AAEE 2012 CONFERENCE
Melbourne, Australia
www.aaee.com.au/conferences/2012/

Implementing multimedia resources in online learning and its effect on student understanding

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BACKGROUND

The Engineering Materials course is one of the common subjects for first year engineering students and provided the ideal opportunity for this study due to the large class size and the presence of certain traditionally complex concepts. Based on the data collected by four international universities, most engineering students face problems in understanding complex topics in the Engineering Materials course, for example, atomic bonds, the binary phase diagram, and the microstructure of materials. It is argued here that introducing multimedia resources and visualization tools such as animations, videos, photos, inking and sketching in teaching could enhance students' understanding of both threshold concepts and complex knowledge.

PURPOSE

The aim of this research was to determine whether students reported an enhanced understanding of concepts identified as complex by previous research, when these concepts were presented in a technologically and visually enriched format.

DESIGN/METHOD

Threshold concepts as well as complex knowledge that require higher order thinking were identified using a subset of data from **data** of the course **collected** in previous semesters. For each concept, a suitable multimedia resource was developed, for example videos and animations. These were then enhanced further by the addition of inking during Camtasia Relay recordings of lectures. The students were subsequently surveyed electronically to determine if there was an increase in their perceived level of understanding.

RESULTS

From the results it was clear that students reported an increase in their perceived levels of comprehension. The implementation of the improved techniques impacted on the final results of the students' grades, with a significant difference between the traditional technique and the new one, i.e. the new technique significantly improved the students' results. An unexpected phenomenon observed was an increase in the level of engagement in electronic forums. It appears that the newly applied technique encourages student discussions via online forums, which in turn enhanced their level of engagement**.**

CONCLUSIONS

The majority of the students preferred the delivery of lectures enriched with multimedia resources and an added layer of inking in the recordings. The survey conducted showed that 73 per cent of the students reported an enhanced understanding of both threshold knowledge as well as complex knowledge in the Engineering Materials course.

KEYWORDS

Multimedia recourses, online engineering education, students' understanding, threshold knowledge, complex knowledge

ABSTRACT

In this study, the impact of employing multimedia resources in the teaching of a common first year engineering course, Engineering Materials, was investigated. The aim was to determine if there was an improvement in students' reported understanding and evidence of student's engagement as a result of using the resources. The multimedia resources were developed using animation software, supplemented by video recordings and inked annotations of each lecture. An online survey was conducted over three semesters utilizing an inbuilt facility in the online learning environment. The initial results showed that implementing the multimedia resources significantly improved the student engagement, quality of teaching and students' understanding of complex topics. About 73 per cent of the students preferred teaching methods using multimedia resources and inking. This preference was very pronounced in the off campus student cohort.

INTRODUCTION

First year engineering courses provide the foundation for engineering students in terms of critical knowledge and skills that would benefit them in their later courses, (Dalacosta et al., 2009, Hao, 2010, Kaveevivitchai et al., 2009, Johnson et al., 2010, Holt et al., 1985). Fostering higher order thinking in first year engineering students can highly enrich the learning experience therefore enabling the lecturer to present more challenging material. Comprehending more complex material becomes possible because higher order thinking leads to greater understanding of critical and complex engineering problems by students, (Dalacosta et al., 2009, Hao, 2010, Kaveevivitchai et al., 2009).

The Engineering Materials course is a foundation course for engineering students in the first year of the study. The course provided the ideal opportunity for this study due to the large class size and the presence of certain traditionally complex concepts. Data collected from four international universities (University Southern Queensland, Nottingham University, Multimedia University, Al-Anbar University, confirmed that higher percentage of most engineering students face problems in understanding certain topics in the Engineering Materials course, for example atomic bonds, the binary phase diagram, and the microstructure of materials, (Ali, 2009, Pao and Meng, 1998).

This paper argues that using technologically enhanced ways of introducing multimedia resources and visualization tools such as animations, videos, photos and inking during teaching, could enhance students' understanding and impact their way of thinking.

Introducing an idea in visual form has been found to be an important tool in the teaching and understanding of threshold concepts. Many authors have pointed out the importance of students' visualization in understandings complex topic (Ali, 2009, Pao and Meng, 1998). Several methods have been used to enhance students' imagination or visualization in order to improve their higher order thinking and comprehension of critical topics, e.g. microstructure of materials, failure mode in materials and formation of alloys, (Dalacosta et al., 2009, Hao, 2010, Kaveevivitchai et al., 2009, Johnson et al., 2010, Holt et al., 1985). In the past, cartoons have been promoted as an important visual language, which combines humour, exaggeration and symbols. Cartoons can be used effectively in the teaching process by providing information with regards to concretely instructive objects, (Hao, 2010). Using cartoons has been found to be a successful technique to transmit information to pre and primary schools students. In engineering education, it is less appropriate to introduce techniques like cartoons in some engineering courses such as Materials, Statics, Dynamics, Design and Heat Transfer. Real life applications are always preferred for engineering students to enhance their visualization and understanding of theories.

Innovations in technology, the user-friendly nature and the low cost of multimedia production provide educators with unprecedented freedom to explore suitable alternatives to traditional education and tools like inking, recording lecture, and cartoons. There is no clear indication in engineering education literature on how multimedia resources could influence student understanding of threshold and complex concepts, (Austin, 2009, Patterson, 2011). This paper attempts to address that gap by studying the influence of embedded multimedia resources on reported student understanding of typically complex concepts in the Engineering Materials course.

METHODOLOGY

A. Evaluation of student understanding

The study originated from reported student difficulties in visualizing and comprehending complex concepts in the course. This point has been drawn from the feedback and comments from students during and at the end of semester. For example, students always suffer in understanding and visualizing the Metal Crystalline Patterns as shown in figure 1.

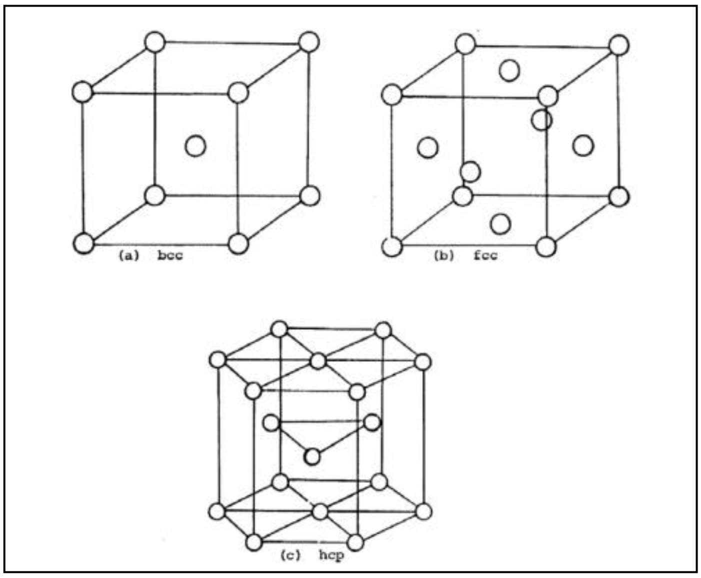


Figure 1: Unit cells for (a) body-centered cubic (bcc), (b) face-centered cubic (fcc), and (c) hexagonal close-packed structures (hcp)

In addition, the course is offered to both on-campus and distance students providing an opportunity to determine whether there is a greater need for multimedia resources in the distance group due to lack of face-to-face contact with the lecturer.

B. Developing multimedia resources

For each complex concept, the best fit in terms of technologically appropriate material was determined. For threshold concepts (for example Mechanical Testing), laboratory video footage was recorded with comprehensive verbal and inking explanations on how the tests should be performed, how data should be collected, and how the data should be interpreted. For Atomic Structure, animations were created and embedded in the lecture to show the movement of electrons around the nucleus. A similar method was implemented in presenting the Covenant and Ionic Bonds (Al2O3), Tensile Behaviour of Metals (starching in metallic bonds), Formation of Eutectic and Eutectoid in Binary Phase Diagrams. Flash objects were developed to illustrate the Formation of Grain to be used in Equilibrium Phase Diagrams, Slip Line in Polymers and Corrosion in Metals. Figures 2-4 display examples of traditional illustrations that were converted into animated ones.

For the benefit of external students, the lectures were recorded using Camtasia Relay software. As part of the lecture, digital annotations were used to augment the explanations in the illustrations, animations and videos.

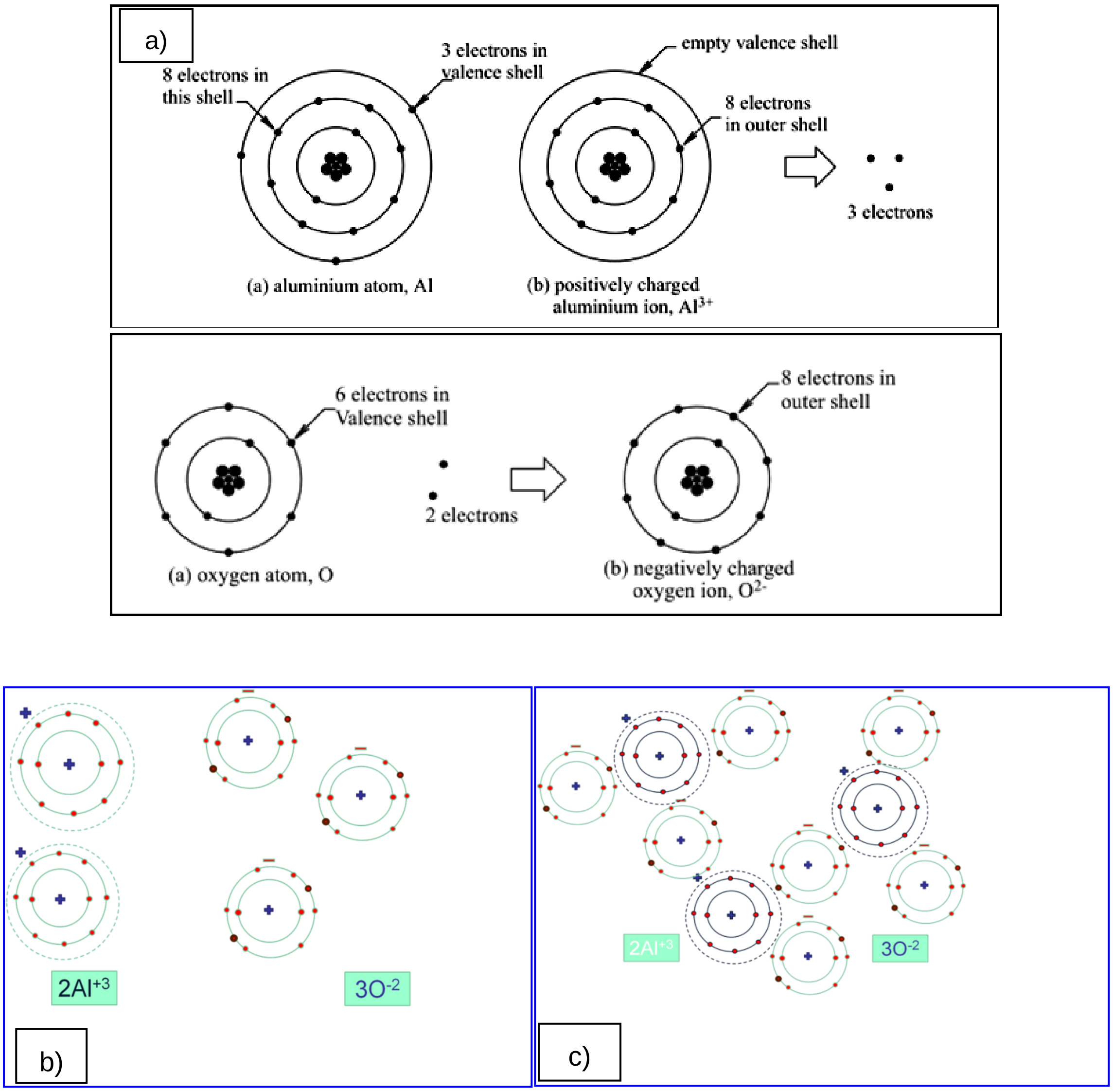
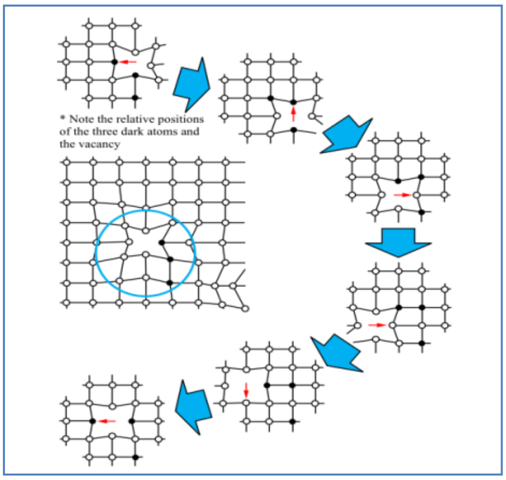
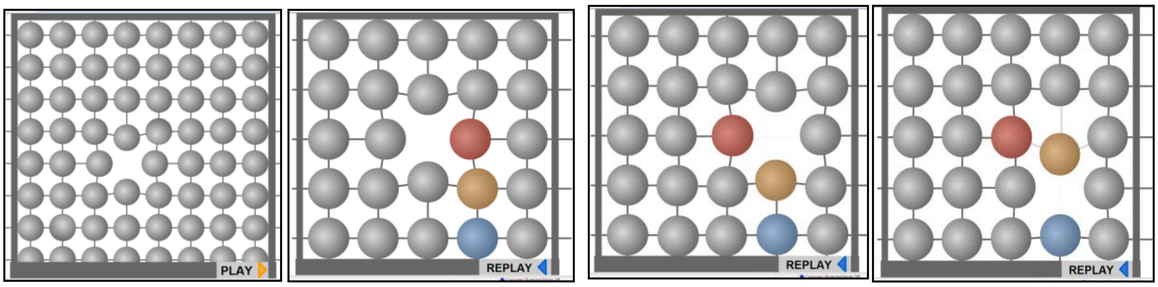


Figure 2: Covenant and ionic bonds in Al_2O_3: a) without animation b) first movement in the animated bonds, c) continuous movement of the atoms.



a)



b)

Figure 3: Diffusion in metal crystalline: a) without animation b) after animating the diffusion at different movements

C. *Implementing Multimedia Resources*

To evaluate the perceived efficiency and impact of the animations embedded in the course content, three complex knowledge topics were selected to be presented in three different ways: as static PowerPoint slides, PowerPoint slides with inking, and lastly PowerPoint slides with inking and embedded multimedia resources such as a binary phase diagram, microstructure of metals and tensile behaviour of metals. The presented topics were recorded using Camtasia Relay software and posted on the electronic publishing platform for use by both the on-campus and distance students.

An electronic survey was made available to 300 on-campus and distance students each semester for three consecutive semesters. The response rate was between 65-70percent. Feedback was collected through the e-mail and online survey facility available in the online study environment, Moodle. The collected qualitative and quantitative data was analysed and plotted using Excel software.

RESULTS AND DISCUSSION

The results were divided into two parts as the qualitative feedback from the students, the impact on the students' perceived understanding and interaction with the teaching team. Figure 4 shows the results of the survey. The responses were divided into three categories based on the three presentation techniques: static PowerPoint slides, PowerPoint slides with inking, and lastly PowerPoint slides with inking and embedded multimedia resources. Eighty per cent of the students preferred the approach with multiple multimedia resources and inking embedded in the lecture slides. This result ties in with the finding that 60 percent of students in a 4000-student survey were sensory learners as evaluated on the Myers-Briggs Type indicators (Beerman, 1996). Students in this category reported an increased ability to understand the engineering threshold or complex concepts. Beerman (1996) reported that multimedia helps average and below average students in particular to learn more effectively. Moreover, presenting threshold concepts and complex knowledge in a technologically enhanced style assisted these students in solving more complex problems in the assignments and the final examinations. Beerman (1996) reported $p < .05$ improvement in test scores where multimedia has been used in instruction. This was highly pronounced in the results of the off campus students. The percentage of failure has dropped to less than five per cent over the three semesters of the research project whilst maintaining the same difficulty level of questions in the final exam. This drop in failure was reported by Beerman (1996) as early as 1996. In spite of these early results that indicate that there multimedia enhancements enable improved comprehension of abstract or complex material, there are still a lack of understanding of the fact that multimedia offers lecturers greater control over how and at what rate material is presented to students (Beerman 1996). It seems the deep understanding of the complex topics assisted the students to solve problems with the same level of difficulties to the introduced topics. At high level of difficulties (e.g. interpreting complicated phase diagrams), about 65 percent of the students achieved 60-70 percent of the total marks. On the other hand, the students' feedback reflect their interest and understanding (e.g. *"even though I performed not well, but I know what are my mistakes"*).

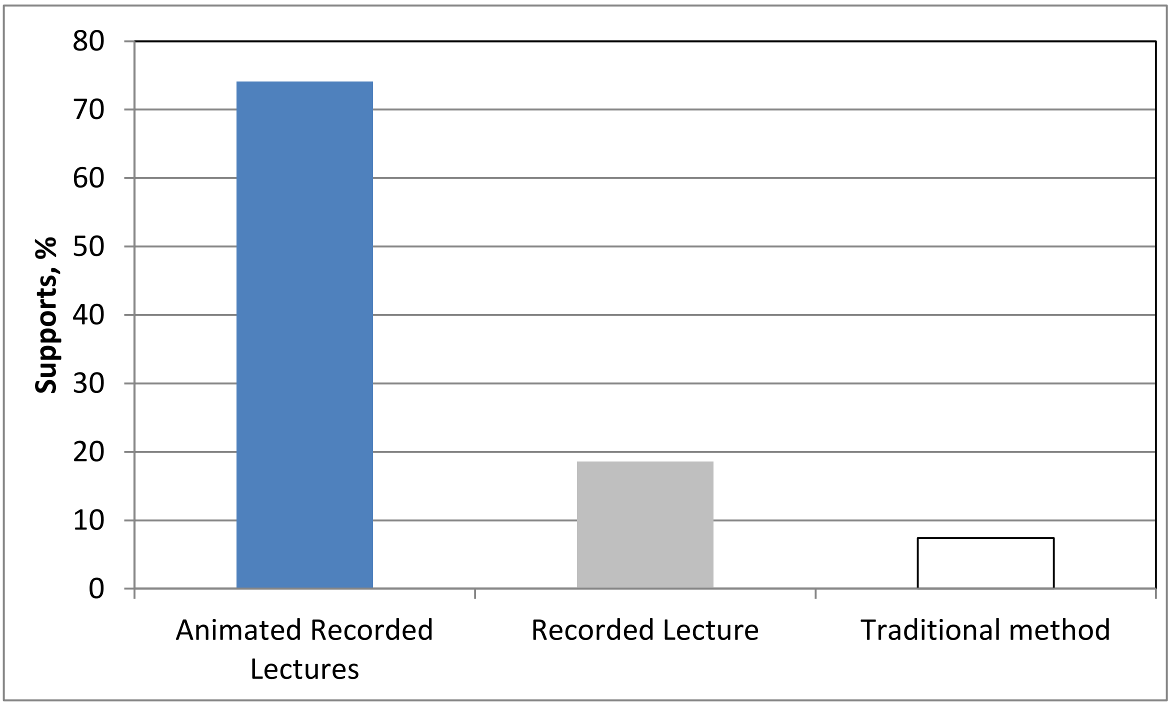


Figure 4: Reported preference for the three teaching techniques or approaches.

In previous offerings of this course, the students were provided with static study materials and recorded lectures without any multimedia resources (traditional method). When the traditional teaching content and methods were used, the interaction between the students was not as significant as during the application of the new method when the posted forums are compared between the previous and new semesters. The volume of interaction was determined through generating, two reports from the online learning environment, figures 5 and 6. The two reports show the number of posts which have been discussed in the online forums and the responses. The online learning environment is available to both on campus and distance students. It appears as if he multimedia enhancements of the lecture content has resulted in higher levels of interaction among the students and the teaching team compared to semesters in which no multimedia resources were utilised. Further research is indicated to determine if this could be ascribed to the multimedia resources per se.

At the end of each semester, students are surveyed to determine their opinion of courses via a student questionnaire on the online learning environment system. One of the survey questions was “What did you find were the most helpful/effective aspects of this course?” Ninety per cent of the students reported the recorded lectures as the most helpful aspect in this course. This tie in with the finding of Hao (2010) that multimedia enhances performance when students need more clues, that it lessens overload and helps students focus and that it is motivating.

In order to gain a more comprehensive view on the impact of embedded multimedia teaching resources on the higher order thinking of students, further research is required. If results are confirmed in further research projects, further embedding of technologically enriched content in this and other engineering courses could be recommended, particularly for enhancing understanding of threshold and complex concepts by distance education students.

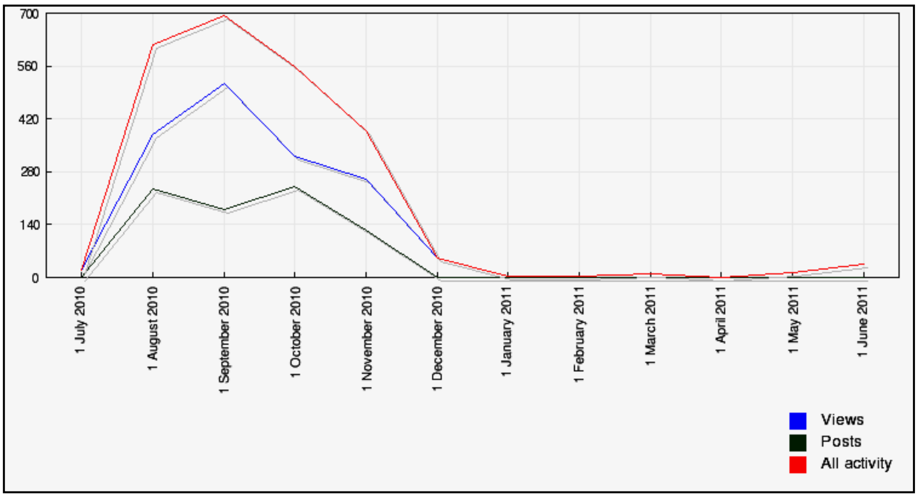


Figure 5: Statistics of the activities by the students and the teaching team for the first semester of implementing the new style of teaching.

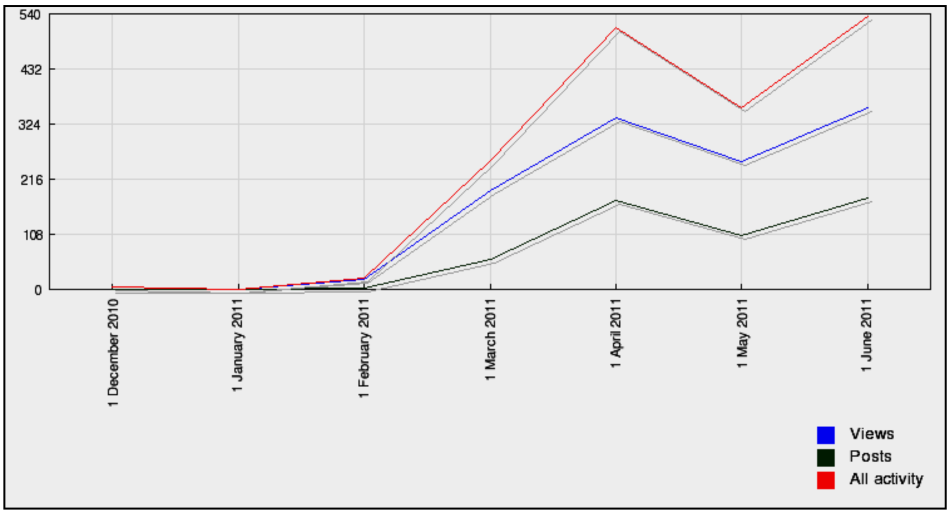


Figure 6 statistics of the activities by the students and the teaching team for the second semester of implementing the new style of teaching.

CONCLUSION

This study investigated the impact of multimedia resources on the students' understanding when used in teaching an engineering materials course. This research concludes that there is a proven need for greater use of multimedia resources such as videos, animations, and inking resources in teaching threshold concepts and troublesome knowledge in engineering courses. The majority of the students reported on in this paper, indicated a preference for lectures with embedded multimedia resources, in particular animation and inking. Moreover, the survey conducted indicated that 73 percent of the students reported an enhanced understanding of complex concepts in the Engineering Materials course. The students ascribed this enhanced comprehension to the embedded technological content and the inking explanations. To gain a comprehensive understanding of the impact of the multimedia recourses on higher order thinking pertaining to Engineering Materials problem concepts, further research is recommended.

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