ANALYSIS OF MULTIMEDIA TECHNOLOGY IN A COMPUTER AIDED DESIGN TRAINING ENVIRONMENT

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ABSTRACT

Innovation in computer and information technology, changing student requirements coupled with a need for modern teaching techniques all act as drivers towards the proliferation of high quality multimedia training material.Our research reports on principles that should be adhered to when designing multimedia training material in a Computer Aided Design (CAD) environment. We also examine the effects of individual differences and learning styles in the learning process. The most effective forms of multimedia and delivery platforms are also identified. Finally, the factors inhibiting the use of multimedia are established and recommendations are made. We found that principles of multimedia learning are valid from the student's perspective however the instructors did not uphold all the principles. Age and gender had little effect on preferences and opinions. Individual learning styles have an effect on the preferred formats and delivery processes. Our sample revealed that computer based material is the most popular and effective way to learn from and that computer technology is the most effective delivery platform. Prohibitive costs, perceived lack of skill and insufficient support are factors inhibiting the use of multimedia material.

Keywords: Best Practice, Computer Aided Design, Delivery Platforms, Design Goals, Learning Styles, Multimedia Formats, Principles Of Multimedia Learning

I. INTRODUCTION

Computer-aided design (CAD) is the use of computer systems and design software to assist in the generation, modification, or optimization of a design [1]. CAD systems allow engineers to manipulate information, such as material specifications, design processes, product dimensions, and tolerances. The engineer is able to use CAD to simulate real world dynamics to take the design of a product from its initial concept through to the prototype and completion stages. The pedagogy of computer aided design training is similar to that of any high end user software package in its context and cognitive structure. Increasingly, instructors who teach the principles of computer aided design have turned their attention to using multimedia techniques to provide students with high quality representations of these principles and models. According to Agnew et al. [2] multimedia design "*offers new insights into the learning process of the designer and forces him or her to represent information and knowledge in a new and innovative way*". Stemler[3] contends that multimedia technologies allow designers to create "*interactive and animated graphical presentations to communicate dynamic information*" in the belief that these presentations are more effective than printed materials. Other researchers have found that interactive multimedia has the potential to create high quality learning environments that have the ability to engage learners and promote deep learning [4]. Effective multimedia design is lauded to enhance the cognitive process and

increase the learner's ability to absorb and assimilate material [5]. Effective designs help learners to focus on relevant information, organize the information into a coherent mental representation, and integrate it with previously gained knowledge. However poorly designed material has a negative impact as too much information can overwhelm and confuse the learner [6] and many applications often contain interactions which are largely gratuitous and do little to support effective learning [7].It seems that there is a lack of empirical evidence on how multimedia works or which environments are best suited to this media. It is also unclear from existing research if the introduction of multimedia material enhances the learning experience or improves student performance. Moreover, there are few comprehensive guides available to developers to influence the effective implementation of multimedia in learning environments. Finally, existing research on the principles of learning by multimedia material is inconclusive. It is now becoming increasingly apparent that these issues must be addressed. The goal of our research is to develop an understanding of what multimedia means in the context of a computer aided design learning environment. We explore empirically established learning principles, such as those outlined in the cognitive theory of multimedia learning and apply them to the computer integrated design training environment. This context lends itself well to the use of multimedia in any computer software package training. We test the validity of best practice design principles from a teachers and a students' perspective. We also identify the effect that individual learning styles and human factors have on learning preferences. In addition we analyse the delivery tools that are available and determine which formats students and instructors prefer to use. Finally, we determine barriers that exist regarding the use of multimedia technology. The nature of this study is clearly multifaceted; (a) exploratory to set the scene and determine the significant issues that arise, (b) descriptive to establish facts and principles and (c) analytical to determine the variables and relationships that arise. As a result of this many research methods are used to collect data including interviews; group discussions; surveys and empirical tests. The research is important for many reasons. It analyses the issues that must be addressed when considering the introduction of multimedia into the training environment. The findings inform the teacher or course designer about the best available tools that offer value to the teacher and student. Consideration of these principles can help form the basis of an implementation strategy for the use of multimedia technology and an alignment between best practice and stakeholder requirements. It can also aid in creating a set of design rules to guide the teacher in the development of a multimedia training toolkit. The remainder of the paper is organized as follows. First a discussion on the concept of multimedia and the principles of multimedia learning is synthesized and presented. In this section we discuss individual differences and learning styles. Second the research approach employed in this study is outlined. Third, the findings from the analysis are presented and discussed. The paper concludes with a summary of the study, a series of recommendations and suggestions for future work.

II. PRINCIPLES OF MULTIMEDIA

The theoretical rationale for learning by multimedia is based on cognitive theories which include dual code theory, cognitive load theory and constructivist learning theory. Pavio [8] examines dual coding theory that suggests that information is processed in two independent channels. The first channel processes verbal information which includes text and audio and the second channel visual information which includes pictures. This division in attention is lauded to enhance learning [9]. Students are able to construct both verbal and visual models when presented with both words and pictures [10]. They can enhance learning by making connections between them more effectively and by processing the information in two separate channels.This improvement in

learning is because multimedia provides the learner with more cognitive paths that can be followed to retrieve the learned information. However cognitive load must also be considered when looking at the learning rationale [6]. This theory proposes that the processing capabilities of the visual and verbal working memories are limited and can become overloaded thus reducing learning capacity. People have the ability to integrate information from different sensory modalities such as the eye, ear and nose to create a meaningful experience. Therefore, the instructional designer is faced with the need to choose between several combinations of modes and modalities to promote meaningful learning [11]. Mayer [10] has conducted extensive research in this area. His research has identified specific principles for designing learning material. Previous studies have found that these principles can improve learner retention (i.e. the ability to remember what was presented) and learner transfer (i.e. the ability to apply what was learned to solve problems). These principles are now discussed in more detail.

2.1 Generative Learning Principle

Mayer[10]developed a multimedia principle that concludes that students learn more from a combination of words and pictures than from words alone. Studies by Yilmaz-Soylu&Akkoyunlu[12] support this principle and refer to it as "*the generative theory of multimedia learning*". Here relevant graphics should be included to supplement written text to improve learning. The theoretical rationale for this is that when presented with both words and pictures students are able to construct verbal and pictorial models and make connections between them. If words are used alone a verbal model is built up as the students read the text but they are less likely to make the same connections limiting the learning. Empirical data in tests conducted by Mayer[10] show that students who received a combination of text and pictures did better in retention of knowledge tests than those who received only text or pictures. In six out of nine tests students performed better when receiving the information in a combined format. In addition it was found that students also did better on transfer of knowledge tests when information was received in combination with nine out of ten tests resulting in improved performance. Moreno and Valdez [13] found that students learn better when provided with visual and verbal knowledge representations rather than visual or verbal representations alone.

2.2 Spatial Contiguity Principle

The second principle that Mayer proposes is known as the spatial contiguity principle and it states that students learn better when words and pictures are presented near to each other on a page or screen. According to Tempelman-Kluit[14] "*when images and text are provided close together, connections linking the two types of information will be made more easily and mental models leading to meaningful learning will occur*." The rationale given for this principle is that learners do not have to exert effort in searching for the information thus reducing the load on the individuals working memory. Mayer [10]found that in retention tests students achieved a 42% improvement in performance when presented with text and pictures placed near to each other rather than apart. This improvement was also evident in transfer tests where students achieved a much higher score with the 68% of students improving their performance.

2.3 Temporal Contiguity Principle

Mayer [10]expands on the contiguity principle and proposes what is known as the temporal contiguity principle which suggests that students learn more effectively when words and pictures are presented together rather than in succession. Empirical data in Mayer's research suggests that although there is no improvement in retention tests there is an improvement in transfer tests with 60% of students achieving improvement in performance.Yue

et al.[15] also concluded in their research that visual elements should be "*synchronized with corresponding narration*". A higher rate of transfer to long term memory will occurif verbal and visual information are presented at the same time rather than with one representation following another [14].

2.4 Coherence Principle

The coherence principle states that unnecessary verbal or visual information should be eliminated because they tempt the learner to focus on the irrelevant information at the expense of the critical information. In retention and transfer tests carried out by Mayer students performed better when irrelevant information was removed from the learning material. There was also an 80% increase in student performance in retention and transfer when irrelevant detail is excluded. Unnecessary information impedes learning as it interferes with the integration of information. When pointless information is included students are required to organize the material. In other words, learners' attention is diverted away from the main theme which can result in a lower performance in retention and transfer tests. There is substantial evidence to suggest that irrelevant information impairs learning[16, 17]. In light of this only educationally relevant pictorial and verbal information should be included.

2.5 Modality Principles

This principle states that words should be put in spoken form rather than in printed form when a graphic or image is the primary focus of the lesson. In four out of five tests Mayer [10]found that students who received animation with narration as opposed to text in the animation did better in both retention and transfer tests. The rationale for this principle rests in the dual coding theory [15]. Dual-coding theory proposes that both visual and verbal information is used to represent information in a learner's mind and students' process information in both visual and verbal channels simultaneously. If the learner uses his or her visual channel to process any images or animations, presenting on-screen text to convey verbal information merely divides the learner's visual attention and reduces the efficacy of the lesson. Studies showed that students who learn with concurrent narration and animations outperform those who learn with concurrent on-screen text and animations [17]. The effect is attributed to the student using reduced mental effort when learning as written text interferes with the process of organization within the visual channel. In light of this, only key words should be placed on the screen to maintain the focus of the lesson on the diagram.

2.6 Redundancy Principle

According to cognitive processing theory learners can only process a small amount of information. Too much information or information that is not clearly presented, or relevant, may lead to cognitive overload which has a negative impact on learning. People learn better from animation and narration than from animation, narration, and on on-screen text [10]. In two out of two tests both retention and transfer were improved when the online text was removed from the material. In this view learning is diminished if animation, narration and on screen text are used together because the learners working memory is overloaded and he or she cannot cope with this. In light of this designers should ensure that on-screen text does not duplicate narration.

2.7 Personalization Principle

Mayer's[10] personalization principle suggests that designers should promote a deeper engagement with learners and that they should aim to create learning material that students can relate to. Strategies to do this include using conversational language rather than a more formal style; use effective on screen coaches or avatars and finally they can try to make the author visible to promote learning. Research found that learners

learn better when the content is conversational, without being overly friendly, rather than when it is delivered with a formal approach [18]. Other studies suggest that students prefer to learn from multimedia material that is prepared by the instructor, claiming that this strengthens the familiarization effect between the two parties [19]. Student's motivation is improved and they work much harder to understand material when they are engaged in the social interaction effectof using personalized material [20]. In light of this the instructor may consider preparing the learning material themselves based on the needs of their students rather than using external generic sources.

2.8 Individual Differences Principle

Mayer[10] subscribes to the individual differences principle in his final proposal by suggesting that high knowledge learners are more successful as they compensate for poorly designed presentations because of their previous experience of learning. Individual characteristicsthat are lauded to affect learning include age, gender, past experience, cultural background and individual learning style.It isessential to take into account the characteristics, abilities and experiences of learners as individuals when beginning to plan a learning environment [21]. Research into the ratios of males and females using multimedia technology show that males are more positive towards the technology than females, with them more likely to adopt the use of the technology on a voluntary basis [22]. The effect that age has on learning is poorly understood but many researchers argue that for multimedia technology to have an impact, ways must be developed to address changes in perception, motor skills, attitudes, motivation and cognitive abilities that occur in older and younger populations. There are many physical changes that may occur as people age, the learner's senses such as eyesight and hearing diminish. Motor functioning becomes weaker with some reflexes becoming slower, bones and joints may also become weaker. The ability of older people to process new information may be lower but the ability to apply concepts could be enhanced. Learning style theories emphasize the unique cognitive approaches favored by individual learners.Learning styles can also affectcognitive processes of creativity and argues that this influence depends heavily on the types of learning materials given to students. Kolb [23] identified four categories of learning styles that describe how students learn. These styles are based on the learner's internal cognitive processes and correlate with an experiential learning cycle that he subscribes to. Kolb groups learners into four categories, namely Divergers, Assimilators,Convergers, and Accommodators.Divergers make use of practical experience in perceiving ideas and rely on reflective observation in organizing information. This type of learners can apply practical knowledge to different situations. Their approach to learning is mainly by observation rather than by taking any action. They are able to make use of previous knowledge and apply it to new areas, are creative and respond well to brainstorming sessions. Assimilators are able to comprehend large amounts of information in order to build up an understanding of the whole picture. This enables them to summarize a topic efficiently by collecting as much information as possible before condensing the material into a form that is easier to understand. They prioritize the validity of concepts rather than their practical use. They are good at planning, creating models, defining problems, analyzing quantitative data and developing new theories. Convergers are excellent problem solvers and can apply ideas to practical situations. They are usually good decision makers taking a considered approach and are excellent with technical tasks. These learners prefer to learning by doing practical tasks. Accomodators perceive information by practical experience and like the divergers prefer active experimentation when organizing material. These individuals tend to like new experiences and planned workloads. They act emotionally when making decisions and get more from discussing problems with other

individuals. They are good team members and like working in groups. They tend to have leadership qualities and are prepared to take a risk.

III. RESEARCH METHODOLOGY

Data was collected from both instructors (n=29) and (n=216) students in a computer aided design training environment in Ireland. Purposive or judgmental sampling was used in combination with non-random sampling in order to identify participants with deep insight into the area multimedia in computer aided design training. All stakeholders operated in the sphere of adult education only. Only experienced computer aided design instructors were included in the sample frame. Students who have not participated in computer aided design courses were excluded from the research. Participation in the research was voluntary and individual responses are strictly confidential. Mixed methods were used to collect data in order to enhance triangulation. Semi-structured interviews allowed a deep insight to be gained into current practices and process. Surveys allowed us to empirically measure opinions, practices and results. Data from experiments was analyzed to validate the generative theory of multimedia learning. Templates ensured that the research protocol was consistent and all interviews were recorded. Interviews were written up within 24 hours and the reports were sent back to the respondents for review. Clarifications and amendments were made where necessary. This activity verified the accuracy of the technique and increased the reliability of the study. Quantitative data was analyzed using SPSSx and excel. A chain of evidence was maintained to ensure that logical relationship existed between goals of the research, the protocol used, the raw data, and the conclusions drawn from results. Consequently we can be reasonably confident that an objective researcher following the same process would arrive at the same or similar conclusions.

IV. RESEARCH RESULTS

4.1 Principles of Multimedia Learning

The validity of the principles of multimedia learning are analyzed to ascertain if the responses from students and instructors match the ideas put forward in the literature. Students found all the principles to be valid. However our results reveal that instructors are unsure about some of the principles, notably the two principles of modality, the personalization principle and the redundancy principle. The key findings are summarized in Table 1.

Principle	**Students**	**Instructors**
	Agree	Agree
Generative Learning Theory	93%	100%
Spatial Contiguity Principle	88%	82%
Temporal Contiguity	95%	71%
Coherence	89%	60%
Modality Principle 1	98%	82%
Modality Principle 2	86%	60%
Redundancy Principle	75%	45%
Personalization Principle	85%	46%

Table 1: Analysis Of Principles Of Multimedia Learning

4.2 Principle Of Generative Learning Theory

This principle states that students learn better when presented with a combination of words and pictures than from words or pictures alone. Both the students and instructors agree that this principle is valid. In the retention of information test carried out on the student sample, those that received information in the picture and word format out performed those who did not. Students who were presented with the combined format averaged a score of 8/10 while those who did not averaged 6/10. There was a slight improvement with pictures only (6.5/10) over words only (6.35/10). Therefore, when developing multimedia material, words and pictures should be combined in any presentation.

4.3 Principle Of Spatial Contiguity

This principle states that students learn better when words and pictures are presented near to each other rather than being placed apart. Both the students and instructors found this principle to be valid. When developing multimedia material, words and pictures should be placed near to each other.

4.4 Principle Of Temporal Contiguity

This principle suggests that students learn better when words and pictures are presented together rather than in succession. The student sample in our study found this principle to be valid. However the instructors were not as convinced as the students with many unsure of the principle. When developing multimedia material the words and pictures should be placed together in accordance with the best practice procedure proposed by this principle.

4.5 Principle Of Coherence

This principle states that learning is reduced when irrelevant words and pictures are introduced. While both the students and instructors found this principle to valid a large number of instructors were unsure about the validity of the principle. Overall our finding suggests that irrelevant words and pictures should be excluded when developing multimedia material.

4.6 The Modality Principles

The first principle of modality states that when animation and narration are used together the student's learning is enhanced compared to when animation is used alone. This principle is based on results from retention and transfer tests that show a higher performance when the two are combined together. Both the students and instructors in our study found this principle to be valid. While it is easier to dub screen capture videos with sound rather than adding narration as a screen capture these results suggest that when developing videos the narration should be recorded as well. When choosing videos from third parties, instructors should ensure that they contain sound and the student has a means of playing back the sound. A second modality principle states that the combination of animation and narration is superior to a combination of animation and text. The rationale behind this principle is that the presentation of animation and on screen text together overloads the visual channel while the use of narration spreads the workload between both the auditory and visual channels. Our study upholds this principle.

4.7 The Redundancy Principle

Mayer[10] states that if animation, narration and on screen text are used together learning is diminished. The majority of students in our study found this principle to be valid. The majority of instructors in contrast found the principle to be either invalid or they were unsure. Previous studies found that concentrating on video, narration and text at the same time overloads the visual channel and auditory channels. This would also overload

the working memory. When developing videos, these combinations should be avoided unless the student can control what appears and choose which functions to use. For example they may want to turn the text off if it does not suit them.

4.8 The Principal Of Personalisation

Moreno[19] states that students prefer to learn from multimedia material that is prepared by the instructor. Student's motivation is improved and they work much harder to understand material when they are using personalized material [20]. The students in our study believed that their learning was enhanced when digital videos were prepared by the instructor. This effect can be attributed to more focused material being used. However, we found that the majority of instructors found the principle to be either invalid or they were unsure.

4.9 Multimedia Formats

This section discusses the forms of multimedia material that are effective as a learning aid and identifies which forms students prefer to use. Practical projects are considered to be the most effective learning aid by both students and instructors in our study. Digital formats are considered more effective than paper based material by both students and instructors. Students prefer to receive content in digital format more than any other medium. The research results show that paper hand-outs and books are the least effective media form from an instructors view point and students least preferred options.

Slide presentations are not popular with either students or instructors. Our results show that this may be attributed to the lack of practical input from the student. Digital videos were considered to be the most effective form of digital media, especially when they include narration and are prepared by the instructor, as in accordance with the best practice procedures of the modality and personalization principles of multimedia learning.

Medium	Students Ranking	Instructors Ranking
Practical Project	1st	1st
Digital Videos	2nd	2nd
Online Tutorials	3rd	3rd
Interactive Website	4th	4th
Courseware Manual	5th	5th
Paper Hand-outs	6th	7th
Books	7th	8th
PowerPoint	8th	6th

Table 2: Multimedia Format Preferences

4.10 Multimedia Delivery Platforms

Material can be delivered to the students in many ways. Paper based material can be physically handed to the students. Material can be emailed to students; downloaded directly from a website or learning management system or it can be copied to a disc or key drive and handed to the students. Our study revealed that students prefer material to be emailed to them. They also prefer to download and view material from a dedicated website when learning rather than using an online learning management system. The students in our sample did not like using learning management systems such as Blackboard or Moodle. Interviews revealed that this was due to the

need to log in and due to poor experiences using such systems in the past. This was in contrast to instructors who found that websites and online learning systems were the most effective tools to use to deliver material indicating a move towards the use of computer based learning aids as suggested in the literature. However instructors did not like the idea of emailing students material due to management of that information issues. Interestingly our study found that both students and instructors did not consider social networking platforms to be beneficial.

Delivery Medium	**Students Ranking**	**Instructors Ranking**
Direct Email	1st	6th
Dedicated Website	2nd	1st
DVD / CD Disc	3rd	4th
Network Drive	4th	3rd
Learning Management System	5th	2nd
Paper Hand-outs	6th	5th
Social Networking	7th	7th

Table 3: Multimedia Platform Preferences

4.11 Individual Differences And Learning Styles

This section analyses the effect that individual differences and learning styles have on the preferences and opinions of sample population. Our research showed that 90% of instructors surveyed believed that individual learning styles have an impact on the effectiveness of the use of multimedia material. Only 17% believed that age affects learning when using multimedia and we found that gender had no effect at all. Instructors were divided on whether students with past experience in using multimedia in a computer aided design training environment performed better than those who had not.

		Principle	Format	Platform
Learning Style	Diverger	No Effect	Practical Projects	Website
	Assimilator	No Effect	Undetermined	Website
	Converger	No Effect	Practical Projects	Website
	Accommodator	No Effect	Digital Videos	Paper Hand-outs
Age		No Effect	No Effect	No Effect
Gender		No Effect	No Effect	No Effect

Table 4: Individual Differences Effect Chart

We were unable to determine if past experience had an effect on student preferences as most of our sample had participated on computer aided design courses that had used multimedia in the past. We in our study we found that individual learning styles, age and gender had no effect on the validity of the principles of multimedia learning. In contrast we found variations existed when we examined the preferred formats and platforms. Although age and gender had no effect on format choices or delivery platforms we found that learning style differences do have an effect. In line with Kolb's (1984) suggestion that assimilators like to gather information, our research showed that this group liked multiple formats equally. We also found that divergers and convergers

preferred practical exercises. We found an interesting anomaly with Kolb's (1984) learning cycle theory in that our research shows that accommodators prefer to watch a task on video rather that learning by practical experience. This group also preferred old style handouts to new technology formats.

4.12 Factors Inhibiting The Use Of Multimedia Material

The research identified cost, lack of skills and the instructor development time required as the major inhibitors to the use of multimedia material. These findings correspond to the issues highlighted in the literature. Resistance to change, lack of available materials, slow internet speeds and a reluctance to recognize the increased work load are also significant factors that inhibit the implementation of multimedia material.

Other retarding factors in multimedia use are that it creates extra workload for the teacher in addition to that laid out in tightly controlled curriculums. The preparation of material involves learning new and often technically difficult skills. The lack of funding especially in the state sector is often the reason for poor take up of multimedia.

Our research discussions and interviews found that there were a number of barriers to the full exploitation of multimedia and technology in the classroom.These finding can be summarized as:

- There is often no coordinated management structure to help develop multimedia.
- Information about techniques and access to it is limited.
- Senior educational managers are not taking a strategic approach to change.
- Educators lack confidence and competence in information technology.
- There is insufficient hardware equipment.
- There are not enough application software packages.
- There is insufficient time to develop material.

V. CONCLUSIONS

Multimedia material is generally defined as the use of a combination of media forms, such as pictures and words, or animation and sound. These combinations can include as many forms as possible but must contain at least two to be called multimedia. A set of learning principles apply to the use of multimedia material and these should be considered to ensure that best practice procedure is followed. We found that words and pictures placed close to each other on a page are more effective than when presented alone, away from each other or sequentially. We also found that irrelevant information should be excluded. We learned that videos should contain narration and should avoid the use of text unless the student can control its visibility. We found that material developed and created by the instructor was considered more effective than material outsourced from a third party. Too much material, excessive combinations of media and the inclusion of irrelevant material should be avoided where possible.The research determined that the effects of age, and gender had a no effect on the results. Our research showed that there was an impact when learning styles differences were considered.We found that learning style only affects the preferred formats and delivery platforms and it did not validate Mayer's principles in this study. While there are many forms of multimedia material available we found that the most effective forms of multimedia material are computer based. Students prefer to use e-books rather than printed books. Online courseware is superior to paper copies and students prefer it if the instructor has prepared the material. Computer networks, learning management systems and individual tutor prepared websites are currently the main platforms of delivery and preferred by both students and instructors. One anomaly that does

occur is students prefer to have material emailed to them directly which instructors do not favor. Instructors on the other hand prefer using learning management systems. Our study found that social networking platforms are not considered beneficial by either students or instructors.

Based on our findings we can recommend the following to designers:

- The principles of multimedia material should be embedded when developing multimedia material. Designers and instructors should familiarize themselves with these principles. Best practice guidelines should also be created to enable this.
- New technologies should be examined by instructors and tested in their training environment to determine if they meet the needs of the learner.
- Instructors should obtain training in multimedia development and delivery tools as the research identifies this as a major inhibitor to the use of multimedia technology.
- We recommend that course managers take a blended learning approach rather than a distance learner approach to their courses. Multimedia material should be used to supplement classroom based training, not replace it.
- Learning management systems are considered useful as a hosting platform for multimedia learning. However we found that web pages provided a more efficient portal for viewing data. We recommend combining the two platforms with the learning management system used solely for administration and management of the course.

This research opens up avenues for future research projects. There is a need for additional experimental testing of the principles of multimedia learning in other learning environments. Any research in this area would require rigorous attention to the testing techniques. Although it is clear what effect multimedia use has in retention and transfer tests it is not clear how the use of multimedia affects specific course objectives. This could be examined in more detail. There is a need for further research on the relationships between the use of verbal and visual communication, in the use of interactivity functions of multimedia and the role of assessment and evaluation in the process. Finally further research could be conducted in the area of past experience effects on learning.

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