Application of e-book multimedia animation in improving student's concept mastery and problem-solving competencies of phase diagram subjects in engineering materials course

by Dr. H. Mumu Komaro, M.t.

Submission date: 25-May-2021 03:03PM (UTC+0700)
Submission ID: 1593757344
File name: 15_Article_-_Mumu_Komaro_-_LA.pdf (265.09K)
Word count: 3836
Character count: 21608

Application of e-book multimedia animation in improving student's concept mastery and problem-solving competencies of phase diagram subjects in engineering materials course

Mumu Komaro[1], Minghat, A.D[2]. Rosdiana Heryanto Putra[3]
[1,3]Department of Mechanical Engineering Education, Faculty of Technology and Vocational Education, Universitas Pendidikan Indonesia. Bandung, Indonesia.
[2]Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, Malaysia
Email: [1]mumu@upi.edu, [2] malmaiah@kfu.edu.sa, [3]rosdianaputra@gmail.com
ORCID of the author(s), Mumu: 0000-0002-5593-3225

Application of E-Book Multimedia Animation in Improving Student's Concept Mastery and Problem-Solving Competencies of Phase Diagram Subjects in Engineering Materials Course

Abstract

The purpose of the study is to analyze the impact of using E-book Multimedia Animation (E-MMA) in the learning process of Engineering Materials course on improving student's learning outcomes in the Phase Diagram subject. The research compares the learning outcome of the students that use E-MMA media during the learning process to students that use a conventional static image as a learning media. Engineering Materials course is very important because it is indispensable for advanced study program expertise courses in an engineering program. This research is motivated by difficulty faced by student in understanding the abstract, complex and dynamic concepts in the learning process of Engineering Materials course. The research used was an experimental method with a randomized control group pretest-posttest design. There were two groups from two classes at Department of Mechanical Engineering Education, Universitas Pendidikan Indonesia Class of 2013 randomly selected as the research sample. The result indicates that the application E-MMA in the learning process of engineering materials can improve student learning outcomes with an increase in the high category N-gain, both in Concept Mastery and Problem-solving competencies. E-MMA is very effective in solving the problems of students in understanding Phase Diagram subject in Engineering Materials courses because of their ability to provide images, visualization and animations of complex and abstract objects.

Keywords: E-book-based multimedia animation, Phase diagram, Concept mastery, Problem-solving

1.Introduction

Engineering Materials course is a fundamental course in the curriculum of the Department of Mechanical Engineering Education (DPTM), Universitas Pendidikan Indonesia. As a fundamental course, Engineering Materials is indispensable for advanced study program expertise courses, including; Metal Fabrication, Joint Engineering, Welding Engineering, Casting Engineering, Machining, Forming, Automotive Chassis, Automotive Body, and Machine Element courses. This course is given in the first semester with a total of two credits and classified as a mandatory course for all students in the Department of Mechanical Engineering Education.

Engineering Materials courses focus on studying the structure of the atom and its behavior which are invisible, abstract, complex and dynamic. For the student, understanding the abstract, complex and dynamic concepts is a problem in the learning process of Engineering Materials is difficult. This problem results in students having difficulty in the learning process of Engineering Materials course and has an impact on student learning outcomes.

The preliminary research has been conducted to analyze the percentage of DPTM student who mastered the essential subject in the Engineering Materials course. The percentage data of students who can understand the concept and solve problems related to the main subjects in Engineering Materials course is 41.6% on average. Most students still have difficulty in understanding the Engineering Materials course. Students have difficulty in visualization due to invisible and microscopic dimension of atomic structure, with abstract, dynamic, and complex characteristics. The resulting detail is shown in Table 1:

Table 1. Percentage of DPTM student who mastered the essential subject in the Engineering Materials course

Exam Type	Percentage of a student who mastered the essential subject (%)				
	2008	2009	2010	2011	2012
Final-term	52	57	63	44	50
Mid-term	24	25	24	42	35
Average	38	41	43,5	43	42,5

As a part of preliminary research, the survey also conducted on 32 students of Department of Mechanical Engineering Education, Universitas Pendidikan Indonesia who had received Engineering Material courses to analyze the student difficulty level faced by students during the learning process. The results showed that the level of difficulty faced by students in the learning process of the engineering material course varied in each main subjects of Engineering Materials course, as shown in Table 2:

Table 2. Difficulty level on Main Subjects of Engineering Materials course

Subject	Student	Percentage
Phase Diagram	19	63 %
Shear Plane	5	17 %
Crystal Structure	6	20 %
Total	30	100 %

According to Table 2, Phase Diagram subject is the most difficult subject in the learning process of Engineering Materials courses. It is validated by 63% of students that choose Phase Diagram as the most difficult subject from three main subjects in Engineering Materials course curriculum. In Phase Diagram subject, students learn the visualization of phase diagrams, phase types, phase changes, phase percentages, and phase images on each alloy in every temperature change from liquid to room temperature. Also, the data shows that about 17% of students have difficulty learning the Shear Plane subject, and 20% of students have difficulty with the Crystal Structure subject.

The difficulty also comes from other problems. Another problem in the learning process of Engineering Materials is that not all students have reference books due to their relatively expensive, especially the original textbooks. Besides, there is also a language barrier in this case. Most of the textbooks and original books of Engineering Materials or Material Science and Engineering are written in English. In general, students do not master

English in the original text, this indirectly adds to the difficulty of students in understanding the Engineering Materials course.

Efforts are needed to solve the problem faced by students in the Engineering Materials learning process. Among the efforts to solve the problems, learning media is needed not only in a theoretical level but also in a practical, economical and accessible media capable of consolidating the concept of the Phase Diagram. Efforts to meet the accessible criteria will be pursued by manipulating the theoretical model (*image*) into a realistic model so that it is easy to teach (teachable) in multimedia form. Based on the results of research by Purnawan (2006), the cause is due to the theoretical model in the form of verbal symbols and available learning media, which are not representative enough to explain the concept of a system realistically, so it is not accessible by students with less effect in learning experiences.

One of the technologies that can be used for this purpose as stated by Widodo (2010) is information and communication technology (ICT), with the consideration that students can easily access computers to be used in the learning process. Previously, Callister has made a special e-book for Engineering Materials, but the animation is still limited to several points, 1) In Crystal structure in the form of unit cells, but it does not contain the characteristics of each unit cell that determines the mechanical properties of the material, 2) In the plane and direction of the Crystal, but it has not included the crystal shear plane which precisely determines whether the material is easy to form or whether it is soft or hard, 3) Interstitial point crystal defects, but not containing substitution point crystal defects and other crystal defects. All of the crystal defects determine the properties of the material, especially the mechanical properties, 4) Has not included the Phase Diagram material which is the most difficult material for students, and 5) Using English as the language of instruction, which is still an obstacle for students in general.

The E-book-based Multimedia Animation (E-MMA) has been developed as a learning media to overcome the student's difficulty in Engineering material course, especially on the Phase Diagram subject as the most difficult subject. The E-MMA was developed in a computer-based application and based on student's requirements, so this media is accessible to all student. The novelty of the E-MMA developed comparing to Callister's E-book for Engineering Materials are as follows:

1. In the material and animation aspects, it contains new materials that have not been previously made, to implement the existing material, such as crystal structures in the form of unit cells containing the characteristics of each unit cell that determine the mechanical properties of the material and the Phase Diagram material.
2. In the language aspect, using Indonesian as the language of instruction, to eliminate the language barrier for students in general.
3. In the function aspect, E-MMA has two functions, as a learning resource and as a learning media. As a learning resource, E-MMA is expected to meet the expectations of students, which contains complete material, easy to understand, and easy to own. As a learning media, it is expected to meet the characteristics of the media that meet the expectations of students and be accessible for the Engineering materials course.

The purpose of this study was to analyze the use of E-MMA in the learning process of Engineering Materials and its impact on increasing the Concept Mastery and Problem-solving competencies of the Phase Diagram subject as the most difficult main subject in Engineering Materials course. E-MMA is used as a learning media in Engineering Materials course to replace a conventional static image media, with the expectation that it can further improve the effectiveness of learning and learning outcomes.

2. Related Work

Many previous studies have been conducted and focused on developing e-learning media to support the learning process using ICT technology. ICT technology is used with the consideration that current students in general can easily access computers to be used in the learning process. Among the alternative use are in the form of e-learning, virtual reality, and interactive multimedia.

E-learning research has been conducted in which web-based e-learning media has been proven to be effective in improving student's learning outcome at Vocational High School (Bisri et al. 2009). Web-based e-learning not only increases learning efficiency but also inspires students to have a strong interest in learning (Huang et al. 2011). Research on the use of interactive multimedia has been shown to improve the quality of learning. The interactive multimedia is proven to improve generic science skills and problem-solving of vocational teacher candidates (Widodo, 2010), improve the ability to read projected images of vocational students (Anam et al. 2009), can improve learning outcomes of vocational high school students' assembly competencies and installation of brake systems for vocational students (Harsono et al. 2009).

3.Methodology

The method used in this research was an experimental method with a Randomized Control Group Pretest-Posttest design. There were two groups from two classes at Department of Mechanical Engineering Education, Universitas Pendidikan Indonesia Class of 2013 and Semester 1 randomly selected as the research sample. Class A as a Control group has 20 students and Class B as an Experimental group has 20 students as a subject, so the total subject in this study is 40 students. The Control group is a class that uses a conventional image or still image as a learning media, while the Experimental group is a class that uses E-book-based Multimedia Animation (E-MMA) as a learning media in the learning process for Engineering Materials course. The main subject that is the focus of this research is Phase Diagram and there will be two competency data from the research results, the Concept Mastery and Problem-solving competencies.

There are three stages in this research, 1) Pretest activity, 2) Treatment activity, and 3) Posttest activity. The stages carried out in the study are as follows:

1. Pretest. Students from both groups are given a test to determine the concept mastery and problem-solving skills of the Phase Diagram subject material before applying the treatment.
2. Treatment. The application of E-MMA for the learning process in the experimental group. While the control group uses a conventional image as a learning media.
3. Posttest. A final test which aims to measure the improvement of student's concept mastery and problem-solving skills after the implementation of E-MMA in the learning process of Phase Diagram subject. Both groups are given a test to determine the comparison between the Control Group and Experimental Group.

The research diagram of the randomized control group pretest-posttest design method as follows:

Table 3. Randomized Control Group Pretest-Posttest Design

Group	Pretest	Treatment	Posttest
Control	X1		X2
Experiment	Y1	T	Y2

To analyze student learning outcomes, the N-Gain test was used in this research to measure the improvement based on the Pretest and Posttest result. The formula used for the N-Gain Test according to Hake (2002) is:

$$g = \frac{T2 - T1}{Sm - T1}$$

Where:
g: Normalized Gain
T1: Pre-test Score
T2: Post-test Score
Sm: Maximum Score

4.Results and Discussions

4.1. Results

The Pretest and Posttest results were obtained with two focus competencies on the Phase Diagram subject, namely the Concept Mastery and Problem-solving competency. The results of Pretest and Posttest data for the application of E-book-based Multimedia Animation (E-MMA) in the Phase Diagram learning process in the Control and Experimental classes are shown in Table 4.

Table 4. Pretest, Posttest and N-gain Result from Control and Experiment Group.

Competencies	Data	Average Score	
		Control	Experiment
Concept Mastery	Pretest	14,15	29,13
	Posttest	25,93	85,90
	N-Gain (%)	33,22	79,40
Problem Solving	Pretest	0,82	4,05

Competencies	Data	Average Score	
		Control	Experiment
	Posttest	66,12	86,57
	N-Gain (%)	65,91	85,80

The Pretest and Posttest data in the control and experimental classes that have been obtained are used to calculate the N-Gain score to determine the student learning outcome results. Based on the results in Table 4, the improvement in student learning outcomes on Concept Mastery competency using E-MMA in the Experimental class reached an average of 79.4% and classified in the high category. This is higher than the improvement in Concept Mastery using image media in the control class which has an average increase of 33.22% or in the low category. While the improvement of the Problem-solving competency using E-MMA in the Experimental class reached an average of 85.80% and classified in the high category. This is also higher than the improvement in Problem-solving using image media in the control class which has an average increase of 65.91% or in the medium category.

4.2. Discussions

The application of E-book-based Multimedia Animation (E-MMA) as a learning media in the Phase Diagram subject of Engineering Materials course can improve students' learning outcome in Concept Mastery and Problem-solving competencies in general. This is because the E-MMA can provide animation and visualization aids of learning materials to the student during the learning process, so the learning process by using E-MMA is not only reading, but also seeing (text, still images, and animated images), and also listening which causes the mastery of the material to increase several times (Munir, 2010). According to Mayer (2008) and Berk (2009), learning outcomes from what is learned with animation will be more deeply understood because it involves long-term memory, and what is learned tends to be remembered longer (Fadel, 2008). The results of Student's Outcome in Phase Diagram subject on Concept Mastery and Problem-solving competencies can be seen in Figure 1 as follows:

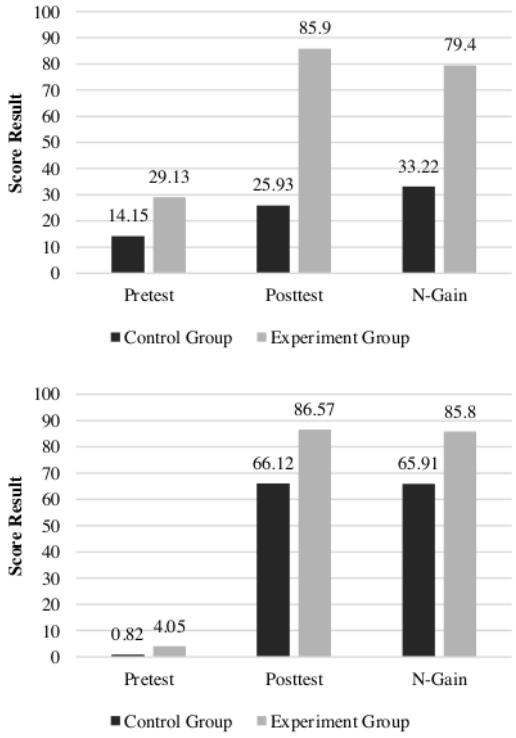

Figure 1. Results of Student's Outcome in Phase Diagram subject on Concept Mastery (Top) and Problem-solving (Down) competencies.

Based on the results of student's learning outcome in Figure 1, the application of E-MMA can improve student's Concept Mastery competency in High category N-gain. Wohl et al. (2010) state that animation-based education has a major effect on correcting cognitive errors. This statement is suitable with Yarden and Yarden (2006) opinion that previous animation has been shown to improve student's understanding and learning process. In Problem-solving competency, the improvement that occurred in the Phase Diagram subject also in the High category. This occurs because the Phase Diagram material with an abstract and invisible concept can be visualized clearly by E-MMA and make it easier to solve the Phase Diagram problem with E-MMA. Learning using E-MMA integrates digital technology, where the application of this technology affects the problem-solving process (Holmgren, 2013; Mayer, 1999).

The use of E-MMA in Phase Diagram material can describe the material phase conditions that are not accessible to the eyes and minds of students to become visible, so that it provides a concrete learning experience, and is no longer abstract. Real images and visualization in learning will have a much better impact on results, referring to the impression that complex concepts can be conveyed with only one image (Nazir et al. 2012). The impact of the learning experiences mentioned is proven to increase better concept mastery. This is in accordance with the high relationship between media and learning objectives as stated by Munadi (2013) which states that media in the form of live-images or animation has a high relationship to learning concepts, and with Falvo (2008) that argues that animation of structures and processes can help teachers convey important scientific concepts. More specifically, the use of multimedia animation in this study can improve the concept mastery of Engineering Materials course.

The advantages of E-MMA that can visualize the abstract concept give an effect to student's Problem-solving competency. Based on the results, the application of E-MMA can improve student's Problem-solving competency in High category N-gain. This is consistent with Widodo (2010) that the use of multimedia is proven to be able to improve generic science and solving skills. Anam et al. (2009) also stated that the use of multimedia animation (MMA) has been shown to improve the ability to read projected images, which in this case relates to abstract material phase images. In terms of skills and practice, the animation can improve skills and practice as stated by Harsono et al. (2009), so that this study has the same results regarding improving problem-solving competency through the use of E-MMA. This result is also reinforced by the opinion of Wohl et al. (2010), which states that animation affects the greater desire of students to use strategies to avoid mistakes, which in this case relates to problems that are given to be solved. Another statement was stated by Holmgren (2013) which states that learning by integrating digital technology affects the problem-solving process, in this case, students' problem-solving skills improved. The results of this study are reinforced by the opinion of Mayer (1999) which states that multimedia learning can promote constructivist learning that allows transferring or producing problem-solving skills.

From the results of the data explanation on the increase in Concept Mastery and Problem-solving competencies in Phase Diagram subject, it is proven that learning using E-MMA can improve Concept Mastery and Problem-solving competencies of abstract material such as Phase Diagram material in the high-level category compared to learning using image media which increases to the low category. This is in accordance with Edgardel's theory as expressed by Fadel (2008) that memory increases with the use of media like multimedia. Multimedia has the ability to display 3D (three-dimensional) concepts efficiently and effectively with a learning curriculum that is systematically designed, communicative, and interactive throughout the learning process. Also, multimedia is an effective and efficient learning media, and increases sensory stimulation, especially because of the inclusion of interactivity. In this case, multimedia can touch the five senses: sight, hearing and touch.

5.Conclusions

The result shows that the application of E-book-based Multimedia Animation (E-MMA) in the learning process of Phase Diagram subject in Engineering Materials course can improve student learning outcomes, both in Concept Mastery and in Problem-solving competencies. The student's learning outcomes of Concept Mastery and Problem-solving competencies increased in the high category N-gain. E-MMA as a learning media is very effective in solving the problems of students in understanding Phase Diagram subject in Engineering Materials courses because of their ability to provide images, visualization and animations of abstract and invisible objects, so students can easily understand concepts and formulas that exist in the Engineering Materials course.

References

Anam, C., Khumaedi, M. & Basyirun. (2009). Pembelajaran Ceramah dengan Media Animasi untuk Mengingkatkan Kemampuan Siswa Dalam Membaca Gambar Proyeksi, *Jurnal Pendidikan Teknik Mesin,* 9 (1), 7-13.

Berk, R. A. (2009). Multimedia teaching with video clips: TV, movies, YouTube, and mtvU in the college classroom.

International Journal of Technology in Teaching and Learning. 5 (1), 1–21.

Bisri, K., Samsudi, & Supraptono. (2009). Effektivitas Penggunaan Metode Pembelajaran E-Learning Berbasis Browser Based Training Terhadap Prestasi Belajar Siswa pada Kompetensi Pemeliharaan/Servis Transmisi Manual dan Komponen. *Jumal Pendidikan Teknik Mesin*, 9 (1), 37-42.

Callister Jr, W. D. & Rethwisch, D. G. (2008). *Fundamentals of Materials Science and Engineering: An Integrated Approach Third Edition*. John Wiley & Sons.

Fadel, C. (2008). *Multimodal Learning Through Media: What the Research Says*. Retrieved from: www.cisco.com/web/strategy/docs/education. Accessed 11 February 2015.

Falvo, D. A. (2008). Animations and simulations for teaching and learning molecular chemistry. *International Journal of Technology in Teaching and Learning*, 4 (1), 68–77.

Hake, R. R. (2002, August). Relationship of individual student normalized learning gains in mechanics with gender, high-school physics, and pretest scores on mathematics and spatial visualization. In *Physics education research conference*, 8 (1), 1-14.

Harsono, B., Soesanto. & Samsudi. (2009). Perbedaan Hasil Belajar antara Metoda Ceramah Konvensional dengan Ceramah Berbantuan Media Animasi pada Pembelajaran Kompetensi Perakitan dan Pemasangan Sistem Rem. *Jurnal Pendidikan Teknik Mesin*, 9 (2), 71 - 79.

Holmgren, R. (2013). ICT as a Catalyst in Problem-Based Learning Processes? A Comparison of Online and Campus-Based PBL in Swedish Fire-Fighter Training. *International Journal of Adult Vocational Education and Technology (IJAVET)*, 4 (2), 1-14.

Huang, C. H. (2011). A Web-based E-learning Platform for Physical Education. *Journal of Network*, 6 (5), 721-727.

Mayer, R. E. (1999). Multimedia aids to problem-solving transfer. *In International Journal of Educational Research*, 31, 611–623.

Mayer, R. E. (2008). Applying the science of learning: evidence-based principles for the design of multimedia instruction. *The American psychologist*, 63 (8), 760–769.

Munadi, Y. (2013). *Media Pembelajaran (Sebuah Pendekatan Baru)*. Jakarta: Referensi.

Munir. (2010). *Kurikulum Berbasis Teknologi Informasi dan komunikasi*. Bandung: Alfabeta.

Nazir, M. I. J., Aftab, H. R. & Ramachandra, V. P. (2012). Skill development in Multimedia Based Learning Environment in Higher Education: An Operational Model. *International Journal of Information and Communication Technology Research*, 2 (11), 820-828.

Purnawan. (2006). Desain Model Komponen Pneumatik untuk Media Pembelajaran Mekanisme Komponen Pneumatik, *Jurnal INVOTEC*, 3 (9), 116 – 124.

Widodo, W. (2010). *Pengembangan Model Pembelajaran "Mikir" pada Perkuliahan Fisika Dasar untuk Meningkatkan Keterampilan Generik Sains dan Pemecahan Masalah Calon Guru SMK Program Keahlian Tata Boga*. Dissertation. UPI Graduate School, Not Published.

Wohl, M. J. A., Kelly-Lyn. C., Kimberly, M. & Hymie, A. (2010). Animation-Based Education as a Gambling Prevention Tool: Correcting Erroneous Cognitions and Reducing the Frequency of Exceeding Limits Among Slots Players. *Journal of Gambling Studies*, 26 (3), 469-486.

Yarden, A. & Yarden, H. (2006). Supporting learning of biotechnological methods using interactive and task included Animations. *SIG 2 Bi-Annual meeting, "Text and Graphics Comprehension"*. The University of Nottingham.

Application of e-book multimedia animation in improving student's concept mastery and problem-solving competencies of phase diagram subjects in engineering materials course

ORIGINALITY REPORT

15%	12%	9%	10%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universitas Pendidikan Indonesia Student Paper	3%
2	www.tandfonline.com Internet Source	1%
3	Www.ejmste.com Internet Source	1%
4	onlinejour.journals.publicknowledgeproject.org Internet Source	1%
5	digilib.unimed.ac.id Internet Source	1%
6	download.atlantis-press.com Internet Source	1%
7	irep.ntu.ac.uk Internet Source	1%
8	repository.upi.edu Internet Source	1%

9	etheses.dur.ac.uk Internet Source	1 %
10	jurnal.stmikasia.ac.id Internet Source	1 %
11	media.neliti.com Internet Source	1 %
12	garuda.ristekdikti.go.id Internet Source	1 %
13	Submitted to University of Nottingham Student Paper	1 %
14	diy.open.ubc.ca Internet Source	1 %
15	hdl.handle.net Internet Source	1 %
16	lib.unnes.ac.id Internet Source	1 %
17	doaj.org Internet Source	1 %
18	studylib.net Internet Source	1 %

Exclude quotes	Off	Exclude matches	< 1%
Exclude bibliography	Off		

Application of e-book multimedia animation in improving student's concept mastery and problem-solving competencies of phase diagram subjects in engineering materials course

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8