DEVELOPMENT AND EVALUATION OF SENIOR HIGH SCHOOL COURSES ON EMERGING TECHNOLOGY: A CASE STUDY OF A COURSE ON VIRTUAL REALITY

Chi-Tung Chen
Center for General Education
National Chi Nan University
Taiwan, R.O.C.
Chitung888@gmail.com

ABSTRACT
In Taiwan, the National Science Council has implemented the High Scope Program (HSP) since 2006. The purpose of this study was to analyze the development and effectiveness of senior high school HSP courses on emerging technology. This study used a course on virtual reality as an example, to investigate the influence of emerging technology courses on senior high school students' attitude toward technology. Research results showed that among students in the experimental group, the following constructs: cognition of the importance of technology, performance of technology-related action, and technology career planning, had been significantly enhanced. This study then developed the "Virtual Reality Course Performance Assessment Scale", and performed cross-evaluation of course teacher and non-course teachers to confirm this scale presenting great content validity, internal consistency validity, and scorer reliability. This scale can provide students and teachers with objective assessment indicators, which can be used to understand the learning effectiveness of students. Lastly, this study discussed the results of this research and external evaluation, as well as provided suggestions for future implementation and modification of the virtual reality course.
Keywords: emerging technology, virtual reality, attitude toward technology, cognition of the importance of technology, interest in learning about technology, performance of technology-related action, technology career planning

INTRODUCTION
Emerging technologies are radical innovations based on developing technologies. Because knowledge in related technological domains is still in continual development, emerging technologies still present high uncertainty in technological innovation, product development, customer demand, market scale, and innovative benefits. However, emerging technologies offer significant market opportunities, and may in the future become a completely new industry. Emerging technologies are also poised to greatly impact existing industries and markets, and therefore have received a great deal of emphasis from governments, research institutions, corporations, and investors (Liu, 2004). Technologies such as gene therapy, high-temperature superconducting materials, micro-robots, luminescent material, nano-material, and green technology are all emerging technologies that will significantly influence humanity and society in the future.

In Taiwan, in order to train up a skilled workforce for future development of emerging technology and scientific research, the Department of Science Education (National Science Council, Executive Yuan) referred to the Japanese "Super Science High School (SSH) Project" and implemented the "Experimental Program for the Development of Science and Technology Courses in Senior and Vocational High Schools" (High Scope Program, HSP) in 2006. The purpose of the plan was to assist senior and vocational high schools in developing science and technology courses in prospective domains and enhance the quality of science and technology education in senior and vocational high schools. Through this project, the government of Taiwan intended to implement the provisional course outlines in 2010 senior and vocational high schools, emphasize the establishment of partner relationships between universities and senior/vocational high schools, and allow senior/vocational high schools to develop innovative science and technology courses. The purpose of these courses was to enhance the quality of senior/vocational high schools nationwide, provide students with a real learning environment, and nurture students' scientific research capacity - such as ability to take initiative to explore the development process of dynamic emerging technology and the influence of technology on humanity (National Science Council High Scope Program, 2007).

The senior high school used in this research (known hereafter as High School A) was a comprehensive high school with considerable flexibility in its curriculum. The most prominent feature of the school was its provision of diversified courses for students to engage in adaptive learning. In 2001, High School A became the affiliated high school of a national university (known hereafter as University C) and received the full support of this university in hardware and software facilities. In 2007, the two schools cooperated to propose the "The Endless Sky: Research on Application of Wireless Hypermedia to Comprehensive High School Curriculum", which received funding from the High-Scope Program of the National Science Council. This allowed the development of emerging technology courses on topics such as wireless Internet technology, virtual reality, and digital astronomy. Through course design, these institutions hoped to boost students' passion in learning about and exploring emerging technologies, guide students in developing correct attitudes toward technology, and link such courses with university curriculum to enhance students' career exploration and reduce their adjustment period upon entry into university.

To assist in solving the problems encountered during the development of these new courses and evaluate the effectiveness of the courses upon implementation, curriculum experts from University C used the CIPP assessment model to conduct external evaluation. The purposes were to assist High School A in building development and instruction models for courses on emerging technology and provide reference for internal or external development of related technological courses. Apart from developing courses, researcher also combined self-evaluation mechanisms and external evaluation to fulfill the above-described predetermined objectives. The researcher in this study was the course developers and used the virtual reality course they developed as an example of course development, as well as utilized teaching experiments to analyze the course and its effectiveness. The purpose of this study was not only to develop a 3D virtual reality course suitable for helping high school students to develop basic technological implementation techniques. Researcher also aimed to use quasi-experimental design to rule out pre-test effects and examine the influence of the course on the various constructs (cognition of the importance of technology, interest in learning about technology, performance of technology-related action, and technology career planning) of high school students' attitude toward technology. In the next stage of planning, researcher intend to incorporate instruction in other academic subjects, to stimulate learners' ability for creative development and facilitate greater competitive capacity in meeting the challenges of the future.

Additionally, in the external evaluation results of course development for the second year, Huang, Lin, Wang, and Hou. (2009) pointed out that without an objective rating standard in assessment of learning effectiveness, the quality of an educational product or course is very difficult to determine. Instructors may say that "Intuition will indicate quality; whether the methodology is strong or not can be determined from a glance". However, if teachers wish to be able to clearly plan the core abilities and subject matter to be learned each week or in each unit, overall assessment at fixed intervals can help teachers to more closely approach the learning situations of students. To solve the problem of objectivity in evaluating students' work, Huang et al. (2009) suggested that the scoring indicators used in various domestic multimedia contests be used as a referential basis for assessing student work. Based on the above-described recommendation, another purpose of this study was to develop a performance assessment scale suitable for use in this course, to comprehend the learning effectiveness of individual students.

LITERATURE REVIEW

1.Virtual Reality

Virtual reality (VR) is a emerging technology that may affect human life. VR is a type of computer-based simulation. VR systems have the potential to allow learners to discover and experience objects and phenomena in ways that they cannot do in real life (Erenay & Hashemipour, 2003). The term was first proposed by VPL Research founder Jaron Lanier, and refers to a fabricated environment that resembles a real-life environment. In actuality, virtual reality is a type of illusion that is simulated by a computer and through our senses produces a type of feeling that is difficult to differentiate from reality. Hsu and Shin (1997) also indicated that virtual reality is a new domain developed from and based on computer graphics, computer simulation, user interface and interactive technology. The realistic interactive simulation results of virtual reality have brought computer users into a new epoch. Virtual reality has the following three essential elements: imagination, interaction, and immersion (Burdea & Coiffet, 2003).

Virtual reality is a computer-generated image simulation. Apart from providing lifelike scenes and images, the scene designer can bring feelings of vividness and fun to the user (student) through imagination. Students must also experience the sound and light effects generated by the virtual scene and imagine themselves present in this virtual space, as well as interact with the virtual scene, in order to achieve the desired results.

The scope of application of VR includes artwork, entertainment, and education (Yoon, 2010). A great number of artists use VR techniques to create an environment for interacting with viewers. In 1999, Camille Utterback and Romy Achituv created Text Rain, an interactive installation in which participants use the familiar instrument of their bodies to lift and play with falling letters on the screen. Other large immersive VR projects include Osmose and Ephemere (Yoon, 2010). The interaction and immersion characteristics of VR techniques are also suitable to be applied for entertainment purposes (Burdea & Coiffet, 2003). Various online games and movies have extensively adopted VR techniques; for example, the movie "Avatar" converted human motion into digital data, and combined the data with virtual characters via motion capture techniques. Regarding educational applications, VR systems allow learners to interact with learning materials, providing learners with real experiences and opportunities to practice continually. If VR techniques can support traditional teaching activities, the integrated education activities can provide learners with a more real, flexible, and effective learning environment (Lai, Huang, Liaw, & Huang, 2009).

2. Attitude toward technology

In the early 1980's, Dutch scholar on science education Jan Raat and Marc de Vries et al. conducted an international study on attitude toward technology titled Pupils' Attitude Toward Technology (PATT), which was successively extended to other studies related to attitude toward technology and concept of technology (Heywood, 1998). In 1993, Jeffrey developed a simpler measurement tool, the Technology Attitude scale (TAS-USA) based on the PATT-USA scale. The purpose was to use this scale to test and measure students' attitude toward technology. Both PATT and PATT-USA consisted of six main constructs: "personal interest in technology", "role of technology", " results of technology", "difficulties with technology", "courses on technology", and "career in technology".

In Taiwan, the constructs of scales related to attitude toward technology have been developed largely from the six constructs of the PATT scale. An example of this is the four constructs of the scale for attitude toward technology developed by Chang (1998): "content of technology", "technological techniques", "technology products", and "influence of technology". The scale for junior high students' attitude toward technology developed by Cheng (2000) was divided into six constructs: "reaction to technological objects", "basic awareness of the importance of technology", "vigilance toward technology", "behavioral inclinations with regard to technology", " assessment of the value of technology", and "organizational analysis capacity regarding technology". The scale for the attitude of junior high school students toward technology developed by Yu, Han, Hsu, and Lin (2005) was divided into five constructs: "learning about technology", "interest in technology", "difficulties of technology", "contribution of technology", and "technology in life".

Combining the above-described references, Huang, Lin, Wang, and Hou. (2008) divided attitude toward technology into four constructs based on the areas of cognition, skill, and affective meaning.

- Cognition of the importance of technology: Refers to individual conception of the influence of technology on life and society
- Interest in learning about technology: Refers to individual reaction to, interest in, and willingness to learn about new information or developments related to technology; preferences and degree of satisfaction with regard to learning about technology, and desire to gain an in-depth understanding of technology.
- Performance of technology-related actions: Refers to the level to which individuals use actions or behavioral inclinations to express their attention to and preferences regarding technology-related objects and matters.
- Technology career planning: Refers to individuals planning for technological study and technological work in their future careers.

Concerning research related to attitudes toward technology, Dutch technology education scholars Raat and de Vries. (1985) surveyed 2500 eighth grade students on their attitudes toward technology. The research results indicate that most of the students conceived of technology as machines or facilities, stimulating the participation of global scholars in research on attitudes toward technology. Hurley and Vosburg (1997) explored the following issues: student attitudes toward emerging technology, whether these attitudes are positive, and whether a significant correlation exists between technology attitudes and attitudes toward emerging technology. The research results found that the student attitudes toward technology and learning attitudes toward emerging technology are positive and significantly correlated.. The research by Boser, Palmer, and Daugherty (1998) investigated the influence of different teaching methods used in technology education courses and their effect on student attitudes toward technology. The research discovered that three out of the four teaching methods have an impact on the student attitudes toward technology; however, in the dimension of "interest in technology", none of the four teaching methods are effective. Moreover, after nine weeks of technology education courses, the students did not exhibit positive performance in the dimension of technological concepts. Scholars in other countries have also engaged in related research. Van Rensburg, Ankiewicz, and Myburgh (1999) adopted the PATT-USA scale to investigate attitudes toward technology among South African students aged between 12 and 16 years. The research results confirmed that technology is a vital issue of curriculum design in the near future. Voke and Yip (1999) translated and revised the PATT-USA scale to the PATT-HK scale. The PATT-HK scale was applied to investigate the attitudes of junior high school students in Hong Kong toward technology in 1999 and 2005. The research results indicate that altering Design and Technology courses with technology development can positively influence student attitudes toward technology (Voke & Yip, 2005).

Accordingly, the PATT scale has been widely applied to research on teaching and course design regarding technology education since the 1980s, facilitating course designers in planning technology education courses that support students' interests and needs. This study uses VR to develop emerging technology courses and the PATT scale to understand the impact of emerging technology courses on high school student attitudes toward technology.

3. Performance Assessment

With regard to the definition of performance assessment, Wu and Lin (1997) pointed out that performance assessment can also be called a non-written test. It is an assessment based on the students' performance in actual completion of a specific task or piece of work. These tasks or pieces of work may be actual practice, a verbal report, a scientific experiment, math problems, or composition. Lu (1998) indicated that the concept of performance assessment and portfolio assessment, also called alternative assessment, was a hot topic in the fields of education and educational testing and assessment in the U.S in the 1990's. Performance assessment can also be used as a strategic method for assessing the performance of the school and comprehending the general level of student achievement.

This study compiled the viewpoints of the above-described researchers (Wu and Lin, 1997; Lu, 1998; Stiggins, 1987) and defined performance assessment as a method of using observation and professional judgment to assess the learning achievements of students. The forms of performance assessment are diverse, and can include constructed response questions, written report, essays, speech, practice, experimentation, data collection, and display of works.

Evaluation items for the VR courses

The VR course developed by this study includes virtual roles and 2D and 3D designs in scenes and space, with the aim to develop students' art and design abilities. Therefore, this study used the evaluation standards of complete art and design work to develop items for evaluating actual performance in the VR courses.

Regarding works of art, the evaluation items include: (1) Completing the works on time; (2) the presentation of the works; and (3) learning attitudes (Liu, 2007; Hung, 2009). The items evaluating the on-time completion of work assess whether students are responsible. The presentation of artwork can reflect the process students in adjusting their physical and mental conditions; thus, an objective and multidimensional evaluation including five items, composition, color, technique, creativity, and completeness, was applied to cultivate the students' confidence. The main purpose of learning attitudes is to assess whether students work hard, focus on their work, and exhibit persistent learning attitudes. Indicators of learning attitudes can affect future student work attitudes and results. The evaluation items for design work suggested by the teachers are listed below in order of importance: (1) Creativity, (2) correspondence to topics, (3) the completeness of the work, (4) function, (5) aesthetics, and (6) presentation techniques (Yan & San, 2008).

Creativity is the most crucial indicator in the presentation of a work. Therefore, this study uses the evaluation items of artwork to evaluate design work. The researcher also increased the weight of the sub-items in creativity. To satisfy the requirements of this course, "composition" was replaced by "correspondence to topics" among the sub-items in the presentation of works.

RESEARCH METHODS

1. Development of Virtual Reality Course

Composition of research team

This group was mainly composed of teachers from the computer science course of the school being researched. The researcher also invited a professor from department of electrical engineering of university C (with many years of experience in teaching, research, and industry-academia cooperation in image processing, video processing, video compression, graphic theory and DSP/IC design) for guidance in professional technology and assessment of learning effectiveness, as well as invited three professors from a graduate insitute of curriculum and instructional technology at university C to assist in evaluating the course.

Stages of Course Development

In the first year, a course development committee was established to explore the core knowledge of virtual reality and teaching material with a structure suitable for high school level. These materials were then tested according to suitability of teaching methods. Each chapter was developed as one unit and comrpehensively discussed by the course development committee. Reflective logs and meeting minutes were also kept. After the course development committee had discussed and modified the material, the course was finalized, and the textual materials were prepared at the end of the year.

In the second year, researcher began to implement the instructional activities of the virtual reality course. With the counsel of the university professors, researcher used quantified experimenal design, qualitative classroom observation, and interviews to investigate whether the teaching materials were appropriate, the teaching methods suitable, and whether the course could enhance the attitude of students toward technology. The resulting data was used to modify the teaching materials and methods.

In the third and fourth years, researcher repeated the implementation of the modified teaching materials and methods, in the hope that the course would more accurately meet the needs of high school students. Lastly, researcher conducted promotional activities in the fourth year, working to extend implementation of the course to senior and vocational high schools nationwide.

Teaching Objectives

The objectives of this course are as follows:

- To enhance the learning motivation and literacy of students with regard to emerging technology through the instruction of an innovative course.
- To use investigation and practical application of virtual reality to increase the degree to which students use actions or behavioral tendencies to express their attention to or preferences regarding technology-related matters.
- To link this course with university curriculum to enhance students' career exploration and reduce their adjustment period upon entry into university.
- To train students to develop the basic abilities of industry professionals and join future technological industries.

Course development model

Organized the "virtual reality course development committee", invited the guidance of expert university scholars and teachers in related domains, and used a three-stage model for course development: A (analysis); I (design), D (development). The committee worked to ascertain core knowledge, establish the course framework, arrange the order of chapters and sections, integrate vertical and horizontal links, discuss learning goals, develop units, write teaching material content, and solicit the opinions of experts and teachers in related domains to modify the material. The committee designed different forms and charts for each stage, to ensure course development quality. This course was developed on the basis of students' mathematics and physics courses, such as coordinate systems, plane coordinate conversion, vectors, matrix, and curves in mathematics courses and kinematics, two-dimensional collision, and three-dimensional collision in physics courses. The virtual reality course framework was planned according to the principles and key elements of virtual reality.

Course Content

The course developed by this study includes a textbook and a teacher's manual, and can be used as a 4-credit point (one academic year) elective course in senior high school. The course units include: (1)What is virtual reality; (2)Input and feedback devices of virtual reality; (3)Design principles of virtual reality; (4)Virtual interior design; (5)Design of virtual scenery; (6)Design of virtual characters, and (7)Virtual reality and 3D technology.

Software and hardware facilities for teaching

In consideration of factors such as funding problems in high schools and the degree of acceptance of beginners, researcher integrated different types of software (such as Poser, Bryce, and Space Magician) in designing this course, with the intention of developing students' ability to operate and use different types of software for "virtual reality" digital creation.

Poser was chosen because Poser was the first tool that could produce complete 3D character animation. Although 3DS is used for most professional scenery design, it is time-consuming for even the most familiar user. Therefore, this study used the recently increasingly popular Bryce in scenery design programs. The userfriendly interface and powerful features of this program make it very suitable for beginners in virtual reality technology.

In the practical part of the virtual reality course, the researcher selected Space Magician as the first step in practice. The reason was that this software is easily learned and easy to understand, and offers a humanized operation interface, specific 3D presentation of space, fast drawing, instant imaging features, easy operation, and absence of complex commands. This program is therefore easy for beginners to learn to use. Additionally, with regard to teaching facilities, because this course involves learning to use related graphics software, higher-end computer facilities are needed, preferably with high capacity memory and separate display chips. With regard to the input/output devices required for the course, high schools that wish to teach this course can, funds permitting, purchase input devices such as lower-priced optical data glove, shutter glasses or head-mounted displays (HMDs) for teaching purposes. Moreover, through school strategic alliances, high schools may also be able to use mid-range and high-end equipment in virtual reality lab of university, allowing students to experience the actual process of 3D virtual reality animation filming such as "motion capture mirrors emotions" how to work, is shown in Figure 1.

Figure 1: students visited to 3D virtual reality lab of nearby university to allow them to experience the actual process of 3D virtual reality animation filming.

Instructional Implementation

Virtual reality courses are usually considered professional or advanced courses, or graduate courses, in university. Therefore, such courses must be adjusted according to the basic abilities of students when taught in high schools, to avoid learning difficulties. However, at the same time, virtual reality is a topic that can spark more interest among students and inspire them to take initiative to explore the development of this new technology, and thereby develop the technological and information-related abilities required. The instructional process of this course is shown in Figure 2.

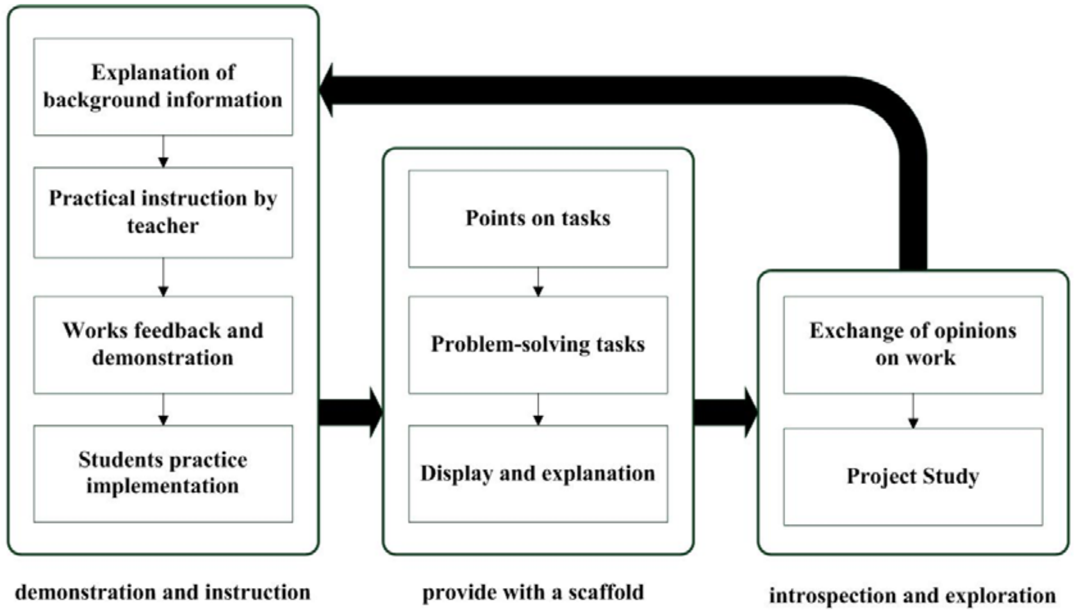

Figure2: Instructional process of the virtual reality course used a three-stage model for instructional Implementation: demonstration and instruction; provide with a scaffold, introspection and exploration.

Evaluation of teaching effectiveness
The PDCA cyclic model was used to construct the model of evaluation for the teaching cycle in this course. From the establishment of teaching goals and selection of teaching content, to implementation of teaching activities and evaluation of teaching results, teachers constantly reviewed the implementation of the teaching process and studied paths for improvement. Review meetings, classroom observation, questionnaire survey, teaching experiments, teacher reflection journals, and creation of teaching files were used to ensure the quality of course development.

2. Experimental Design
This study recruited 89 eleventh grade students majoring in science of High School A in 2010. To better understand the impact of the VR course developed by this study on the high school students' attitudes toward technology, the recruited students were divided into two groups according to their course selection results. The experimental group was composed of 31 students who selected the VR course, and the control group encompassed 21 students who did not select any emerging technology courses. To avoid disruptions to internal validity caused by the students selecting other emerging technology courses, the 37 students who selected other emerging technology courses were excluded from the control group.

Regarding the experiment design, this study used quasi-experimental research methods to investigate the difference in attitude toward technology between sophomore students (experimental group) who had attended the virtual reality course, and sophomore students (control group) who had not attended the course on emerging technology. Researcher conducted pre-testing in the first week of the 2010 school year, and conducted post-testing in the 11th week; the teaching experiment period was thus 10 weeks. The experiment design is explained in Table 1.

This study considered only the course structure of the High School A, and respected the free will of students to take elective courses; therefore, a true experimental design could not be conducted. The conclusions of this study can only be applied to students majoring in science, instead of general senior high school students.

Table 1: Experiment design.

Group	Pretest	Experimental Treatment	Posttest
Experimental Group	O_1	X	O_2
Control Group	O_3		O_4

1. The experimental group: those who took the VR course.
2. The control group: those without any experimental treatment.

3. Instruments

Scale of high school students' attitude toward technology

The test instrument in this experiment was the "Scale of High School Students' Attitude toward Technology". This scale was developed by the academic evaluators of this course (Huang et al., 2008). This scale was divided into four constructs: "cognition of the importance of technology", "interest in learning about technology", "performance of technology-related action", and "technology career planning". After being tested for construct validity by experts and modified, the scale was developed into a pre-test questionnaire. The targets of the pretest were 220 high school students. After the questionnaires had been returned, a valid sample of 202 students was obtained, making a 91.81% questionnaire recovery rate. Researcher then conducted item analysis and factor analysis, and removed seven items. With regard to reliability testing, the Cronbach's α of the overall questionnaire on attitude toward technology was .927, and the Cronbach's α values of the four constructs were .712, .846, 847, and .871. These results showed that this questionnaire had high reliability.

Performance assessment scale

To understand the effects of the students' actual practice and learning, this study developed a valid and objective performance assessment scale. Students' work was provided to the course teacher for assessment from his/her professional angle. Two professional teachers who had not taught the course were invited to provide assessment, after which students were allowed to self-evaluate their work using the assessment scale. Statistical analysis was used to test the validity of the assessment scale developed by this study. In developing and modifying the evaluation indicators in the assessment scale, this study referred to the assessment scale developed by Liu (2007) and the various evaluative indicators used in assessment of entries in the design category at the National Commercial Art Technology Competition in Taiwan, as well as solicited the opinions of experts.

RESEARCH RESULTS

1. Descriptive Statistics Analysis

Table 2 shows the mean, standard deviation, and adjusted mean corresponding to each variable as derived from data generated by the pre-testing and post-testing of students in the experimental group and the control group. Overall, students who had competed studying the virtual reality course performed better with regard to the four constructs of attitude toward technology, as compared to their pre-course performance. Their performance also exceeded that of the control group.

2. **Covariate Analysis**

Due to the limitations of class structure, this study was unable to use random allocation in research design, and therefore used the pre-test as a covariate to implement statistical control. This study then conducted analysis of covariance (ANCOVA) of the experimental group and control group. Prior to conducting ANCOVA, this study first conducted a test of homogeneity of group regression coefficients. The results of the interaction between the independent variables and the covariates were as follows:

"Cognition of the importance of technology": $F(1, 48) = 1.20$, $p > .05$,"Interest in learning about technology": $F(1, 48) = .47$, $p > .05$, "Performance of technology-related action": $F(1, 48) = .51$, $p > .05$, "Technology career planning": $F(1, 48) = .01$, $p > .05$.

These results did not reach a level of significance, indicating that the linear relationships between the covariates and dependent variables of each group were consistent.

Table 2: Mean and standard deviation of variables in attitude toward technology

Variables	Experimental group (N=31)		Control group (N=21)	
	M	SD	M	SD
Cognition of the importance of technology (pre-test)	38.35	3.00	35.90	3.66
Interest in learning about technology (pre-test)	44.45	5.09	44.57	5.09
Performance of technology-related actions (pre-test)	53.81	9.84	53.90	13.43
Technology career planning (pre-test)	15.23	2.85	15.57	4.15
Cognition of the importance of technology (post-test)	38.29	3.33	33.95	4.57
Interest in learning about technology	46.32	5.86	43.14	7.74

(post-test)				
Performance of technology-related action (post-test)	56.68	8.99	49.14	13.40
Technology career planning (post-test)	17.16	3.16	14.71	3.86
Cognition of the importance of technology (adjusted)	38.29		33.96	
Interest in learning about technology (adjusted)	46.33		43.14	
Performance of technology-related action (adjusted)	56.68		49.14	
Technology career planning (adjusted)	17.16		14.71	

3. Development of the performance assessment scale

Apart from using the above-described standardized measurements to assess the effectiveness of the course, this study also designed the "virtual reality course performance assessment scale" (see Appendix), based on suggestions provided by Huang et al. (2008) after her external assessment of the course. The analyses which follow are the validity and reliability analyses of the scale.

Table 3: Summary of one-way analysis of covariance regarding attitude toward technology

Source of variation	SS	df	MS	F	η^2
Cognition of the importance of technology					
Pretest(covariance)	.01	1	.01	.001	
Group	205.48	1	205.48	13.44 **	.22
Error	749.33	49	15.29		
Interest in learning about technology					
Pretest (covariance)	3.35	1	3.35	.08	
Group	127.05	1	127.05	2.80	.05
Error	2222.00	49	45.35		
Performance of technology-related actions					
Pretest(covariance)	19.29	1	19.29	.16	
Group	711.71	1	711.71	5.81 *	.11
Error	5998.06	49	122.41		
Technology career planning					
Pretest (covariance)	.09	1	.09	.01	
Group	75.04	1	75.04	6.14 *	.11
Error	598.39	49	12.21		

$^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

Content Validity

In designing the assessment scale, this study referred to the assessment scale developed by Liu (2007) and the various evaluative indicators used for scoring purposes in the National Commercial Art Technology competition. To judge whether the constructs and items of the scale were appropriate, professors from the Graduate Institute of Curriculum Instruction and Technology of University C were invited to review the first version of the scale along with professors from art departments of other schools. This study modified each dimension and item according to the suggestions provided by the experts, indicating that the scale has a certain internal validity.

Correlation Analysis

Six dimensions for assessment of work were developed: communication of theme, creativity, color, technique, structure, and comprehensiveness. Prior to assessment, researcher discussed the evaluation indicators corresponding to these six dimensions, and Pearson's product moment correlation coefficient was used to investigate the relationships among the six dimensions and total score. Table 4 shows that no significant correlation existed between communication of theme and color (r =.284) or structure (r =.341). However, moderate and positive correlations were found to exist among the other dimensions. The research theme of this study was design-related courses, and the assessment indicators (creativity, technique, comprehensiveness, communication of theme, color, and structure) were found to be moderately and positively correlated, which indicates that except for color and structure, each dimension has a high correlation coefficient, meaning that these dimensions are highly correlated.

Moreover, as can been seen in Table 4, the six dimensions and the total score of the scale are significantly correlated, indicating a high internal consistency.

Scorer Reliability
Scorer reliability refers to whether different scorers demonstrated consistent assessments on the same indicator of performance. To assess whether the scale has scorer reliability, this study used the assessment of the course teacher (T_A) and the scale-based assessments of non-course teachers (T_B, T_C); of these, T_B is a computer teacher and T_C is an art teacher. Student work consisted of two parts: part one was a personalized suite, and part two was residential design. Course teacher used his professional viewpoint for assessment, and non-course teachers assessed the work according to the assessment scale. To understand whether differences existed between the assessment scores given, this study tested for differences among the scores.

Table 4: Correlation analysis of the six assessment dimensions

Measure	Communication	Creativity	Color	Technique	Structure	Comprehensiveness
Communication	-					
Creativity	$.393^{*}$	-				
Color	.284	$.618^{**}$	-			
Technique	$.546^{**}$	$.652^{**}$	.445*	-		
Structure	.341	$.667^{**}$	$.553^{**}$	$.710^{**}$	-	
Comprehensiveness	$.505^{**}$	$.751^{**}$	$.550^{**}$	$.841^{**}$	$.764^{**}$	-
Total	$.657^{**}$	$.881^{**}$	$.713^{**}$	$.839^{**}$	$.809^{**}$	$.899^{**}$

$^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$

The course teacher used 100 as the full score when performing assessment. When using the assessment scale for evaluation, the non-course teachers first subtracted the subjective dimensions of "work finished on time/attitude toward learning"; therefore, the full score used was 80. The score of the non-course teachers times 100/80, then all of them use 100 as full marks.

Based on the calculated scores, the researcher of this paper used Kendall's coefficient of concordance to analyze the level of consistency of the three scorers on the two works. The analysis shows consistent results regarding the design work of "personalized suites" (Kendall's coefficient of concordance = .680, chi-square value = 53.056, and p < .05) and "living house" (Kendall's coefficient of concordance = .611, chi-square value = 47.652, and p < .05); indicating that a significant correlation exist among the three scorers. Because the analytical result shows consistency among the three scorers, this study infers that this scale possesses scorer reliability.

DISCUSSION AND CONCLUSIONS

The above-described analysis results showed that after 10 weeks of attending the virtual reality course, students in the experimental group performed better in two constructs of attitude toward technology (performance of technology-related action, and technology career planning) as compared to their pre-course performance. Their performance also exceeded that of the control group. This showed the preliminary results of the course in enhancing the comprehension of students with regard to knowledge of emerging technology and the development of technological ability. The research results of this study prove that emerging technology courses do not positively influence the cognition of the importance of technology; this conclusion is similar to the research result of Boser, Palmer, and Daugherty (1998), which found no positive correlation between technology courses and student concepts of technology. The researcher infers that the cause might be an overemphasis on the teaching of technical abilities, leading to reduced importance on the cognition of technology. These results can serve as a reference for further course design.

The course also provided students with career exploration opportunities. Several graduates of High school A who attended the course have already entered good universities and technological universities with related departments (such as department of multimedia design, department of game creation, department of interior design…etc.) through college admission such as personal applications or recommendations by high schools, which corresponded to the originally established course objectives.

However, the course did not result in significant difference in the students' interest in learning about technology. The researcher infer that the reason for this may have been that this course was an interdisciplinary elective course (among 10-12 courses) in High School A, and students who opted for the course had selected it after attending a course description seminar and fully understanding its content. Students who selected this course from among a variety of courses may have already had a high level of interest in virtual reality technology, so that although students' interest in learning about technology was increased after the course, the increase was not significant. Therefore, the researcher suggests that future course teachers appropriately integrate teaching strategies that increase students' learning motivation during the implementation of the course, such as adding current examples of application of virtual reality or 3D technology, and explaining more about future learning approaches and career development in related domains. This should assist in enhancing students' interest in learning about technology.

In external evaluation of this course, Huang et al. (2009) pointed out that compared to mainstream virtual reality technology, the resources and facilities of high schools are limited and high school students must be seen as beginning learners in dynamic digital technology. Therefore, the arrangement of subject matter, learning process, and technological content must naturally correspond to practicality and feasibility. Therefore, based on the course development and evaluation in the first year, the course in the second year was modified to reduce focus on abstract theory in learning. The timetable of the course was modified to delay teaching such theory until after students had a certain amount of practical operational experience with virtual reality, which would naturally make subsequent learning more meaningful. Also, to enhance students' interest in learning about virtual reality and provide them with a preliminary understanding of related university departments, in addition to visit to nearby universities (or technological universities) with related departments, The researcher suggests that visits to multimedia companies can be added to the course in the future, in order to provide students with a more complete vision.

Performance assessment, whether it involves Q&A sessions with students or teacher assessment, is usually very time-consuming. With regard to student work in design-related fields, students must not only use the skills and principles learned but also incorporate their individual subjective consciousness, to order to comprehensively express the idea of their work. When teachers assess such work, apart from performing evaluation from the angles of academic principles and facts, they also use their individual and extremely subjective viewpoint and ideas in assessment. Therefore, performance assessment is often discriminated against.

Although performance assessment is costly, time-consuming, and difficult to conduct, when viewed from the angle of its principles and methods, it still offers many advantages; for example: emphasizing students' practical performance, shifting from previous methods of assessment that overly emphasized written examination, guiding students to take initiative in learning, and emphasizing teacher-student interaction in the instructional process. Therefore, education authorities should still encourage teachers to use performance assessment. At the same time, if an objective and valid assessment scale was provided, teachers could perform evaluation according to existing assessment indicators and scores. Before creating their work, students would also be able to understand which key points should be a focus. After assessment, students could use their score on the scale as a form of feedback to understand their strengths and weaknesses.

This study conducted correlation analysis of the six dimensions (communication of theme, creativity, color, technique, structure, and comprehensiveness) in the assessment scale. Results showed that the dimensions were moderately correlated, and the six dimensions with the total score of the scale are significantly correlated, indicating a high internal consistency. However, when designing the proportional scores for the six dimensions of the scale, this study was limited by research time and the number of research targets; therefore, the weights were determined according to the personal experience of each researchers. Thus, whether the proportional specific weight of each dimension is appropriate must be determined through scientific and objective analysis. In the future, if further research could be conducted on the proportional specific weight of the scale dimensions, this would make the indicators in the performance assessment scale more complete.

ACKNOWLEDGEMENTS
The author would like to thank the National Science Council of the Republic of China, Taiwan, for financially supporting this manuscript under contract number NSC 97-2514-S-643-001-GJ, 98-2514-S-643-001-GJ, 99-2514-S-643-001-GJ, and 100-2514-S-643-001-GJ.

REFERENCES

Bame, E., Dugger, W., Jr., de Vries, M., & McBee, J. (1993). Pupils' attitudes toward technology - PATT-USA. *Journal of Technology Studies, 19*(1), 40-48.

Becker, K. H., & Maunsaiyat, S. (2002). Thai students' attitudes and concepts of technology. *Journal of Technology Education*, *13*(2), 6-20.

Boser, R. A., Palmer, J. D. & Daugherty, M. K. (1998). Student's attitudes toward technology in selected technology education programs. *Journal of Technology. Education, 10*(1), 4-19.

Burdea, G. C. & Coiffet, P. (2003). *Virtual reality technology.* (2nd ed.). NJ: John Wiley & Sons, Inc.

Chang, Y. S. (1998). A study of college students' attitudes toward technology. *Journal of National Hualien Teachers College, 8***,** 297-315.

Chen, Y. F & Martin, M. A.(2000). Using performance assessment and portfolio assessment together in the elementary classroom. *Reading Improvement, 37*, 32-38.

Cheng, C. M. (2000). *A study of junior high school students' attitude toward technology in Taipei*. Unpublished master's thesis, National Taiwan Normal University, Taipei, Taiwan.

Erenay, O. & Hashemipour, M. (2003). Virtual reality in engineering education: a CIM case study. *The Turkish Online Journal of Educational Technology, 2*(2), 51-56.

Heywood, J. (1998). *Pupils' attitudes to technology: A review of studies which have a bearing on the attitudes which freshmen bring with them to engineering*. Retrieved June 25, 2003, from http://fie.engrng.pitt.edu/fie98/papers/1406.pdf

Hsu, M . L. & Shin, J. C. (1997). The application of virtual reality in Education. *Distance Education, 3*, 19-23.

Huang, S. L., Lin, J. J., Wang, C. P., & Hou, S. C. (2008). *The evaluation of endless sky- research on application of wireless hypermedia to comprehensive high school curriculum (1/4).* Research report of National Science Council High-Scope Project (NSC-96-2514-S-260-001-GJ). Nantou: National Chi-Nan University.

Huang, S. L., Lin, J. J., Wang, C. P., & Hou, S. C. (2009). *The evaluation of endless sky- research on application of wireless hypermedia to comprehensive high school curriculum (2/4).* Research report of National Science Council High-Scope Project (NSC-97-2514-S-260-001-GJ). Nantou: National Chi-Nan University.

Huang, S. L., Lin, J. J., Wang, C. P., & Hou, S. C. (2010). *The evaluation of endless sky- research on application of wireless hypermedia to comprehensive high school curriculum (3/4).* Research report of National Science Council High-Scope Project (NSC-98-2514-S-260-001-GJ). Nantou: National Chi-Nan University.

Hung, T. H. (2009). The implementation and application of art work performance assessment in classes of the pupils with art talent. *Gifted Education, 117*, 8-17.

Kalawsky, R. S.(1993). *The Science of Virtual Reality and Virtual Environments*. Wokingham: Addison-Wesley.

Lai, C. M., Huang, H. M., Liaw, S. S., & Huang, W. W. (2009). A study of user's acceptance on three-dimensional virtual reality applied in medical education. *Bulletin of Educational Psychology, 40* (3), 341-362.

Liu, Y. C. (2007). *The assessment criteria of art teaching for Jian sing primary school in Pingtung county***.** Retrieved June 25, 2010, from http://163.24.16.21/icheng_web/jack_web/table_file/jsps_art%20standard.doc

Lu, S. M. (1998). The promises, problems and challenges of performance evaluation. *Bimonthly Journal of Educational Resources and Research, 20*, 1-5.

National Science Council High Scope Program. (2007). *2007 Annual Plan Outline*. Retrieved July 10, 2010, from http://www.highscope.fy.edu.tw/(96)plan-brief-introduction.asp

Popham, W. J. (1995). *Classroom assessment: What teachers need to know*. Boston: Allyn and Bacon.

Raat, J. H., & de Vries, M. (1985). *What do 13-Year old pupils think about technology? The conception of and the attitude towards technology of 13-year old girls and boys.* Eindhoven University of Technology, Netherlands. (ERIC Document Reproduction Service No. ED 262 998)

Stiggins, R. (1987). Design and development of performance assessment. *Educational Measurement: Issues and Practice, 6*(3),33-42.

Tseng, D. C. (2010). *Virtual Reality* (8th Ed.). Unpublished manuscript, National Central University, Chungli, Taiwan.

Van Rensburg, S., Ankiewicz, P., & Myburgh, C. (1999). Assessing South Africa learners' attitudes towards technology by using the PATT (Pupils' Attitudes Toward Technology) questionnaire. *International Journal of Technology and Design Education,* 9, 137-151.

Voke, K. S., & Yip, W. M. (1999). Gender and technology in Hong Kong: A study of pupils' attitudes toward technology. *International Journal of Technology and Design Education,* 9, 57-71.

Voke, K. S., Yip, W. M., & Lo, T. K. (2003). Hong Kong pupils' attitudes toward technology: The impact of design and technology programs. *Journal of Technology Education, 15*(1), 48-63.

Vince, J. (1995). *Virtual Reality Systems*. Wokingham: Addison-Wesley.

Wu, C. S. & Lin, T. Y. (1997). Performance assessment, portfolio assessment, & authentic assessment. *Bimonthly Journal of Educational Resources and Research**,** 15**,*** 68-70.

Yen J. & Sun C. C. (2008). A study on the design teachers' and students' recognition of performance evaluation and evaluation Criteria. *Journal of Science and Technology,17*(1), 41-57.

Yoon, S. (2010). *Virtual reality in art education*. Unpublished master's thesis, School of the Arts Virginia Commonwealth University, Richmond, Virginia.

Yu, K. C., Han, F. N., Hsu, I. Y., & Lin, K. Y. (2005). The development of attitude toward technology scale for junior high school students. *Kaohsiung Normal University Journal, 19*, 69-83.

Appendix. Performance assessment scale for the virtual reality course

Name:			Final score:		
Item	Assessment indicators		Score		
			-	+	+ +
Completed work on time (10%)	a. Can hand in work assignments on time according to teacher instructions				10
	b. Can complete work before deadline after limited reminders from the teacher		5	7	9
	c. Work is not completed without constant urging and supervision from the teacher		0	1	3
Work assignment (80%)	Communication of theme (25%)	a. The work and the theme closely interlock	20	23	25
		b. Does not have a good grasp of the theme; work does not fully express the theme	10	13	17
		c. Considerable distance exists between the finished work and its theme; ability to communicate theme requires improvement	1	4	7
	Creativity (15%)	a. Work is creative and unique	11	13	15
		b. Work has some uniqueness but is not outstanding	7	8	9
		c. Additional guidance, examples, or demonstration is needed from the teacher before the student can develop his/her own ideas and creativity	1	3	5
	Color (10%)	a. Use of colors is appropriate; does not often use concept colors, giving the image a rich feeling	8	9	10
		b. Skill in color use could be improved; richer color functions could be used to enhance the work	5	6	7
		c. More guidance from the teacher in techniques of color use is needed to enrich this work	1	2	3
	Techniques (10%)	a. Student is proficient in use of software components and understands the strengths and limitations of software	8	9	10
		b. Can use basic components, but creative skills need improvement	5	6	7
		c. Needs more guidance form the teacher to understand the strengths and limitations of the software and become proficient in these skills	1	2	3
	Structure (10%)	a. Content is rich and comprehensive, corresponds to psychological development, presents aesthetic balance	8	9	10
		b. Has spatial feeling and expresses individual thought, but requires improvement in screen configuration relationships	5	6	7
		c. Lacks in structure, requires more guidance form teacher	1	2	3
	Comprehensiveness (10%)	a. Understands creative concepts, construction process, and related principles; can make full use of software components	8	9	10
		b. Can complete a project but needs improvement or remedial work in some areas	5	6	7
		c. Work has some incomplete and unsatisfactory parts; insufficient use of software components	1	2	3
Attitude toward learning (10%)	Creative process (10%)	a. Willing to make class presentations, attentive in creative work, helpful and willing to instruct others	8	9	10
		b. Can follow the teacher's instructions, works hard, does not interact much with other students	5	6	7
		c. Cannot work independently, requires constant supervision and goading from the teacher, rarely interacts with classmates	1	2	3
Comments from teacher					