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A study of the effects of multimedia dynamic teaching on cognitive load and learning outcome

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The statistics reveals that about many students have learning difficulties. For this reason, appropriate curricula and materials should be planned to match with multimedia teaching design in order to reduce students'learning frustration and obstacle caused by insufficient experiences and basic competence. Multimedia dynamic, a curriculum oriented teaching instrument combined with cognitive psychology, cognitive load theory, and multimedia teaching theory, could easily attract students 'attention in the performing process so as to guide the learning, reduce the load of working memory, and further reduce the cognitive load. With multimedia dynamic presentation, teachers could design materials matching with class teaching for the attention guidance to help students actively search, select, and organize information, reduce the load of working memory and cognitive load, and enhance the learning effect. It is expected to apply multimedia dynamic teaching to attention guidance in this study. Under the principle of material design, multimedia dynamic teaching is regarded as the design subject and three classes are proceeded the teaching experiment. The results show that including images into structural text information presents significant effects on students'learning outcome and the reduction of cognitive load.

Keywords: multimedia dynamic teaching, cognitive load, learning outcome

INTRODUCTION

The rapid development of computer technology and the innovation of information products, from hardware to software and from tangible to intangible, in the beginning of the brand-new 21st century have the life become more convenient and people present more dependence on them. For this reason, promoting the information literacy and information application capability of the citizens through information education in schools is a key task in education reform. The approach of information times has educational sectors successively enhance information

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equipment in schools and promote the technology policy of applying information assisted instruction to schools that highlights the importance of information integrated instruction. Proper application of information technology indeed could benefit students' learning. However, information integrated instruction is a burden for most teachers, including the selection of information materials, the selection of information instrument, the design of learning activities, and the selection of integration methods, integration timing, and applicable subjects. The constant progress of information media results in changes between teaching and learning and increases more possibilities. Nonetheless, manipulating media is like a double-edged sword; the teaching effect could be largely reinforced when they are well utilized, while opposite effects might be caused when applying media without planning. Research on the theory of multimedia learning therefore becomes popular recently. Moreover, it reflects to the contents of cognitive load theory that many researchers attempt to integrate multimedia and human cognitive psychology with experiments to develop multimedia teaching material design principles.

State of the literature

- It is expected to apply multimedia dynamic teaching to attention guidance in this study. Under the principle of material design, multimedia dynamic teaching is regarded as the design subject and three classes are proceeded the teaching experiment.
- Manipulating media is like a double-edged sword; the teaching effect could be largely reinforced when they are well utilized, while opposite effects might be caused when applying media without planning.
- With multimedia dynamic presentation, teachers could design materials matching with class teaching for the attention guidance to help students actively search, select, and organize information, reduce the load of working memory and cognitive load, and enhance the learning effect.

Contribution to the literature:

- Information integrity and structure should be considered in the design of teaching materials. When there is too much information, it should be segmented and presented step by step. Fine segmentation might increase burden on students' working memory, as local effects are hardly generated.
- The accessibility and relevance of information need to be taken into account when designing teaching materials. Connected and sequenced information allows students presenting microcosm and integrity on the information in the learning process.
- students should be given time for establishing relevance, including the connection between spoken and word information. Teachers' spoken languages are the guidance, rather than interference.

LITERATURE AND HYPOTHESIS

Multimedia dynamic teaching

Hayati & Mohmedi (2011) defined multimedia as words and pictures. Words, referring to verbal form, contained printed words and spoken words; and, pictures, as pictorial form, covered static pictures (illustration, plots, diagrams, photos, and maps) and dynamic pictures (animation and films). From the viewpoint of multimedia proposed by Coleman et al. (2012), the media mix of words (Chinese words on the screen or spoken narratives) and pictures (animation, illustration, or films) in a multimedia encyclopedia or the media mix of words (printed words) and pictures (static pictures) in books could be regarded as the multimedia mix. Blackboard-writing, spoken languages, pictures, images, animation, physical teaching aids, and virtual teaching aids, which teachers in classes, are the media for teaching. Adamson (2012) defined multimedia learning as learning with materials presented by words (including printed words and spoken words) and images (covering illustration, pictures, photos, maps, animation, and images). Cognitive load theory is based on human cognition to discuss the effects of information presentation on information learning and memorizing. There are many types of theories related to human cognition and memory. After integrating the theories and viewpoints of several researchers, Eisenberg (2013) proposed multimedia learning cognition theory based on dual channels, limited capacity, and active processing to explain how human cognitive system distributed and processed multimedia message during multimedia learning (Murphy & Atala, 2014).

Cognitive load

Garrison (2011) pointed out Cognitive Load as an individual perceiving mental load and mental effort load during executing certain work, assignments, or tasks. Sweller mentioned that students' learning process was to acquire concepts and form schema and then develop personal problem-solving strategies and model. Abundant or irrelevant information might occupy the short-term memory in the learning process to enhance the cognitive load. Cullen et al. (2013) pointed out the meaning of cognitive load as learners' metaconcepts of "psychological" or "physiological" load, worries, failure, and frustration induced by information contents (quantity, quality, context), learning environment, transmission environment, and interaction exceeding the perceived cognitive capability in the information receiving, processing, and applying process. Adamson (2012) also regarded cognitive load as a "multi-directional" structure, which added a special task on learners' cognitive system. The essence of learners' cognitive load lied in the "effort" of researchers made on mental effort that the more effort was needed, the larger cognitive load would be. Horváth et al. (2015) regarded cognitive load as the load on the cognitive system (particularly working memory) caused by cognitive capacity or cognitive resources required for the operation characteristics in the operation process. Overload on the cognitive system caused by the total cognitive load exceeding the load which learners could bear might result in psychologically and physiologically negative effects. Such interference might be caused by improper teaching approaches or teaching contents to result in negative effects and reduce learners' learning effect because of cognitive overload in the learning process. Referring to Kirk et al. (2011) who analyzed from the aspect of teaching design, it is considered in this study that three types of cognitive load would be generated in the process.

(1) Internal cognition: It is internal cognitive load because teaching material difficulties are fixed. In general, larger internal cognitive load would appear when teaching materials are more difficult (Mechling & Seid, 2011).

(2) External cognition: External cognitive load is mainly affected by the presentation of teaching materials, the design of teaching materials, and teaching activities themselves. Improper presentation of teaching materials, without taking information structure and learners' cognition structure into account, could easily generate different degrees of load on learners, i.e. message recipients, in the teaching process.

(3) Germane cognition: It aims to enhance learning by offering learners with information, requesting learners with learning activities, and guiding learners to focus on learning contents (Song et al., 2011).

Learning outcome

Kelley et al. (2013) concluded that both teachers and students would expect to realize the outcome and the acquired value after the teaching and learning. The evaluation of understanding and value of such outcome was instructional assessment, in which the teaching activities contained the teaching of teachers and the learning of students. Accordingly, instructional assessment could be assessed from teachers' teaching and students' learning. However, student learning assessment was considered more important in pedagogies. Bull & Berry (2011) indicated that instructors could understand what students learned as well as realize students' responses to different teaching approaches by observing student performance in the learning process and the response to learning, or designing some formal class experiments. Gilakjani (2012) regarded learning outcome evaluation as a series of data and information collection about student capability achieving the lesson goal; such evaluation was executed in the lessons and was generally preceded by assignments. Kostakis et al. (2014) pointed out learning evaluation as collecting correct data related to learners' learning behaviors and achievement with scientific methods and technology and then analyzing, studying, and evaluating learners' learning performance, according to teaching goals. Davies et al. (2010) regarded evaluation as acquiring qualitative and quantitative data from measurements for fine and deep analyses and value judgment of the results to determine the achievement of teaching goals or the manifestation of learning outcome.

Referring to Liu & Stewart (2011), learning outcome evaluation is divided into Diagnostic Evaluation, Formative Evaluation, and Summative Evaluation in this study.

(1) Diagnostic Evaluation: Practicing pretests, diagnostic tests, and checklists in the beginning of teaching or encountering learning difficulties to understand learners' entry learning behaviors as the reference for designing the contents of teaching materials and determining teaching approaches or diagnosing the factors in learning difficulties (McMenamin et al., 2014).

(2) Formative Evaluation: Teachers observing and recording students' learning performance, in the teaching process, with evaluation scales for informal evaluation.

(3) Summative Evaluation: Testing students' learning achievement, by the end of teaching activities or after the completion, with regular examinations or tests, in which standard subject tests and quizzes compiled by teachers are preceded for formal evaluation (Noyes & Deligiannidis, 2012).

Research hypothesis

Dornyei & Ushioda (2013) indicated that students had to move around representations so that the transformation capability would affect the learning performance. Besides, students, because of limited working memory, could not process large amount of information at the same time that a lot of people concerned about how to help students select, organize, process, and transform representations. Multimedia dynamic presentation allowed hiding some essential information till necessary so that students could effectively reduce cognitive load by not processing large amount of information. After reviewing several literatures, Lin, Y.T. indicated that providing proper visual guidance, when designing multimedia teaching materials, would result in better learning outcome of students. Multimedia dynamic presentation would guide students' attention to highlighting and reinforcing information, without dispersing attention, to effectively reduce cognitive load (Klopp et al., 2014). The following hypotheses are therefore proposed in this study.

H1: The group with multimedia dynamic presentation reveals significantly lower internal cognition than the group with general instruction.

H2: The group with multimedia dynamic presentation shows remarkably lower external cognition than the group with general instruction.

H3: The group with multimedia dynamic presentation appears notably lower germane cognition than the group with general instruction.

Hammersley (2013) found out the better learning outcome of students learning multimedia teaching materials with properly designed flexible indices than those learning without flexible indices. Kreiger et al. (2014) further discovered that multimedia dynamic presentation could assist students with lower learning achievement in the learning outcome; and, from permutation problems, students with either low or high learning outcome presented better performance on memory and transformation tests (Taylor & Hutton, 2013). Accordingly, the following hypotheses are proposed in this study.

H4: The group with multimedia dynamic presentation presents significantly higher performance than the group general instruction on diagnostic evaluation.

H5: The group with multimedia dynamic presentation reveals remarkably higher performance than the group with general instruction on formative evaluation.

H6: The group with multimedia dynamic presentation shows notably higher performance than the group with general instruction on summative evaluation.

Lipson & Kurman (2013) pointed out the strong relevance between information. For instance, teaching materials with high difficulties and requiring certain knowledge bases would result in large cognitive load. Liu et al. (2014) explained that the design or performance of teaching materials requiring lots of information or prior knowledge would cause extreme working memory load to reduce students' learning outcome. Pachler & Daly (2011) mentioned that a large amount of schema, specific problems, and problem-solving strategies were stored in the long-term memory; learners without adequate schema or immediately correlated problem-solving strategies would proceed reasoning and searching in the short-term memory to waste the capacity of working memory, appear cognitive load, and generate learning difficulties. In this case, information with remarkable relevance and contrast characteristics would have learners presenting more working memory on reasoning and exploring (Rabionet, 2011). As a result, the following hypothesis is proposed in this study.

H7: Cognitive load reveals significantly negative correlations with learning outcome.

METHODOLOGY

Measurement of research variable

1. Cognitive load

Referring to Kirk et al. (2011), cognitive load is divided into (1) internal cognition, (2) external cognition, and (3)germane cognition.

2. Learning outcome

Referring to Liu & Stewart (2011), (1) diagnostic evaluation, (2) formative evaluation, and (3) summative evaluation are discussed.

Research subject and research design

To effectively achieve the research objective and test research hypotheses, the nonequivalent pretest-posttest experimental design model is utilized in this study for the quasi-experimental research. Total 216 students in four classes in Fujian Agriculture and Forestry University are selected as the research subjects. Two experimental classes (108 students) are proceeded multimedia dynamic teaching, while another two control classes (108 students) remain the didactic teaching approach in general traditional instruction for the 16-week (3hr per week for total 48 hours) experimental teaching research.

Analysis approach

Analysis of Variance is applied in this study to discuss the effect of multimedia dynamic teaching on cognitive load and learning outcome, and Regression Analysis is further used for understanding the relationship between cognitive load and learning outcome.

ANALYSIS RESULT

Effects of multimedia dynamic teaching on cognitive load and learning outcome

Variance analysis of multimedia dynamic teaching on cognitive load

Analysis of Variance is utilized for discussing the effect of multimedia dynamic teaching on cognitive load. From Table 1, teaching approaches present notable differences on internal cognition, and on which multimedia dynamic teaching (3.67) appears lower than general traditional instruction (4.33) that H1 is supported. Various teaching approaches reveal significant differences on external cognition, and on which multimedia dynamic teaching (3.17) shows lower than general traditional instruction (4.83) that H2 is supported. Distinct teaching approaches show remarkable differences on germane cognition, and on which multimedia dynamic teaching (3.34) reveals lower than general traditional instruction (4.59) that H3 is supported.

Table 1. Variance analysis of multimedia dynamic teaching on cognitive load

Variable		F	P	Scheffe post hoc
Multimedia dynamic teaching	Internal cognition	8.633	0.000*	Multimedia dynamic teaching (3.67) <general traditional instruction (4.33)
	External cognition	7.597	0.000*	Multimedia dynamic teaching (3.17) <general traditional instruction (4.83)
	Germane cognition	9.162	0.000*	Multimedia dynamic teaching (3.34) <general traditional instruction (4.59)

** stands for p<0.05*

Variance analysis of multimedia dynamic teaching on learning outcom

Applying Analysis of Variance to discuss the effect of multimedia dynamic teaching on learning outcome, various teaching approaches present notable differences on diagnostic evaluation, and on which multimedia dynamic teaching (4.91) reveals higher than general traditional instruction (3.74), Table 2, that H4 is supported. Different teaching approaches show significant differences on formative evaluation, and on which multimedia dynamic teaching (5.16) appears higher than general traditional instruction (3.91) that H5 is supported. Distinct teaching approaches reveal notable differences on summative evaluation, and on which multimedia dynamic teaching (4.83) presents higher than general traditional instruction (3.59) that H6 is supported.

Table 2. Variance analysis of multimedia dynamic teaching on learning outcome

Variable		F	P	Scheffe post hoc
Multimedia dynamic teaching	Diagnostic evaluation	17.632	0.002*	Multimedia dynamic teaching(4.91)>general traditional instruction(3.74)
	Formative evaluation	2.337	0.000*	Multimedia dynamic teaching(5.16)>general traditional instruction(3.91)
	Summative evaluation	19.461	0.003*	Multimedia dynamic teaching(4.83)>general traditional instruction(3.59)

** stands for p<0.05*

Correlation Analysis of cognitive load and learning outcome

1. Correlation Analysis of cognitive load and diagnostic evaluation
From Table 3, internal cognition (β=-1.697*), external cognition (β=-1.833*), and germane cognition (β=-1.739*) show significant effects on diagnostic evaluation.

2. Correlation Analysis of cognitive load and formative evaluation
From Table 3, internal cognition (β=-2.166**), external cognition (β=-2.338**), and germane cognition (β=-2.242**) appear remarkable effects on formative evaluation.

3. Correlation Analysis of cognitive load and summative evaluation
From Table 3, internal cognition (β=-1.947*), external cognition (β=-2.169**), and germane cognition (β=-2.073**) reveals significant effects on summative evaluation. Accordingly, H7 is supported.

Table 3. Analysis of cognitive load towards learning outcome

Dependent variable→	Learning outcome					
Independent variable↓	Diagnostic evaluation		Formative evaluation		Summative evaluation	
Cognitive load	β	Beta	β	Beta	β	Beta
Internal cognition	-1.697*	0.149	-2.166**	0.194	-1.947*	0.179
External cognition	-1.833*	0.162	-2.338**	0.212	-2.169**	0.196
Germane cognition	-1.739*	0.156	-2.242**	0.205	-2.073**	0.187
F	23.845		26.733		31.297	
Significance	0.000***		0.000***		0.000***	
R2	0.233		0.251		0.279	
Adjusted R2	0.016		0.021		0.028	

*Note: * stands for p<0.05 and ** for p<0.01.*
Data source: Self-organized in this study

CONCLUSION

The research findings show notably better performance of the experimental group than the control group on cognitive load, revealing that the remarkably lower internal cognition of the group with multimedia dynamic presentation than the group with general instruction, the notably lower external cognition of the group with multimedia dynamic presentation than the group with general instruction, and the remarkably lower germane cognition of the group with multimedia dynamic presentation than the group with general instruction. Such a result conforms to the research results in the literatures. The group with multimedia dynamic presentation appears higher performance on diagnostic evaluation, formative evaluation, and summative evaluation than the group with general instruction. From the analyses, cognitive load reveals negative correlations with learning outcome, presenting that reducing students' cognitive load might enhance the learning outcome.

DISCUSSION

Using multimedia dynamic teaching for picture changes allows students realizing and comparing pictures so that visual images could be applied to replace abstract thinking. Presenting contents with images could reduce students' cognitive load. The teaching materials are segmented and distinguished with colors, and the pictures are gradually presented step by step. Such processing approaches could reduce students' perceived difficulty of teaching materials and allow students constantly connecting to old pictures and old experiences and activating the brain operation. Students could deepen the thinking by picture changes to gradually develop various changes and create the overall perception. However, when students with slow thinking are not able to find out the correlation with the information on the picture and the course is continuously moving to the next action, such development might result in students' cognitive load and hinder students from thinking. Such factors could result in worse learning effect of low-achievement students, while high-achievement students would show more integrated concepts with clearer images.

SUGGESTION

Based on the research results, the following suggestions are proposed in this study.

1. Teaching materials designed with trigger-based dynamic teaching could promote students' learning effect. Students present lots of misconceptions on the text questions in teaching materials because of not integrating with information. For this reason, information integrity and structure should be considered in the design of teaching materials. When there is too much information, it should be segmented and presented step by step. Fine segmentation might increase burden on students' working memory, as local effects are hardly generated. The relationship between blocks need to be established that block diagrams should be used for establishing the relationship and gradually guide students to acquire integrated concept.

2. When teachers apply multimedia teaching design, a large amount of information would appear and increase students' cognitive load. Besides, repeated search and selection are required in the multimedia process in order to search data for deep learning. As a consequence, the accessibility and relevance of information need to be taken into account when designing teaching materials. Connected and sequenced information allows students presenting microcosm and integrity on the information in the learning process.

3. Application questions with images and words presentation reveal more information than single information. In this case, teachers should guide students, rather than repeatedly narrate, in the teaching process. Time control is also primary; students should be given time for establishing relevance, including the connection between spoken and word information. Teachers' spoken languages are the guidance, rather than interference. As a result, improper spoken languages to interfere in students' learning should be avoided in the statement.

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