malone, 1980) and the existing research relating to the role of games in learning (Roberts, Arth, and Bush, 1959; Gredler, 1994; Denzin, 1977; Bower, 1974) and the use of computer games in education (Gredler, 1994; Alessi, 1991; White, 1981; Banet, 1979) have been used to identify the features of the ICG.

2. Proposed Work

2.1. Instructional Design and Motivational Principles

A comprehensive list of instructional design and motivational guidelines is identified based on the theories of instructional design and motivation. Kemp's (1971) framework and the theories of instructional design provided the instructional design guidelines. Motivational guidelines are identified based on Malone's (1980) framework and other theories of motivation.

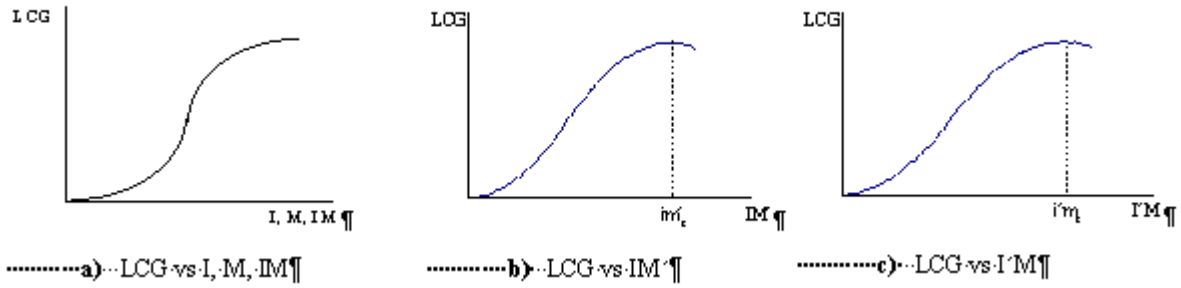


Figure 1. Relationships between LCG and each feature set

Instructional design guidelines include the following items: Select the topic and general purposes. Identify the characteristics and individual differences between the students. Determine terminal and enabling objectives, enable the student first to learn facts, then use facts to identify concepts, and build relationships among concepts to identify principles and develop problem solving capabilities. Evaluation should be in agreement

with the objectives and it should be based on how well the objectives attained not on relative standing of each student with respect to others. Evaluation should sample the possible domains of items adequately. Subject content should be in alignment with the objectives. Only relevant and essential information should be included. Pretest is necessary to see if the student is ready to study the topic. Feedback should be provided about how well one is doing. Means to practice newly acquired skills and knowledge should be provided. The sequence of instruction should match the events of instruction (Gagné, 1972). Motivational guidelines are identified as challenge, making the outcome uncertain, intrinsic fantasy, and curiosity (Malone, 1980).

Following the identification of instructional design and motivational guidelines, they are translated into instructional content features and motivational features of the ICG. These features are grouped according to the relationship among them. Finally, a set of ICG design guidelines are presented.

2.2. Translation of Guidelines into ICG Features

The two sets used to group the ICG features are Instructional Content (IC) features and Motivational (MT) features. The features included in IC set enhances the instructional value of the computer game The features included in MT set enhances the motivational value of the computer game. These features make the ICG more entertaining and desirable. There is either positive or negative interaction between the members in the intersection region of the two sets. Set I includes only the features that enhances the instructional quality of the computer game but has no effect on the motivational aspects of the game. Similarly M includes only the features that enhances the motivation while having no effect on

instructional quality. Set IM´ includes the features that effect instructional quality positively while affecting motivation of the game negatively. Conversely, set I´M includes the features that have positive impact on motivation but negative impact on the instructional quality. IM includes all the features that have positive effect both on instructional quality and motivation.

The features are categorized into subgroups such as academic skills, goal, feedback, problem structure, adaptability, difficulty and reality, role assignment, branching, scoring, directions, and chance. After identifying the set members, the relationships among the features are analyzed. The purpose is to fine-tune the coupling between instructional features and motivation features so that the combination, as a final product, yields optimum learning.

The features in sets I, M, IM will increase the learning, probably with a decreasing slope after a certain point. On the other hand, the features in sets I´M and IM´ will only increase Learning by Computer Game (LCG) up to a certain point and then cause a decrease in learning. This is due to the conflicting nature of the features. For example, increasing randomness may increase the motivation but if the game dominantly depends on luck rather than skills, this will conflict with the principle that guessing should be

differentiated from deductive reasoning and the game will cease to be an effective ICG. Figure 1 shows the expected shapes of the relationships between LCG and each feature set:

im´c (im´critical) and i´mc (i´mcritical) symbolize the critical points beyond which the contribution of the feature to the enhancement of learning becomes negative.

Although increasing I, M, and IM features results in enhanced learning, the marginal utility of each feature is decreasing. Since there is a cost associated with each feature, we can always achieve minimum cost, for a specific learning level, by a balanced combination of features instead of having excessive amount of features of one kind (e.g. I) while having very little of another (e.g. M). The LCG can be simply represented on an "IC" vs. "MT" space as in Figure 2.

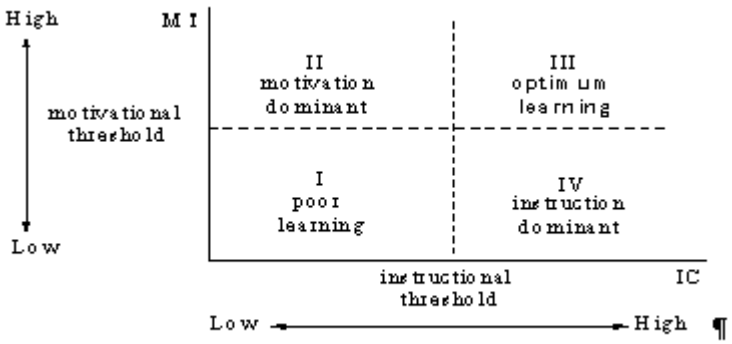


Figure 2. Learning Regions

Regions II and IV will yield learning which is equal to or inferior to region III for a higher cost. Optimum learning is achieved for a minimum cost by a balanced combination of motivational and instructional features. By using this simplified representation, a set of guidelines can be obtained for the design of instructional computer games.

2.3. ICG Design Guidelines

Based on the interaction between the sets, the degree of features included in sets I, M, and IM should be maximized subject to all possible constraints.

On the other hand, the features included in IM´, and I´M deserve more attention. Due to their conflicting nature, they should be balanced in order to optimize learning by computer game. Therefore it is very important to keep these features below the critical levels beyond which the impact becomes negative.

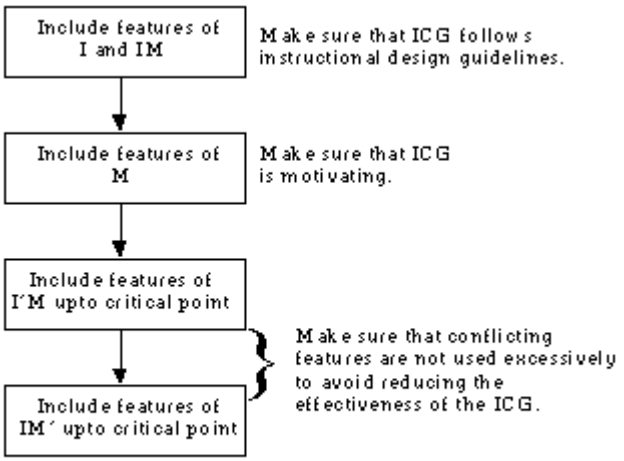
2.4. Validation Of The Proposed Work

The validation process starts with the identified features and demonstrates that they fit in the guidelines dictated by the corresponding underlying theory. Although it is very

complicated, if not impossible, to identify the ideal combination, the results presented in this study can guide the

designer in decisions regarding which features must be included, which ones can easily be discarded, which features should be increased and which should be reduced.

Instead of using trial and error, the designer may begin with an initial set of features. The results show that the two sets, IM´ and I´M are rather small, compared to the others, which implies that learning and computer games are not conflicting. By balancing the features, learning can actually be enhanced, compared to the learning achieved by traditional instruction techniques.



→ **Figure·3.···Design·Guidelines·for·ICG¶**

3. Conclusions

The major objective of this paper is not to define the design process but to identify the key features of the ICG and to group them as instructional and motivational features. This paper, therefore has answered the first two research questions by identifying the members of sets IC, and MT. It has also been shown that these sets are not separate by identifying the members of sets IM, I´M, and IM´. We showed that adding motivational features to a computer game does not necessarily reduces the instructional quality of the game. Finally it has been shown that some motivational features and instructional content features (members of sets I´M and IM´) are conflicting and based on the relationship among the features simplified design guidelines has been proposed.