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Incorporating Kansei Engineering in instructional design: Designing virtual reality based learning environments from a novel perspective

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Abstract

In recent years, the application of virtual reality (VR) technology in education is rapidly gaining momentum. The educational benefits offered by such technology have prompted many educators as well as instructional designers to investigate ways to create effective and engaging VR learning. Instructional designers have examined widely the capability of VR in influencing the cognitive capacity as well as motivational processes of learners. Nonetheless, one often-neglected aspect is its ability to stimulate emotions, which in turn can affect learning. With the current intense interest in designing emotionally sound instructional applications, this paper proposes a new outlook by incorporating Kansei Engineering methodology in the instructional design process. Specifically, as part of an on-going project, it describes how Kansei Engineering method can be incorporated in the design of VR based learning environments based on the model suggested by Chen, Toh and Wan (2004). The proposed method is not only able to facilitate the instructional designers in identifying desired design elements but also to refine the methods prescribed in an instructional model.

Keywords

instructional design, virtual reality, kansei engineering, educational technology

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Introduction

New virtual minds are populating our classrooms. The new occupants of our schools are almost technological natives: children, adolescents and young adults for whom the computer is a fundamental part of everyday life. This situation triggers an explosion of interests in using computer-based learning materials in various educational settings for a wide range of learning purposes. The role of instructional designers, thus, becomes even more challenging in meeting the demands of creating effective instructional materials. Virtual reality (VR) is one of the many technologies that has gained extensive attention by instructional designers due to its ability to simulate the real world for learning. It allows learners to create their own experiences and knowledge by exploring three-dimensional visualisation of events or environments in which distance, time, cost and safety would not be a hindrance. Thus, the compatibility of VR capabilities with constructivist learning principles (Chen & Teh, 2000) has seen its proliferation in various education applications (Bricken & Bryne, 1993).

Among the many forms of VR system, desktop VR is the most widely utilised educational tool primarily because of its feasibility and cost-effectiveness. Application of VR on desktop computers without the need of expensive peripherals has opened up greater opportunities for its implementation in education. In recent years, researchers and instructional designers (Cobb, Neale, Crosier, & Wilson, 2002; Roussos, 2004) have scrutinized the capability of desktop VR in influencing the cognitive capacity as well as motivational processes of learners. However, one often neglected aspect is its ability to stimulate emotions, which many tend to ignore its vital role in promoting learning. While there has been a noteworthy amount of studies conducted on how emotions can be induced in computer games (Bryant & Zillmann, 2002), research on emotional principles in instructional design, particularly those related to VR-based learning environment is still limited. Hede's (2002) comprehensive reviews of multimedia elements in instructional design process, for instance, excluded completely the emotional perspective. Furthermore, previous studies on desktop VR application in instructions were mainly on usability issues (i.e. user-friendliness, software and hardware requirements) and have shed little light on aspects of user experience in particular the affective quality. As such, there is a need to investigate further the role of emotions in guiding the design of VR-based instructional environments.

Instructional Design and Emotions

The field of instructional design has evolved rapidly over the past half-century from an initial narrow focus on programmed instructions to multidimensional field of study. Despite that, the ultimate goal of instructional design remains the same, which is to make learning more effective, efficient and engaging. As stated by Reigeluth (1999), instructional design is concerned with understanding, improving and applying methods of instruction. It is thus a process of deciding what methods of instructions are best for bringing about desired learning outcomes. In this constant thrust of improving learning experience, instructional designers have incorporated knowledge from numerous areas of study such as psychology, learning sciences and more recently, emotional design.

According to Wilson (2005), though emotion has been recognised as an important factor that affect learning, for most instructional designers, the need to consider the "emotional value" of any instructional application is often deserted. In Wilson's proposed four pillars of instructional design practice, aesthetics are considered as the immediate experience of learning. He mentioned that instructional designers are not only designers of materials, but they are also designers of experience. On both levels, they move beyond purely technical issues of theory application and enter into the realm of aesthetics that unavoidably involves human feelings and emotions (Wilson, 2005). Many instructional designers are beginning to realise such importance despite the traditional division between cognition and affective in learning (Jones & Issroff, 2005) and are starting to examine affective factor in instructional design more carefully. The review done by Jones and Issroff (2005), for instance, indicated that most studies on collaborative learning technologies emphasised heavily on cognitive aspects and more studies are needed to investigate the affective factors pertaining to the use of technologies in educational settings.

Undeniably, it is generally agreed by educationists that learning are more likely to occur when learners are in a positive state of emotion. Isen and Reeve (2005) reiterated that learners who are in a positive emotional state make more constructive judgments because they interpret situations more positively than they would at other times. In relation to this, two recent studies (Park & Lim, 2007; Um, Song & Plass, 2007) have investigated how aesthetic elements such as colours, layout and graphic illustrations of multimedia learning materials could increase the positive emotions of the learners whose emotional state in the beginning of the learning was neutral. This, in turn, improved their problem solving and decision making ability as shown in their transfer test results. Both studies have highlighted the need for instructional designers to incorporate principles of emotional design in instructional design as it is able to affect learners' learning experiences and performance.

In another attempt to link emotions and instructions, Astleitner (2000) suggested that there are five emotions that educators need to consider in learning context, which are fear, envy, anger, sympathy and pleasure (FEASP). He added that instructional designers have to consider these emotions in order to optimize the learner's emotion states during the learning process. Astleitner and Leutner (2000) further conceptualised the FEASP approach in guiding the design of computer-assisted instructions. They outlined several strategies in identifying emotional problems faced by learners during the use of instructional technology and suggested ways to improve those problems. However, on close examination of Astleitner's proposed approach, the problems are twofold. First, without a proper method, it is not easy to figure out what emotions that need to be considered in learning environments as his suggestion of the five emotions are rather limited and negative in nature. Second, it is also questionable how the emotions could be categorised to facilitate instructional designer in using the information during the actual design of instructional materials. Therefore, due to the systematic procedure in which it is possible to evaluate quantitative relationships between emotions and design elements, Kansei Engineering is seen as a potential method in offering plausible solutions to these problems.

Kansei Engineering

Kansei Engineering (KE), which is also referred to as emotional design or affective engineering, is a methodology that assimilates human Kansei (psychological feelings and emotions) into design elements, with an aim to create products or designs that user will satisfy. Broadly, Kansei is a Japanese term that refers to human's sensitivity, sensibility and feeling, in which when presented with a stimulus, it will be evoked and hence influences the judgement of a person on that stimulus. Such concept is then combined with the engineering realm in assisting the development of new products that suits consumers' affect.

Ever since Nagamachi (1989) made it popular, KE is mainly implemented in product design such as consumer and industrial items (Nagamachi, 2002). KE is based on subjective estimations of products and concept properties and helps users to express their demands on the product including those which they might not be aware of. In this case, semantic tools such as Semantic Differential method developed by Osgood et al (1969, as cited in Schütte, 2002) are used in order to quantify the emotions. As compared to other methodologies, KE is able to gather and prioritise users' feelings due to its ability to build mathematical prediction models on how feelings are connected to design elements (Schütte, 2002). Furthermore, according to Nagamachi (2002), KE can be performed at any point in the product design development cycle where sensible flexibility exist in making decisions concerning any design aspects of the product.

Kansei Engineering in its fundamental structure contains four important steps (Nagamachi, 1995):

i Selection of appropriate Kansei words.

In the first step, the Kansei words are selected and collected by interviewing customers or experts, as well as by referring to literature or product magazines. Depending on the object or design under studied, the number of adjectives can vary. The collection of Kansei words if too large (i.e. more than 100), should be reduced using statistical method as some words may have similar meanings and can be grouped accordingly. One of the most commonly used methods is factor analysis. Factor analysis reduces a large number of variables into a smaller number of groups called factors. Thus, a smaller set of Kansei words with salient meanings can be obtained.

ii Assessment or evaluation of the design elements or components.

In the second step, an experiment to collect users' impressions on a specific product property or parameters is conducted. Users evaluate products according to the given Kansei words presented on a Semantic Differential questionnaire. This questionnaire can either be paper-based or computer-based such as using web survey. Users' responses on the given designs are then recorded and quantified either manually or using statistical packages.

iii Multivariate analysis of gathered data.

In the third step, the correlation between the Kansei words and design attributes (i.e. colour, layout, size) is measured using statistical and data visualization method. The most frequently used method is Hayashi's Quantification Theory Type I (Nagamachi, 1995). This method is a variant of the linear multiple regression analysis that can shows the connection between the properties and each Kansei factor. The method covering the first three steps is also known as forward KE.

iv Constructing a system connecting (i) to (iii).

In the fourth step (which is optional), the obtained relations are converted to rules that a computer uses for reasoning. These rules are used to develop a retrieval system, which is often called as KE expert system. This expert system can generate a design that corresponds to the user's Kansei from their input of adjectives. The process involved in such expert system is referred to as backward KE.

Many studies conducted have reported positive results from the use of KE methods in enhancing user's satisfaction on a particular product (Nagamachi, 1995). Advantages of using KE are that abstract feelings are visualised and made comprehensible. Thus, it may provide a structured support for integrating affective values into product design, especially in early and late stages of the product development process (Schütte, 2005). Despite that, KE methods are not restricted only to the field of industrial and product design. There have been various attempts to incorporate KE in other fields such as website design and community design (Schütte, 2002). Its application in instructional design, on the other hand, remains a domain worth to be studied and explored.

The Proposed Framework

Of the various KE methods as categorized by Nagamachi (1997), this paper proposed the use of forward KE method in identifying user's subjective responses towards design elements in line with the chosen instructional model. In this type of KE method, the connections between Kansei and design properties are made using statistical tools (Schütte, 2002) as explained in the earlier section. Figure 1 illustrates the proposed Kansei Engineering concept in instructional design in general.

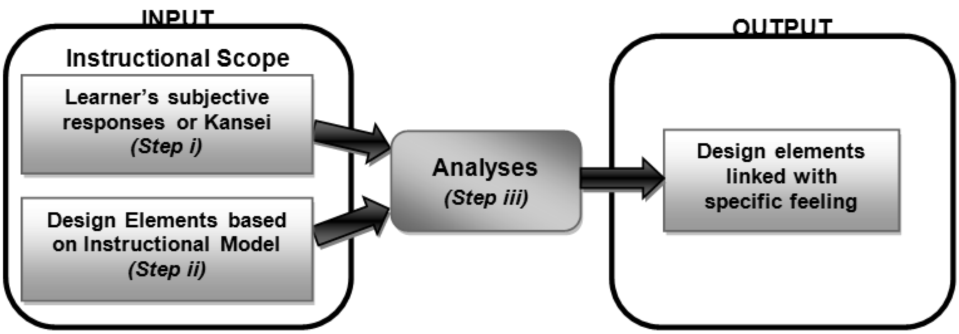

Fig. 1. Proposed framework for Kansei Engineering implementation in instructional design

In most instructional design processes, a designer would select a guiding model based on the scope of the instructional materials. The scope would include the descriptions of target learners, content as well as objectives. Once the instructional design model is chosen, the designer would then proceed by generating the design elements based on the prescribed methods or steps of the model. With the help of rapid prototyping, users' subjective responses on the design elements are obtained and analysed. The analysis process using the prescribed statistical methods in KE can create links or relationships between user's emotions and the design elements and form groups of design elements linked with specific feelings or emotions. Thus, in applying the KE methodology in instructional design, three important steps need to be emphasised: 1) determination of the design elements to be evaluated 2) selection of Kansei words for user evaluation 3) multivariate analysis of gathered data.

Selection of Kansei Words

User evaluation of a particular design element in KE can be done using various techniques but the most common one is via Kansei survey, which includes a set of Kansei words (feelings, affections and emotions). Researchers or instructional designers can obtain these words from various sources such as pertinent literature, target users, as well as experts. However, unlike in product design, the scope of Kansei words to be used in evaluating instructional learning materials is somewhat different. The selection of Kansei words for such purpose should cover emotions or adjectives closely related to the learning process. An affective model by Kort, Reilly, and Picard (2001) shown in Figure 2, is one example that can guide the Kansei words selection process.

Axis	-1. 0	-0. 5	0	+0. 5	+1. 0
Anxiety-Confidence	Anxiety	Worry	Discomfort	Comfort	Hopeful	Confident
Boredom-Fascination	Ennui	Boredom	Indifference	Interest	Curiosity	Intrigue
Frustration-Euphoria	Frustration	Puzzlement	Confusion	Insight	Enlightenment	Ephipany
Dispirited-Encouraged	Dispirited	Disappointed	Dissatisfied	Satisfied	Thrilled	Enthusiastic
Terror-Enchantment	Terror	Dread	Apprehension	Calm	Anticipatory	Excited

Fig. 2. Model relating phases of learning to emotions (Kort, Reilly & Picard, 2001)

The emotions listed in the model are the common emotions involved in the learning process and it can serve as a guide in generating more Kansei words within the same scope. Moreover, researchers or instructional designers should also be aware that the words selected for evaluation should be comprehensible to the users in order to obtain feedback that is more accurate and reliable.

Determination of Design Elements

In the application of KE methods in product design, the design elements are normally selected from the available products in the market. A Kansei evaluation on mobile phone designs, for example, would take into account the available designs of mobile phones from numerous brands. However, in the case of instructional design, such selection method may not be possible. Instead, in determining the design elements, careful reference to the components within the chosen instructional design model is crucial. Firstly, a complete instructional material fulfilling all the components in a chosen instructional model is developed. Then, depending on the intent of the instructional designer, design elements related to each component will be "manipulated" or "removed" accordingly. This will thus create a set of designs with different highlighted component for user evaluation. Figure 3 shows an example of how design elements based on a model with components A, B, C and D are generated.

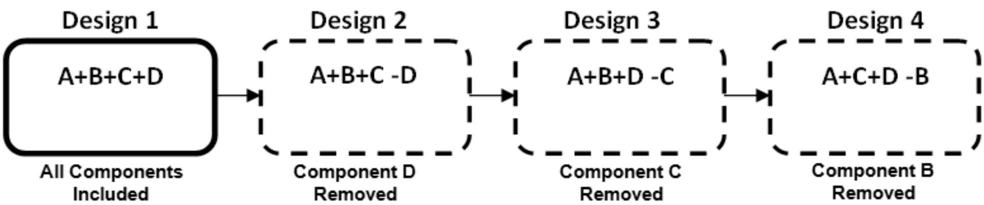

Fig. 3. Generated design elements for Kansei evaluation

As shown in Figure 3, a model with components A, B, C and D can generate at least four design instances to be evaluated by the users. Users' subjective responses can be obtained on these four design instances and changes to their emotional state can be noted when one of the components is removed as in Design 2, Design 3 and Design 4. Therefore, such process of determining the design elements is qualitative in nature as allowed by the KE methods.

Multivariate Analysis of Gathered Data

In Kansei Engineering, multivariate analysis is employed to find latent relationships between various designs and elements. As mentioned in the earlier section, Quantification Theory Type I has been widely used for such purpose. This method is essentially a subset of multiple regression analysis that deals with nominal scale values as explanatory or independent variables (Nagamachi, 1995). It can derive an expression of relations between a value y (dependent variable) and variables, $x_1, x_2,..., x_n$ (independent variables) and predict y value from $x_1, x_2,..., x_n$ values. Independent variables in KE correspond to product parameters, which can either be quantitative (i.e. length of skirt) or qualitative (i.e. types of skirt). In the context of this proposed framework, they refer to the design elements in instructional material that are created based on the components of the chosen instructional design model such as the interface layout, types of icons used for navigation and presentation style of learning problems. Users' estimation of Kansei words, on the other hand, is used as the dependent variable. Thus, the relationship between a specific emotion and sets of design elements can be quantified. These design elements will then provide valuable information for instructional designer in the development process.

Incorporating KE in the Design of VR-based Learning Environments

To illustrate further the application of KE methodology in instructional design, a specific reference to an on-going project on the design of VR-based learning environments known as *SafeKid* is presented. *SafeKid* is a desktop VR-based learning kit for teaching children and young teenagers road safety skills. Though there are numerous instructional design models available, the project has chosen the use of recently suggested model by Chen, Toh and Wan (2004) as shown in Figure 4 as it serves as a feasible and useful template to guide the design of desktop VR based learning environments. In general, the model integrates the concept of integrative goals (Gagné & Merrill, 1990) with the model for designing constructivist learning environments by Jonassen (1999). They serve as the macro strategy, which according to Reigeluth and Merrill (1978), concerns with the selection, sequence, and organisation of the subject matter topics that are to be presented. Additionally, a number of design principles, derived from the cognitive theory of multimedia learning (Mayer, 2002) serve as the micro strategy that basically, concerns with the strategies for effective presentation of the learning contents.

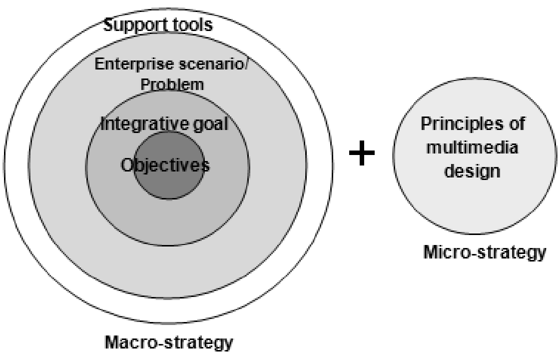

Fig. 4. Instructional design theoretical framework of VR based learning environment (Adapted from Chen, Toh & Wan, 2004)

Based on the chosen model, design instances of a desktop VR learning environment on a predetermined scope are created. In the *SafeKid* project, the VR learning scenarios on road safety skills are designed and developed fulfilling all the components within the model. Each specific skill (or problem) is addressed by a distinct module that consists of VR-based scenarios generated using Virtual Reality Modelling Language (VRML), which share the same small town setting and cast of characters. Then, specific components of the model are identified for Kansei evaluation. In this case, two components within the macro strategy are selected: 1) Enterprise scenario/ problem and 2) support tools. The other two components (objectives and integrative goal) are not chosen mainly because they are the core principles in the design of VR based learning environment, without which a learning environment would not function according to the intended purpose. In addition, the principles of multimedia design (the micro strategy) that mainly concern with the interface design are also evaluated. Design elements related to these components are then manipulated as elaborated in the previous section for the purpose of Kansei evaluation. For example, in the "support tools" component, tools such as guidance cues and help buttons on traffic safety tips provided in the *SafeKid* learning environments are removed in the second design instance for the purpose of indentifying its impact on learners' emotional state. Once the final sets of design instances to be evaluated are decided, they are then presented to the target group for data collection.

During the data collection process, the chosen respondents will rate their feelings toward each set of design elements based on the given checklist that consists of Kansei words organised on a 5-grade Semantic Differential scale. Their subjective responses will be quantified using Quantification Theory Type I with the help of statistical software in order to identify the link between the design elements and the Kansei words. Such relationship will then be used to form a set of guidelines for instructional designer in deciding what and what not to be included in the instructional materials in relation to specific emotions. It can also provide invaluable information in refining the chosen model to accommodate different situationalities by understanding how specific sets of design elements in relation to the instructional model can stimulate specific feelings of the learners.

Conclusion

This paper has presented a conceptual framework for the integration of Kansei Engineering to instructional design by referring to the instructional design model of VR-based learning environments proposed by Chen, Toh and Wan (2004). This paper has also highlighted the need for instructional designer to refocus on the often-neglected affective aspects of a design. It is noted from the literature (Jones & Issroff, 2005; Wilson, 2005) that instructional designers have often put affective factors into secondary position and overlooked its role in promoting effective and engaging learning. The current available studies, which attempted to link emotions and instructions are still inadequate and confined to the study of general design issues (Park & Lim, 2007; Um, Song & Plass, 2007). There is lack of research in investigating how the relationship between emotions and the design of instructional materials can be quantified or examined appropriately in order to guide the instructional design process. As such, the proposed framework of incorporating KE methods can be considered as a suitable alternative. Though still in its initial stage, the possible link between KE methodology and instructional design is useful in helping instructional designers to create emotionally sound materials, which in turn facilitate learning. Moreover, KE methods can also serve as a tool to refine the methods prescribed in a chosen instructional model.

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