



Effects of Virtual Reality Integrated Creative Thinking Instruction on Students' Creative Thinking Abilities

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Since the popular applications of information technology, digitalized materials, media, and equipment have become the essential abilities and instruments for teachers in modern education. In addition to some curricula requiring computing & reasoning and operation & demonstration, the situations of teachers utilizing transparencies, films, and network communications present that digitalized materials have become the mainstream teaching instruments. Creative Thinking Instruction is also largely promoted in school education that various creative teaching strategies are created. Such teaching strategies or models aim to develop and cultivate students' creative teaching abilities through various effective routes and approaches. The effects of teaching approaches and strategies on students' learning achievements and interests as well as the use of distinct teaching strategies and approaches for the promotion of teaching effectiveness are considered as the research motivation. The quasi-experimental research is preceded with the nonequivalent pretest posttest control group design model, where 104 students in two classes in a national university are selected for the experiment. The research results show that 1.Creative Thinking Instruction presents higher sensitivity than general traditional instruction, 2.Creative Thinking Instruction reveals higher fluency than general traditional instruction, 3.Immersion in virtual reality appears the highest sensitivity on Creative Thinking Instruction, and 4.Interaction in virtual reality presents the highest fluency on Creative Thinking Instruction

Keywords: Virtual reality, creative thinking instruction, creative thinking ability, sensitivity, fluency, brainstorming

INTRODUCTION

From primitive to civilization, human societies have experienced millenniums of changes, when industrial revolution, invention of computers, and space technology are the promotion of human intelligence (Singh, 2015).

That is, human beings, based on existing foundations, constantly apply rich imagination and creativity to promote civilization and culture to higher levels. The cultural history of human beings therefore could be regarded as a history of creation.

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Since the popular applications of information technology, digitalized materials, media, and equipment in modern education have become the essential abilities and instruments for teachers.

In addition to some curricula requiring computing & reasoning and operation & demonstration, the use of transparencies, films, and network communications reveals that digitalized materials have become the mainstream teaching instruments for teachers.

Recently emerged e-learning, m-learning, and u-learning are the learning achievements and convenience brought by such digitalized material instruments and media being applied to instruction. Creative Thinking Instruction is also largely promoted in school education that various creative teaching strategies are created.

Such teaching strategies or models, through effective routes and approaches, focus on developing and cultivating students' creative teaching abilities for a new learning area. Regarding the technological teaching activities, theories and knowledge are often introduced orally and through pictures in traditional teaching activities to have students acquainting with technological systems. It would make the lessons difficult and dull. Virtual reality could reinforce the reciprocity of learning contents and allow the users, through virtual reality, really viewing the potential interaction (Alberto Valentín et al., 2013) and constructing technological systems for the appearance design, material behaviors, structural combinations, and functionality of technological products by introducing technological products in life. The students therefore could better know and clarify the applications of technology and the relevant knowledge.

The promotion of new educational reform policies in past years in Taiwan is making progress, and the information technology is gradually emphasized internationally. The mass society consider that the education stresses too much on knowledge input, but ignores the cultivation of mental enlightenment and creative teaching abilities so that the students committing to memory are full of knowledge, but lack of interrogation, deliberation, discernment, and practice (Carol et al., 2010). Education in Taiwan is facing enormous impact because of the advance of industry, the rapid development of high technology, the structural change of economic industry, and the demands for diverse society. Ministry of Education and a lot of education researchers have planned and invested in the research on improving the functions and objectives of school education in past years as well as reviewed and improved materials and teaching approaches for professional courses in order to enhance students' diverse learning and the creative thinking and problem solving abilities. From above statements, the effects of teaching approaches and strategies on students' learning achievements and interests as well as the use of distinct teaching strategies for the promotion of teaching effectiveness are investigated in this study.

State of the literature

- The effects of teaching approaches and strategies on students' learning achievements and interests.
- The use of distinct teaching strategies and approaches for the promotion of teaching effectiveness are considered as the research motivation.
- To discuss the effects of Creative Thinking Instruction on students' creative thinking abilities.

Contribution of this paper to the literature

- Students are the body in the curriculum design for Creative Thinking Instruction and teachers apply different creative thinking strategies based on distinct learning objectives.
- The feasibility and completeness of originate, rare, and feasible novelty, as well as the performance on delicate and beautiful value multi-purpose.
- Virtual reality allows the expression of abstract reality, the presentation of abstract visual experiences, and the operation of the first person aspect, 3D visual effect, and interactive scene and functions. Besides, it could induce students' imagination and enhance the creative concepts to develop various feasible, unique, and novel creative concepts

LITERATURE REVIEW

Virtual reality

Wan et al. (2013) pointed out virtual reality (VR) as to construct an environment through the simulation of computer equipment and add real or virtual pictures in the simulated situations to realize the situation. Such an environment presents highly authentic interaction, allowing the users viewing the pictures generated by computers, operating and interacting with the objects through the man-machine interface, freely moving in the space for the senses of immersion and participation, and further experiencing personally on the scene. The operation of virtual reality contains 1.being generated by a computer, 2.being constructed in a 3D space, 3.being able to interact and converse with objects in the space, 4.being able to freely move as the user's will, and 5.showing senses of immersion and participation. In 3D virtual reality, the computer interaction is extended from purely visual interaction to diversified interaction that the users could interact with objects in virtual reality with the perceived experiences and cognitive processing abilities as in the real world, and the feeling is close to the changes in the natural world (Chang et al., 2010). Alberto Valentín et al. (2013) mentioned that virtual reality not only removed the field experiments with lots of manpower and resources, but the best advantage was to immediately acquire the efficacy and results through virtual reality. Lin et al. (2011) pointed out virtual reality as the best practice of situated teaching theory. The situations in virtual reality could provide the users with a natural interface between the real world and an abstract logic, allowing the users' perception exceeding the knowledge on books to further develop self-concept and relationship.

Liu et al. (2013) proposed three elements to construct a virtual reality situation, namely immersion, interaction, and imagination, which were called "3I's" of virtual reality.

1. Immersion: Immersion referred to the virtual reality situation allowing the users perceiving the function of "being personally on the scene" and immersing in the virtual reality simulated virtual world.
2. Interaction: Interaction was the interactive feedback between the user and the virtual environment. The sensual stimuli and responses in the situation were important and necessary for a virtual reality system. With any types of man-machine interface, the systems had to promptly respond to the users' actions and had the users perceive such responses in the simulated situations.
3. Imagination: Imagination was the direction to construct virtual reality. In addition to allowing the users perceiving the acousto-optic stimulation, the scene design and the object attributes in a simulated situation were full of imagination.

Creative thinking instruction

Andrew Clifton & Claire Mann (2010) indicated that psychology school started in 19th century with the evolution of configuration school, functional approach, behaviorism, Gestalt psychology school, and psychoanalysis school, where behaviorism and Gestalt school revealed the deepest influence on curriculum design. The stimulus-response learning theory in behaviorism regarded all human activities being responded to stimuli. In this case, the function of education was to give learners proper stimuli to generate responses, i.e. knowledge was learned through proper stimulus-response to accumulate experiences. Gestalt school, on the other hand, considered learning as the organization and recombination of the entire perception system and emphasized that individuals should thoroughly know and understand the learning environment (Cornelia Schoor & Maria Bannert, 2010; Sadi, 2015).

Claudio Pacchierotti et al. (2014) pointed out four learning areas in behaviorism, including classical conditioning theory, associationism—Laws of Learning (law of exercise, law of readiness, law of effect), approach theory, and reinforcement theory. The effects of the four learning theories on curriculum design were briefly described, as below. 1. Use of unit behavioral objectives: In vocational practicum courses, each unit contained the unit objectives, based on which students had to complete the objectives within preset schedule. 2. Application of programmed teaching approaches: Teaching processes reflected the conditioning process. According to instructional objectives, Programmed Instruction determined students' learning and segmented learning units to apply various instructional media and materials to achieve students' learning objectives. 3. Reinforcement in the learning process: According to reinforcement theory, appropriate reinforcement would have learners be more willing to learn. A school utilized different media and real objects for the instruction to real-time reinforce the students. 4. Application of individualized instruction: According to students' individual needs and abilities, individualized instruction provided individualized instruction to have the students with distinct variance receive appropriate development (Cummings & Duncan, 2010). Wang & Reid (2011) indicated that Gestalt school included insight theory, field theory, and sign gestalt theory. The applications of Gestalt school to curricula were summarized as following. 1. Learning stressing on thinking: The curriculum design therefore requested to focus on students' inner thinking and the knowledge learning of reasoning, concepts, and principles. 2. Emphasis on knowledge pursuing process: Learning processes were more important than results. 3. Student-centered curriculum design: Behaviorism and Gestalt school presented deviation of learning area because of different learning claims. Behaviorism paid attention to activities and simplified or regularized learning, while cognitive theory in Gestalt school was suitable for learning complicated affairs, such as thinking and reasoning (Jennifer et al., 2011).

Jianxia Cao & Akinori Nishihara (2012) proposed following approaches for Creative Thinking Instruction.

1. Brainstorming: Jones (2011) regarded Brainstorming as the most direct and common approach to training creative teaching abilities; it was the sudden appearance of ideas and aesthetic feeling, which would stimulate the partners to induce resonance.
2. Attribute Listing: Attribute Listing was to listed old thoughts, ideas, and principles for recombination or modification to become novel. The creation of new products mostly was the remodeling of old objects, and the remodeling was to change the attributes.
3. Morphological Analysis: Attribute Listing stressed on modification, while Morphological Analysis paid attention to combinations.
4. Syntectics: Developed by Gordon, Syntectics utilized analogy and metaphor for helping thinkers analyze problems so as to form various points of view (Kui& Kun, 2014).
5. Reviews of 6 w: It intended to review current regulations or products from 6 angles of (1) Why, (2) What, (3) Who, (4) When, (5) Where, and (6) How.

Creative thinking ability

Anja Bockers et al. (2014) regarded creativity as the ability to perceive the deficits of an object, form and test new hypotheses, and communicate results. Creativity is a divergent thinking ability which performs on the fluency, flexibility, and uniqueness of thinking, sensitivity to problems, and redefines and fines existing ideas (de la Torre, 2011). Sheu & Chen (2014) regarded it as the ability to find out the truth, discover problems, find out ideas, and seek for solutions. Gough et al. (2014) indicated that

creation utilized thinking abilities and went through exploratory processes to make novel and unique performance with the properties of sensitivity, fluency, and flexibility. The indicated thinking abilities covered convergent thinking and divergent thinking; the exploratory processes were related to consciously and unconsciously thinking processes; the fluency referred to the smoothness of thoughts, which were the combination of texts or ideas on learning; the flexibility revealed the changes of thoughts; and, the novelty and uniqueness performed on different ideas, texts, or actions. Erhan et al. (2014) stressed on the importance of knowledge and the mental operation process based on cognition, including divergent, productive & associative thinking and assessment & communication skills, while Yakar and Baykara (2014) highlighted the features of fluency, flexibility, and uniqueness for creative thinking. Summing up various opinions, Jones (2011) defined creativity, from personality trait, thinking ability, mental process, and behavior, as an individual with curious, adventurous, brave, and imaginary personality traits proceeding fluent, flexible, and unique thinking of problems through psychological activities to present the novelty and uniqueness of objects.

Referring to Robert (2012), who regarded creation as abilities and stressed more on individual behaviors through thinking (Shead, 2010), creative thinking abilities in this study contain

1. Sensitivity: Sensitivity refers to sensitive perception abilities to objects, being able to discover the relationship, deficiency, unusualness and supplement among objects. Such abilities are the key elements to generate creation. For example, discovering the inconvenience of daily living equipment and further proposing improvement is an innovative product.
2. Fluency: Fluency refers to the abilities to generate more ideas in a short period of time. One with good fluency presents constant responses to same stimuli.

Research hypothesis

According to Torrance's investigation, Brüttsch et al. (2010) indicated that 72% of the 142 creative thinking trainings, which was classified into 9 categories, could effectively enhance creativity. Huebner (2010) discovered that students with the abilities above medium and creative teaching far exceeded those short of creative teaching on the creativity to solve mathematical questions. Stronge (2010) explained that instruction with both virtual reality e-learning and traditional learning could enhance students' cognitive abilities, the virtual reality e-learning group enhanced higher scores than the traditional learning group, the virtual reality e-learning group comprehensively outperformed the traditional learning group, and virtual reality e-learning could enhance students' learning attitudes and appeal the attention. Tamara et al. (2013) mentioned that virtual reality could promote memory, comprehension, learning & thinking sensitivity, and learning & thinking fluency. Particularly, Creative Thinking Instruction could significantly promote different items, and the same effect could be reached with distinct virtual reality models. The following hypotheses are therefore proposed in this study.

H1: Creative Thinking Instruction presents notable effects on sensitivity.

H2: Creative Thinking Instruction reveals remarkable effects on fluency.

H3: Creative Thinking Instruction shows the optimal effect on promoting sensitivity in virtual reality.

H4: Creative Thinking Instruction appears the optimal effect on promoting fluency in virtual reality.

RESEARCH FRAMEWORK

Research framework

Based on domestic and international research on Creative Thinking Instruction and creative thinking ability, the research framework is proposed to discuss the correlations between Creative Thinking Instruction and creative thinking ability in this study (See Figure 1).

Research participant and research design

To effectively achieve the research objectives and test the research hypotheses, the nonequivalent pretest posttest control group design model is utilized for the quasi-experimental research. Total 104 students in two classes in a national university are studied. The experimental class (52 students) is taught with Creative Thinking Instruction, while the control class (52 students) remains the general traditional instruction of didactic teaching. The experimental instruction lasts for 16 weeks, three hours per week (total 48 hours).

ANALYSIS

Analysis of variance of sales channel on business performance

The effects of Creative Thinking Instruction on sensitivity and fluency are explored with Analysis of Variance. From Table 1, Creative Thinking Instruction and general traditional instruction present significant differences on sensitivity, where higher sensitivity appears on Creative Thinking Instruction. H1 therefore is supported. Creative Thinking Instruction and general traditional instruction reveal remarkable differences on fluency, where the higher fluency appears on Creative Thinking Instruction. H2 therefore is supported.

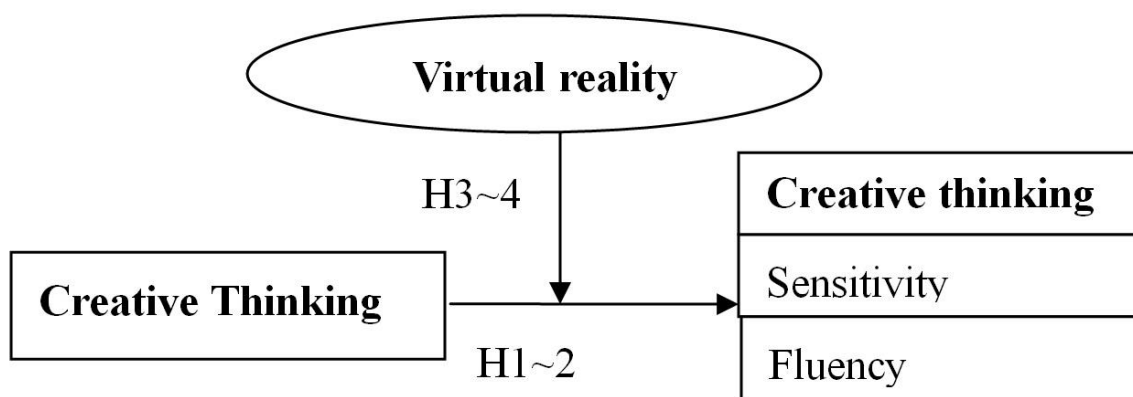


Figure1. Research framework

Table 1. Analysis of variance of creative thinking instruction

Variable		F	P	Scheffe post-hoc test
Creative Thinking Instruction	Sensitivity	12.377	0.002**	Creative Thinking Instruction>general traditional instruction
	Fluency	16.527	0.000**	Creative Thinking Instruction>general traditional instruction

*stands for $p < 0.05$, ** for $p < 0.01$

Effect analysis of virtual reality integrated Creative Thinking Instruction

The differences between virtual reality integrated Creative Thinking Instruction and creative thinking ability are investigated with Analysis of Variance; and, two-way

Analysis of Variance is applied to discuss the interaction between virtual reality and Creative Thinking Instruction in order to verify the promotion of virtual reality. From Table 2, immersion in virtual reality shows the highest sensitivity on Creative Thinking Instruction, while interaction in virtual reality appears the highest fluency. Notable interaction appears obviously on the margin mean diagrams in Figure 2 & 3 that H3 and H4 are supported.

Table 2. Analysis of variance of creative thinking ability in creative thinking instruction

Variable	Sensitivity			Fluency		
	F	P	Scheffe post-hoc test	F	P	Scheffe post-hoc test
Creative Thinking Instruction	12.377	0.002**	Creative Thinking Instruction>general traditional instruction	16.527	0.000**	Creative Thinking Instruction>general traditional instruction
Virtual reality	11.623	0.000**	13>2	11.731	0.000**	2>13
Creative Thinking Instruction*virtual reality	27.633	0.000**	11>13>12>21>23>22	24.514	0.000**	12>13>11>22>23>21

* stands for $p<0.05$, ** for $p<0.01$

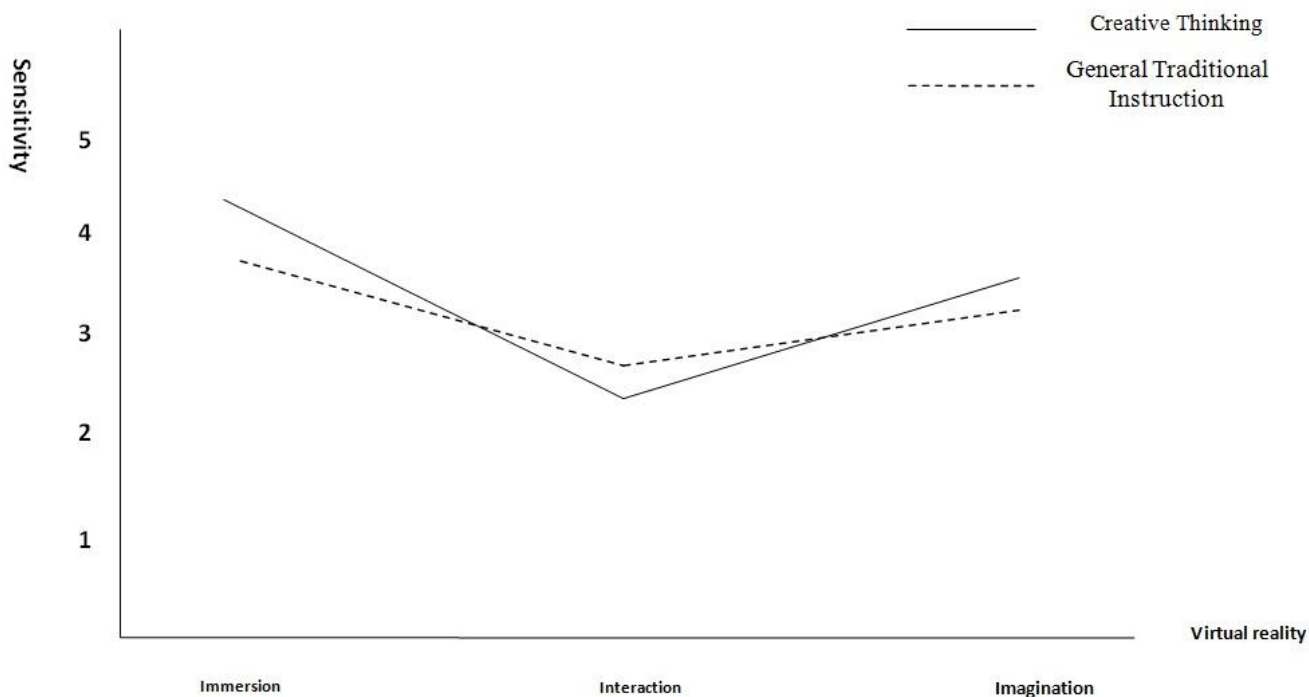


Figure 2. Margin mean of sensitivity

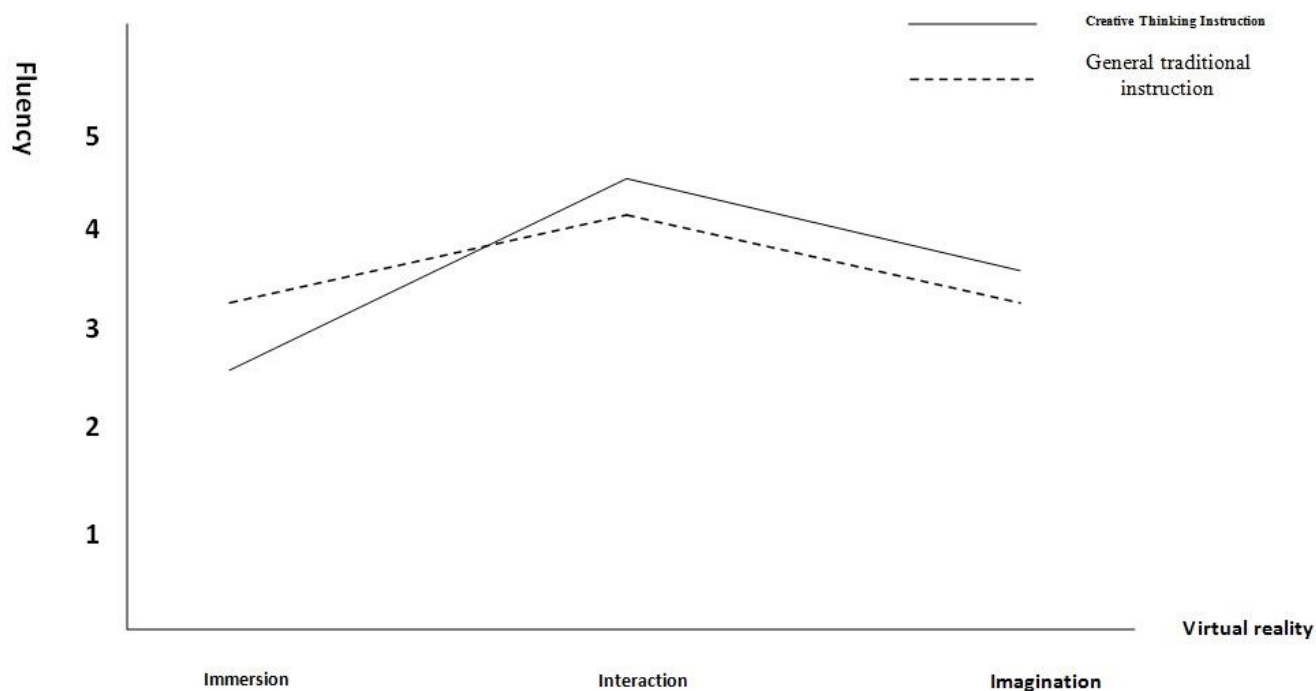


Figure 3. Margin mean of fluency

CONCLUSION

This study intends to discuss the effects of Creative Thinking Instruction on students' creative thinking abilities. The results show that students are the body in the curriculum design for Creative Thinking Instruction and teachers apply different creative thinking strategies based on distinct learning objectives to guide and help the students achieving the problem solving objective. Apparently, both the control of instruction situations and the actively participation of teachers and students are the key factors in the successful instruction.

According to the statistics, the application of virtual reality to education is potential. Virtual reality allows learners freely observe and operate objects from different angles and even interact with objects that it provides a situation for observation, exploration, and active learning. Virtual reality offers a safe environment in various attempts and practice, and the first person aspect, 3D animation, text, and speaking voice could enhance users' attention (Van Wyk, 2011). Accordingly, virtual reality could assist students in the concept creation, the feasibility and completeness of originate, rare, and feasible novelty, as well as the performance on delicate and beautiful value multi-purpose. It presents that virtual reality allows the expression of abstract reality, the presentation of abstract visual experiences, and the operation of the first person aspect, 3D visual effect, and interactive scene and functions. Besides, it could induce students' imagination and enhance the creative concepts to develop various feasible, unique, and novel creative concepts.

SUGGESTION

1. Strengthen creative thinking abilities and counseling competency. It is found that creative teaching abilities cover broad areas that it is especially difficult to solve open and divergent problems. How to ask questions, induce learning motivation, promote cognitive memory to creative and critical levels, and control learning atmosphere and group discussion orders in the teaching

process would test the teachers' profession and counseling competency. It is therefore suggested that schools could regularly open relevant training to strengthen teachers' profession and counseling competency, have teachers understand the suitability of teaching contents and materials for virtual reality, and allow teachers designing learning sheets to guide the students learning from virtual reality. In addition to virtual reality, other media could also be appropriately applied.

2. Well utilize diversified instructional resources and systemized curriculum design. Creative Thinking Instruction is not an independent course but could assist other different teaching approaches, as virtual reality discussed in this study. It is suggested to, based on current curriculum, change the teaching environment, match and apply diversified instructional resources and systemized course design, and coordinate the instruction to make learning vivid and lively and induce students' creation and potential.
3. Provide full information to support and assist learners. Since virtual reality aims to provide students with active exploratory situations, sufficient information and design, such as visual interaction images, object labels, and convenient control keys, should be offered for the material content design so that the students could easily control the situations and objects during the free exploration as well as observe various desired enquiries.

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