Multi-Board (Multimedia-Blackboard) Approach for Engineering Education

HILMI COSKUN
Civil Engineering Department
Mustafa Kemal University
Iskenderun, Hatay
TURKEY
hcoskun@mku.edu.tr

Abstract: The rapid advances in computers have led to the implementation of advanced computer-based methods and new opportunities for the delivery of instruction in engineering education and practice. It is anticipated that the technology will continually change the way of which instruction is imparted throughout the educational system. This study is based on the assumption that students can better understand the difficult subjects by using animated lessons in addition to instructors' explanations called here as multi-board approach. Several modules on selected engineering freshmen courses based on perceptional and conceptual difficulties of the students are prepared. The main features of the developed courseware are (i) animated interactive learning materials, (ii) virtual and real video recording of lab experiments, and (iii) a web based learning environment. The courseware was tested and evaluated at different institutions. Student assessments of the instructional materials and the multi-board approach were obtained using quantitative evaluation questionnaires. The initial results indicated that this approach was helpful for learning and teaching.

Key-Words: internet, interactivity, multimedia, modular learning, courseware, visualization.

1 Introduction

The use of computers has been widely recognized as an effective and efficient tool in delivering course materials. Through computer software interactive and visually appealing media, such as, animations, graphics, simulations, and sounds can be incorporated to illustrate the engineering theories and concepts. The possibility of developing programs with superior graphic quality and efficient interactivity is very likely on raising student interest. Besides, the development of such media will perhaps have a positive impact on the quality of education [1].

Early research comparing graphics to text-only instruction had shown that graphics increased the amount of learning [2, 3]. Similarly, the learning experiences of groups using text only, text plus graphics, and text plus animation showed less study time and more learning for the animation group [4, 5]. In some other research, however, it was found that the animation did not result in a greater quantity learnt after comparing the animation-based instruction with carefully designed verbal presentations [6]. It was shown also that students in mathematical learning were able to learn more from the animated lesson and scored significantly higher than those using the graphics lesson [7].

There has been not much research into the use of animation in the early days of computers, because the required skills and equipment were scarce. Fortunately nowadays, animation can be created more easily with the help of inexpensive user-friendly software for introducing the technology into courses and laboratories [8]. Most universities and higher learning institutions are now using interactive tools and associated learning and teaching technologies to improve their educational system and update their curricula accordingly [9-15].

The technological advancements have made it relatively inexpensive and easy to use and develop multimedia. Effective educational multimedia development, however, is still very difficult and expensive. The main concerns in the development of educational materials can be summarized as; aesthetics, interactivity, user-friendliness, and cost [16-18]. Additionally, the developed course material should be used both on the web and as a standalone program. The software to develop educational materials should not be too complex, to be easily used on web browsers, and to be programmable.

Emerging learning technologies offer tremendous opportunities to support students in gaining a deeper understanding of specific subject-matters. Computer software is a potential educational tool; therefore, it is important to study how such tools can be implemented into classrooms in order to enrich the learning experience. Learning technologies can also be used to enhance some of the cognitive processes that have been associated with inquiry in science, including generating ideas, coordinating ideas with evidence, evaluating findings, weighing alternative explanations, constructing models that can be useful for making later predictions, and generating further ideas and questions.

2 Purpose of the Study

This study is based on the assumption that students can better understand the difficult subjects by using animated lessons in addition to instructors' explanations called here as multi-board approach. It should be clearly emphasized here that triangle of classical teaching system which consists of teacher, blackboard and chalk, never thought to be set aside. It is considered that the technology based developed materials should not substitute the classical teaching materials but support them.

Many theoretical explanations and examples that contain subjects from mechanics of material, engineering dynamics, and selected experiments are animated to be used by instructors and students alike. The impact of these courseware is evaluated by conducting questionnaire among students and instructors. The comments and thoughts of students about the produced course material is also sought after. Survey responses are summarized as graphical presentations for assessment.

3 Design and Implementation

The prepared course materials are used in active teaching environment as a supporting material of the classical teaching system. These modules are implemented in the engineering mechanics course thought to civil engineering students at the Mustafa Kemal University. Computer based user interactive modules have been developed for students of statics, dynamics and mechanics. In these courseware modules, interactive simulations and animations of real problems have been created. The modules guide students to grasp the fundamental principles and to have an intuitive sense of the meaning of key quantities. The modules are designed in such a way that students can use them independently and interactively. A website is created to enable students to reach the courseware through internet.

The topics of the modules are divided into two areas, namely, Software Enhanced Course Modules (SECM); and Virtual Lab Experiment Modules (VLEM). The content of the SECM consist of texts, pictures, interactive animations and questions. The content of the VLEM consist of test explanation and interactive test objects. These modules are presented through a media called "CemLib-Virtual Learning Environment" [19].

For example, in the vector module a catapult modeled by software was animated in order to visualize the concept of vector addition with the parallelogram method (Figure 1). As shown, students have an opportunity to link theory of vector addition to real life example by simply observing the working principle of the catapult. This implies that instructors are able to bring the real life situations into the classroom easily.

In another example, a screen capture of a tensile testing video recording of a laboratory experiment is shown in Figure 2. This video recording is performed within the CemLib project at the laboratories of the University of Maribor. Since it is time consuming and also expensive to repeat such a test for many different specimens, using the software helps a lot to provide an opportunity for both students and instructors to have the animation and visualization of such test. The modeling is presented in Figure 3 where it is shown that several of materials are tested and their mechanical behavior, stress-strain relations, are animated.

4 Testing and Evaluations

The developed educational materials are evaluated by presenting them to an audience comprising by students and instructors of three different universities and five different departments. These departments and universities are; (1) Mustafa Kemal University (MKU), Civil Engineering Department; (2) Mustafa Kemal University (MKU), Mechanical Engineering Department; (3) Gaziantep University (GU), Mechanical Engineering Department; (4) Gaziantep University (GU), Civil Engineering Department; (5) Cukurova University (CU), Civil Engineering Department, all of them are located in Turkey.

4-a Students' Views

A self-evaluation questionnaire was prepared. An introductory seminar followed by a sample

lesson. In the introductory seminar, the materials were presented to students. After the seminar and sample class, the questionnaire was answered by participating students. Overall, 416 students responded. The demographic distribution of the participating students is presented in Table 1. Unfortunately, there is no way of knowing which paper belongs to which student since the survey was done as a unanimous study.

Table 1. Class distribution of responding students

	MKU. Civil Eng.	MKU. Mech. Eng.	GU. Civil Eng.	GU. Mech. Eng.	CU. Civil Eng.	*Total*
Freshmen	31				2	*33*
Sophomore	75	53	4	1	29	*162*
Junior	11	16	34	50	4	*115*
Senior	3	34	25	10	34	*106*
Total	*120*	*103*	*63*	*61*	*69*	***416***

The questionnaire is designed to answer some basic issues about computer enhanced learning environment. These questions can be viewed as to look for whether the materials perform as expected.

Students' evaluation questionnaire:

1. These materials contributed to my generation, evaluation and understanding relationships between scientific variables
2. This class would be more effective for me if the instructor provided the information and rules instead of asking me to gather information from the animations in class and generate relationships myself.
3. I find it difficult to use the animations in computer environment.
4. Generally, the computer animations had an affect to better understand the course subjects.
5. Sometimes, I can use the animations several times to understand the concepts of interest.
6. In this class, it is difficult for me to develop a relationship between reality and theory.
7. I can use these materials to understand the concepts when I study myself outside the class.
8. An important advantage of the computer animations is that they visualize some of the difficult concepts in course.
9. I can better understand how scientists assess and modify theories about unobservable events and processes with these materials.
10. Using the in-class computer animations may compound confusion instead of clarifying the concept.
11. Instructor guidance is necessary for the effective use of animations.
12. I better understood causality relations in this class.
13. This course has increased my curiosity about some phenomena in science.
14. The animations have contributed to the development of my ability to critically analyze a problem and analytical thinking.
15. Supporting visual learning by animations makes the concepts more tangible.
16. Animated concepts stimulate my analytical abilities by helping me to find similarities and differences.

The students are asked to evaluate the question by circling one of the following choices: *I don't know; I do not agree; Undecided; I agree*. Only some figures which thought to be representative of typical ideas are given along with some explanations. Some responses received from the students are evaluated and grouped as shown in the Figures 4 to 10.

The Question.1 is aimed to evaluate if students think that the computer animations helps them to better understand the course subjects (Figure 4). Many students agree that the simulations help them so. Students are confused in Question.2 about the usage of materials (Figure 5). This confusion is understandable because the question is long and actually states two somewhat different conditions. Although responses to Question.5 indicate that the materials can be used outside the class by students, this type of usage should be done only after class if an effective usage is desired (Figure 6). Answers to Question.10 show that most of the students think the animations help to clarify the subject (Figure 7). Answers to Question.11 indicate that the animations and simulations can be better understood if the instructor in class explains them (Figure 8). Question.2 and Question.11 are related in a way that whether the materials would be more effective in class instead of self study. Question.12 asks whether it was the right choice of course to develop such materials, namely engineering solid mechanics (Figure 9). The answers show students are somewhat unsure. According to results for Question.14, most students think that the animations

help them to develop critical analyzing capability (Figure 10).

4-b Student Opinions

These questionnaires also included a section about asking the students' opinions in general. The questionnaires are kept anonymous so that we have no knowledge about who gave which answer regarding their class or grade. Each answer is numbered on the questionnaire paper, so, the numbers in the parentheses indicate the paper from which the comment is taken. Some randomly selected views that come from students are presented as follows:

- CU-Civil-#33: If the goal is to reach the wide masses, this technique should be developed more. Because a person who did not see these subjects before can have difficulty in understanding them. Besides, as you have said at the beginning, any person who has an interest in engineering does understand nothing from these subjects. In the end, again there is a need for instructors.
- CU-Civil-#44: It is better to see these than not seeing but unless we can do it ourselves, watching is not much permanent in minds. I think it will be more beneficial that if we are told very in a wider scope how we do these applications at least in virtual environment if not in reality, and also helped to apply.
- CU-Civil-#68: It is a nice study. But if a work, like this, is done for all courses, then no one comes to classes.
- GU-Civil-#13: This method is a study that is nice and can answer to most needs. But it would be better doing this in real life experimental environment for both complementing the subjects better and also seeing the experimental setting.
- GU-Civil-#14: The colourful computer animations in this class are really effective in reflecting real life.
- GU-Mechanical-#9: We can better learn by doing the experiments by ourselves or maybe by observing a flawed experiment. But, we may not reach the settings we need for doing the experiments at all the times. Because of this, it is good from one perspective but not enough. And also, these simulations do not provide full productivity to a student who sees this subject for the first time. For this reason, the instructor must do the explanation and provide his/her own experiences and firsthand knowledge.
- MKU-Civil-#4: I do not think that this new class system will be beneficial. Holding the attention is very difficult. I think the best system is that a student listens the class by writing...
- MKU-Civil-#5: In this educational system, getting rid of the blackboard is not right. For example, if free-body diagram is projected to blackboard by using a computer and the forces on it are drawn with a blackboard pen, then this system is to be more beneficial. I think, blackboard and computer should be a whole.
- MKU-Civil-#26: The animations are very good but not enough by themselves during a lesson. It could be more oriented toward taking notes. Making a student to take notes by instructor has a lot of influence in better understanding a course. Student understands while writing.
- MKU-Civil-#41: I agree that it will be more productive in difficult subjects. Nonetheless, I also agree that if this method is used after giving enough information as a preliminary view, mastery of the subject will be very great and good.
- MKU-Civil-#51: I think there is no need for this type of systems in order to make a course understandable. If instructors become sincere while teaching a subject and spend a little more effort to make the course understood, then there will be no demand for these types of systems.
- MKU-Civil-#82: Use of the animations provides better understanding by providing visual learning. But things are passed quickly to save in time and may be forgotten. It is needed that the instructor must render a lot of contribution and support.
- MKU-Civil-#83: Not only getting rid of cleaning the blackboard but there is also an opportunity of going back to drawn and cleaned shapes on blackboard.
- MKU-Mechanical-#1: ... it would also be logical to do these in the laboratory really one-to-one. It will be more beneficial for students.
- MKU-Mechanical-#11: Not only computer support is enough, also the skill of the narrator is important.
- MKU-Mechanical-#31: These animations and simulations gain meaning when they are applied with an instructor's support and systematically.
- MKU-Mechanical-#36: Teaching a course with animations lets the instructor pacified that means because it shadows student-instructor relationship, student loses his/her enthusiasm. So, instead of teaching a course this way, the

animation should be put into internet and any interested student should be able to reach it.

- MKU-Mechanical-#70: Founding a group in which student and instructor can work together in a class environment is a good thing. If students help to prepare animations and visual elements, I think, the interest in the course will be increased.
- MKU-Mechanical-#71: In general, it is a nice project. But when 'university' said, is not the first thing coming to a mind a formal education instead of distance learning? And by becoming this education as a standard in the future education, it will cause to a new work profession be born: artificer and animator.
- MKU-Mechanical-#72: Using an animation in subject teaching and problem solving may ease the understanding of subjects. Especially, in engineering education classes, showing machines or used parts by animations, ease the understanding of working mechanism. It provides a permanency in mind.

4-c Discussions of Student Opinions

In this paper, only a handful of randomly selected student comments are written. The main idea among these comments emerges as; these works should complement the in-class education. The animations are very helpful but only to some degree. Unless they are explained by an instructor they could be very well meaningless. Another point is the motivation; as students suggest, coming into class make the students feel that they belong to some sort of class. They say they need to feel the enthusiasm to attend the classes to follow the subject or to understand the subject. If the goal were only to pass the knowledge to younger generation then we could expect students to read the books and that would be it. But, education is not only passing the information, it needs also some interactions and discussions to effectively learn things.

Of course, some students are not very enthusiastic about these materials. However, still as always with the new things, some students see it with some sort of skepticism. These skepticism are expressed such as, no one is expected to attend the classes, or not to be able to understand the subjects.

Some suggest that working together in the preparation of materials, students can learn more about the subject. Although this sounds plausible, getting students in such an involvement can be very difficult. One reason for this difficulty is that the students have an already a lot of credit hours to take and the other is the lack of the necessary skills. Some students vaguely see the consequences of widespread use of this type of approach in education; such as necessitating some new jobs.

The findings indicate that students are well prepared to see the computer enhanced materials in classroom. However, they think that these materials alone are not sufficient. Understandably many say that these should be used as complementary materials. Since these materials by themselves may not suffice for understanding some phenomena but rather an introduction to the fundamentals, the materials should accompany an instructor's lesson. Students should be introduced the concepts not only in classrooms but also in laboratory. Practical situations help students to put the theory in some context frame.

As always these materials cannot substitute the good instructor's place in classroom or lessen his/her importance. The instructor should not rely on these materials for students' understanding the subjects either in classroom or alone on the internet.

Another good point mentioned is that complementing the theory with real life scenarios should be more easily achievable by using appropriate software and applying good settings.

5 Instructors' Views

During the evaluation period, in addition to students' responses, those of instructors are also sought. The following questions are prepared. The responses to these questions are given in Table 2. In total, 13 responses from academic persons were received and evaluated.

Instructors' evaluation questionnaire:

Ins-1. I can use these materials in addition to my notes in-class.
Ins-2. It is difficult to integrate these materials.
Ins-3. I can teach the course subjects more effectively with these materials.
Ins-4. Using these materials is difficult and causes the loss of time.
Ins-5. These materials can increase the interactivity between student and instructor.
Ins-6. I can use them as reference materials if they are ready to use in CD-ROMs and internet.
Ins-7. The class time can be used more effectively and efficiently.
Ins-8. The readily available material in the internet helps students to be prepared for class beforehand.

Table 2. Responses of instructors to questionnaire

Questions	I don't know	I don't agree	Undecided	I agree
Ins-1	0	1	3	9
Ins-2	2	8	2	1
Ins-3	0	2	1	10
Ins-4	3	7	1	2
Ins-5	0	2	2	9
Ins-6	0	0	2	11
Ins-7	0	4	0	9
Ins-8	0	0	2	11

The strongest response comes to the Questions Ins-6 and Ins-8. According to these responses, instructors tend to see these materials mostly as reference materials or as a material for students to get some more additional information. If we look at the students' response to the Student Question.7, 70% of students see these materials also as helpful materials outside class. This may not be as strong statement as saying that these materials are reference materials but still point to similar views of instructors. Another point is that although these should be viewed as class materials, putting them into internet should definitely help increase their effectiveness.

Questions Ins-1, Ins-6 and Ins-8 have the related views about the usage of the materials. The responses to them are also similar. According to Question Ins-1, almost 70% of instructors agree to use materials in addition to their paper notes. Very small percentage, 8% of them do not want to use the materials in-class and 23% of instructors are undecided.

Many instructors believe that the materials help them in increasing teaching effectiveness based on the results of the Question Ins-3. This effectiveness may come from several sources; (1) having many realistic examples available; (2) better visualization of concepts instead of blackboard drawn figures; (3) more free time to explain or discuss the concepts or examples.

About half of the instructors said these materials are not difficult to use as indicated in Question Ins-4. But this is not a great percentage because some 15% think the materials are difficult to use, and about one-third are either undecided or do not know. These results indicate that there is a mixed view toward this question. This result may have come from the way the materials are used in these demonstrations or maybe from the resistance to an unknown.

When asked if these materials can increase the interactivity between student and instructor, almost 70% said "yes" for the Question Ins-5. The rest is half unsure and half undecided. Of course, the interactivity between instructor and student cannot be expected to change dramatically with the use of animations. As a matter of fact, without these materials even better interactivity can be provided. Nevertheless, allowing more time for discussions, using animations and simulations may prove to be useful.

About one-third instructors said the materials provide effective use of class time for the Question Ins-7. This leads to another question however, why one-third instructors are not thinking that way. It can be speculated that since the materials and methodology are relatively new, the instructors may not be sure how to use them effectively. If this one and Question Ins-4 are thought together, the resistance to use the materials could be better understood. Responses to Question Ins-4 indicate that using these materials may cause loss of time.

Instructors in a great percentage, 85%, see that internet can be helpful for students to prepare for the class in response to the Question Ins-8. This is understandable since internet has become a helpful tool in every way to reach the needed knowledge. In this sense, having these materials available for everybody's use is good, but for guidance or to ask any questions an instructor is still needed.

In general, the percentages related to the questions indicate that the instructors welcome the use of these types of materials and teaching-learning environment. Although some instructors may be against using the materials, this situation may change if the positive aspects of the method are pointed out and understood.

6 Conclusions

There have been many tools to be used in developing effective educational materials. Several researchers developed simulation tools to achieve a better learning environment. In recent years, the trend is developing the educational materials to be used over the internet. This attitude has provided a more flexible -in the settings, audiences and objectives- approach. It is believed that the proficiency and common use of learning technologies would improve the quality of learning significantly in the classroom of all subject matters.

Although the creation of good quality course materials require skills and hardworking particularly if developing highly interactive teaching materials, it is obvious that their supplementary usage to

traditional materials will boost the thinking process of the students; improve the confidence and ability of students in analytical assessment and help them to avoid from strictly memorizing and provide the instructor more flexibility in his/her lecture in clarifying subjects. Various technology tools, embedded within the curriculum, can support inquiry-based teaching and meaningful learning in engineering education by engaging students in cognitive tasks that otherwise might be too complex or prohibitive.

The methodology and solutions as the multi-board approach presented here should be useful to educators who have interest in developing educational software. With the introduction of user friendly interactive animation programs with short learning curve and only minimal user intervention in the technical details of the solution process, rapid introduction and effective use of these software in engineering education and practice can be envisioned. The conclusions drawn from this study should also support and complete the bases for the construction of multimedia materials in engineering education.

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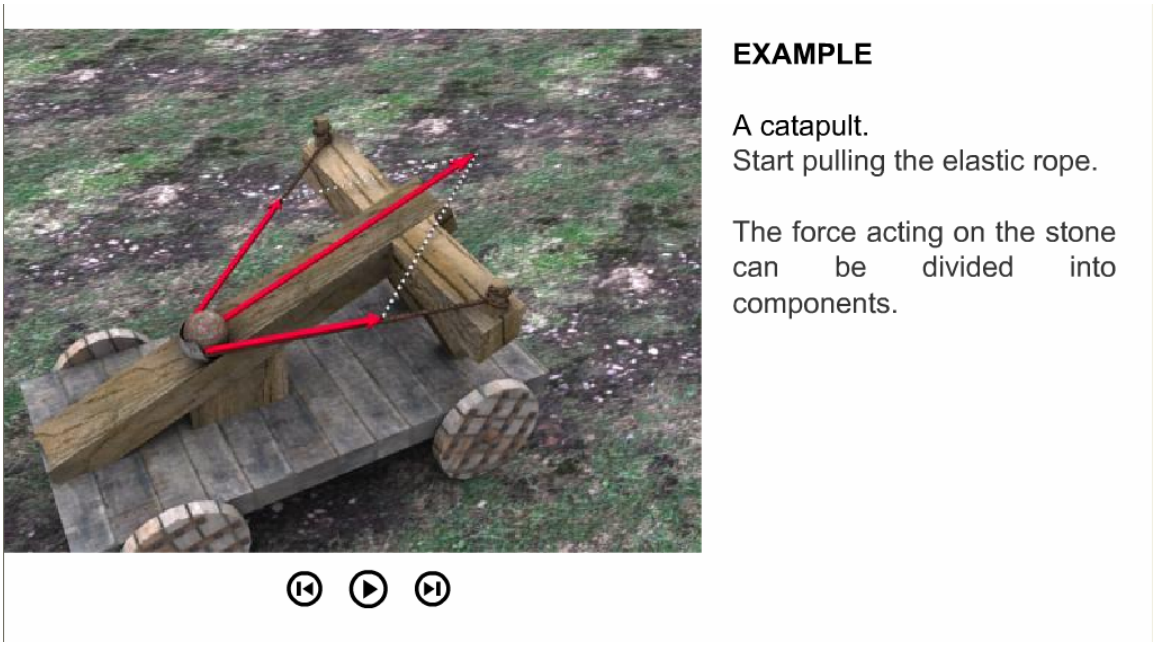

Fig. 1. Screen captured interactive Flash animation for teaching of vector module.

Fig. 2. Screen capture of an illustration from the video recording of a tensile testing experiment.

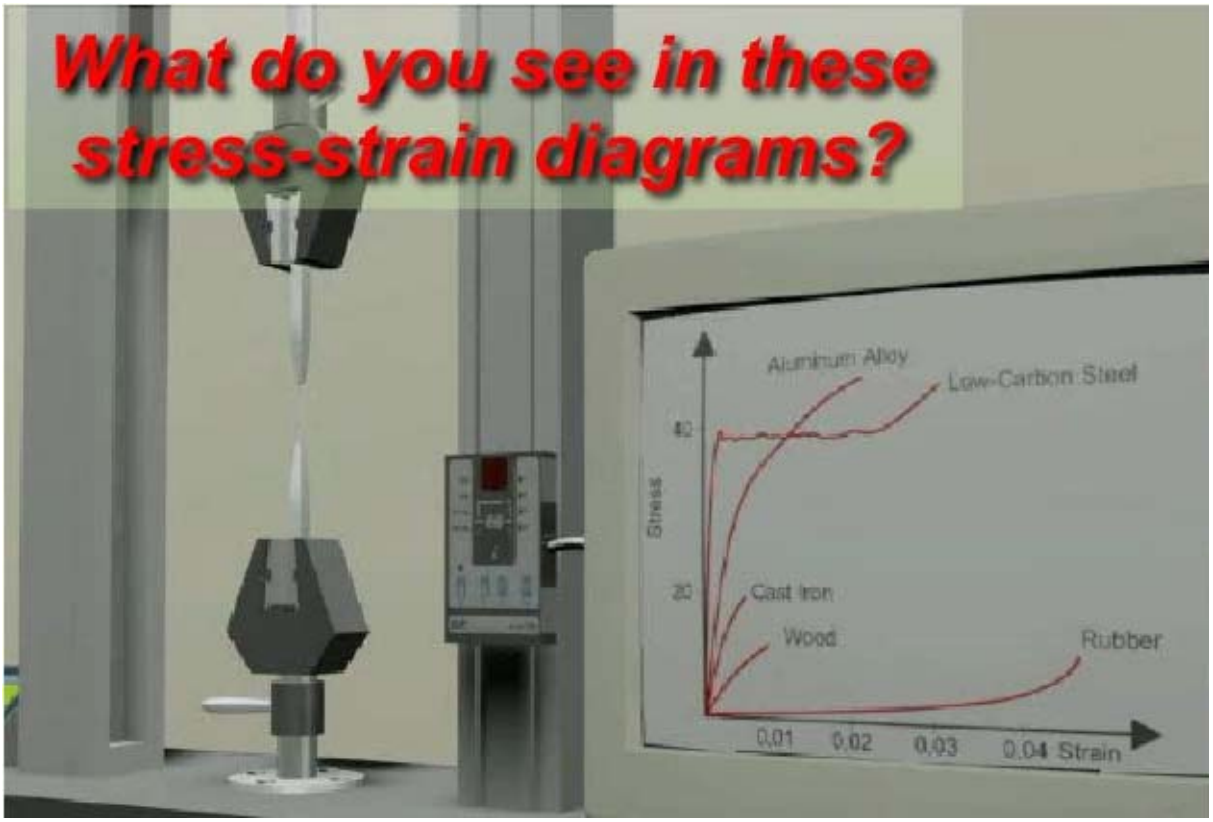

Fig. 3. Illustration of embedding 3D-StudioMax model in the Flash for the tensile testing.

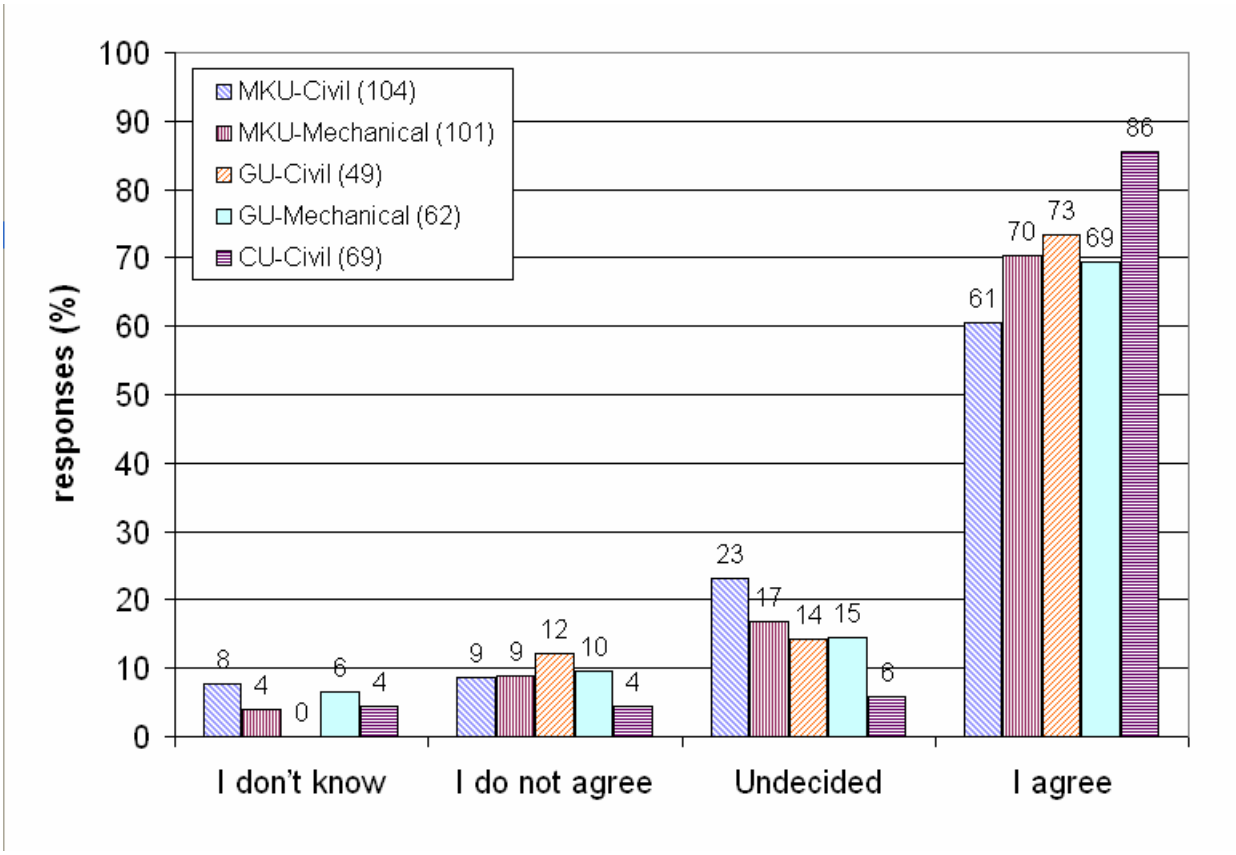

Fig. 4. Student responses to question 1: These materials contributed to my generation, evaluation and understanding relationships between scientific variables.

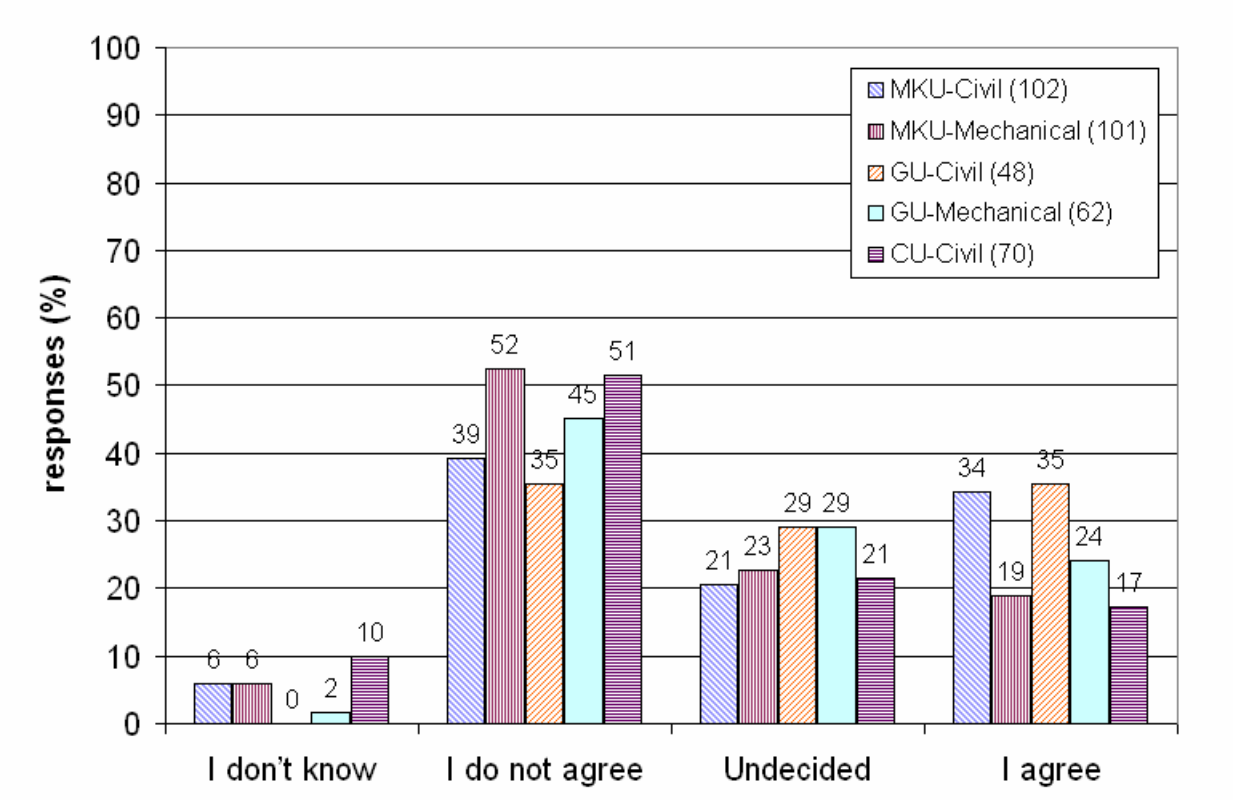

Fig. 5. Student responses to question 2: This class would be more effective for me if the instructor provided the information and rules instead of asking me to gather information from the animations in class and generate relationships myself.

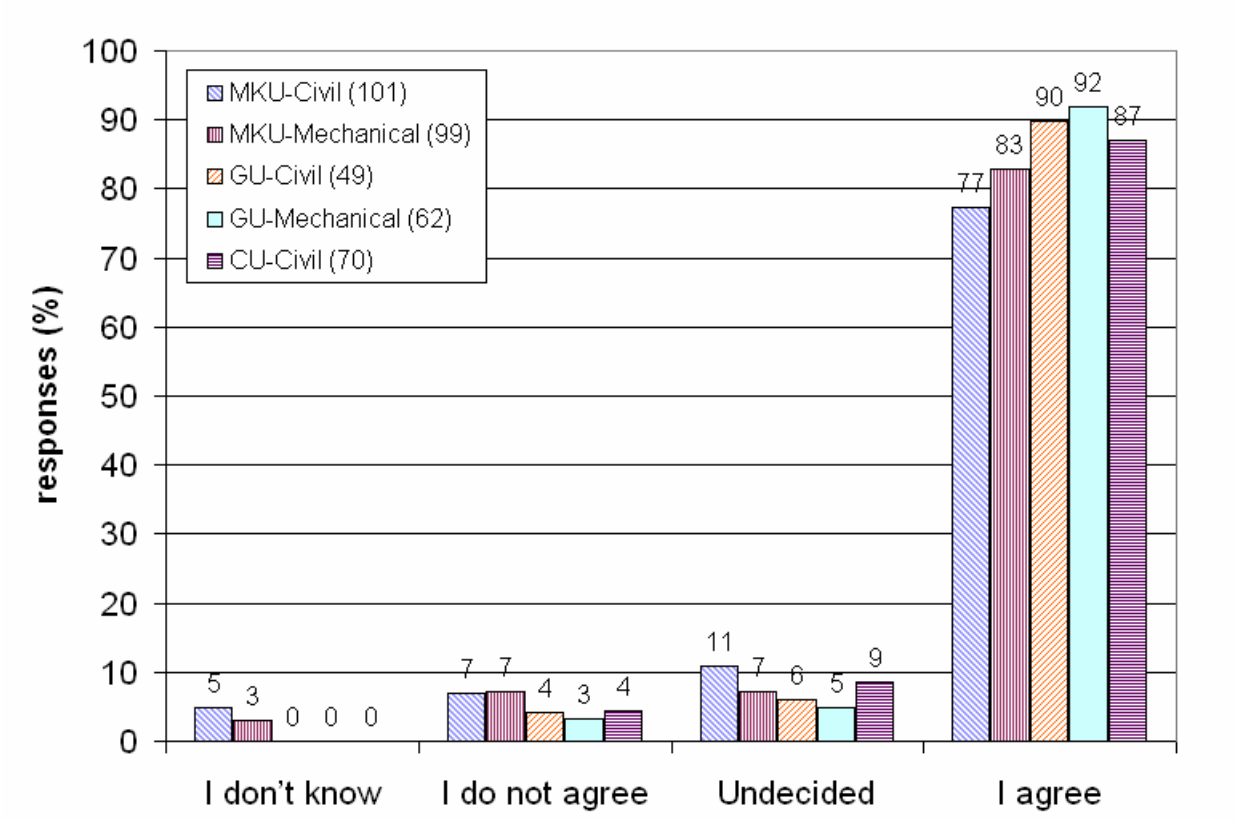

Fig. 6. Student responses to question 5: Sometimes, I can use the animations several times to understand the concepts of interest.

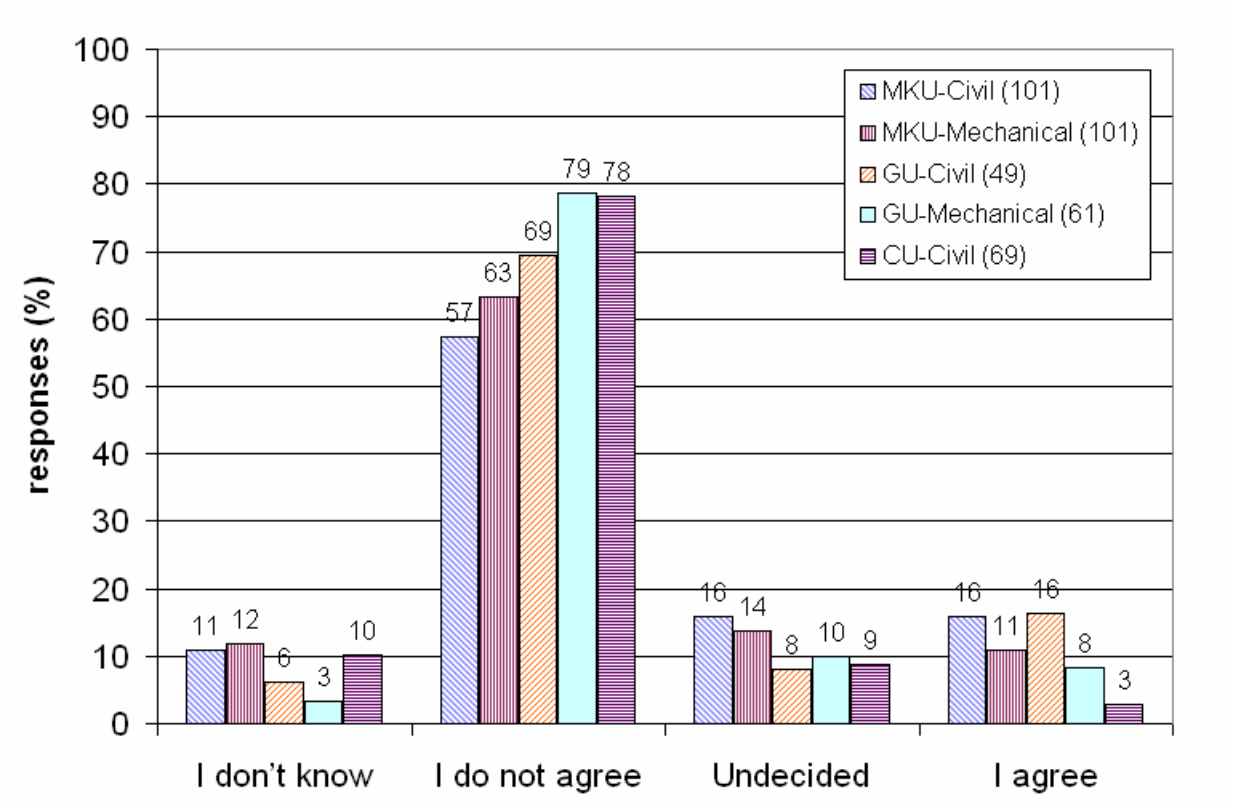

Fig. 7. Student responses to question 10: Using the in-class computer animations may compound confusion instead of clarifying the concept.

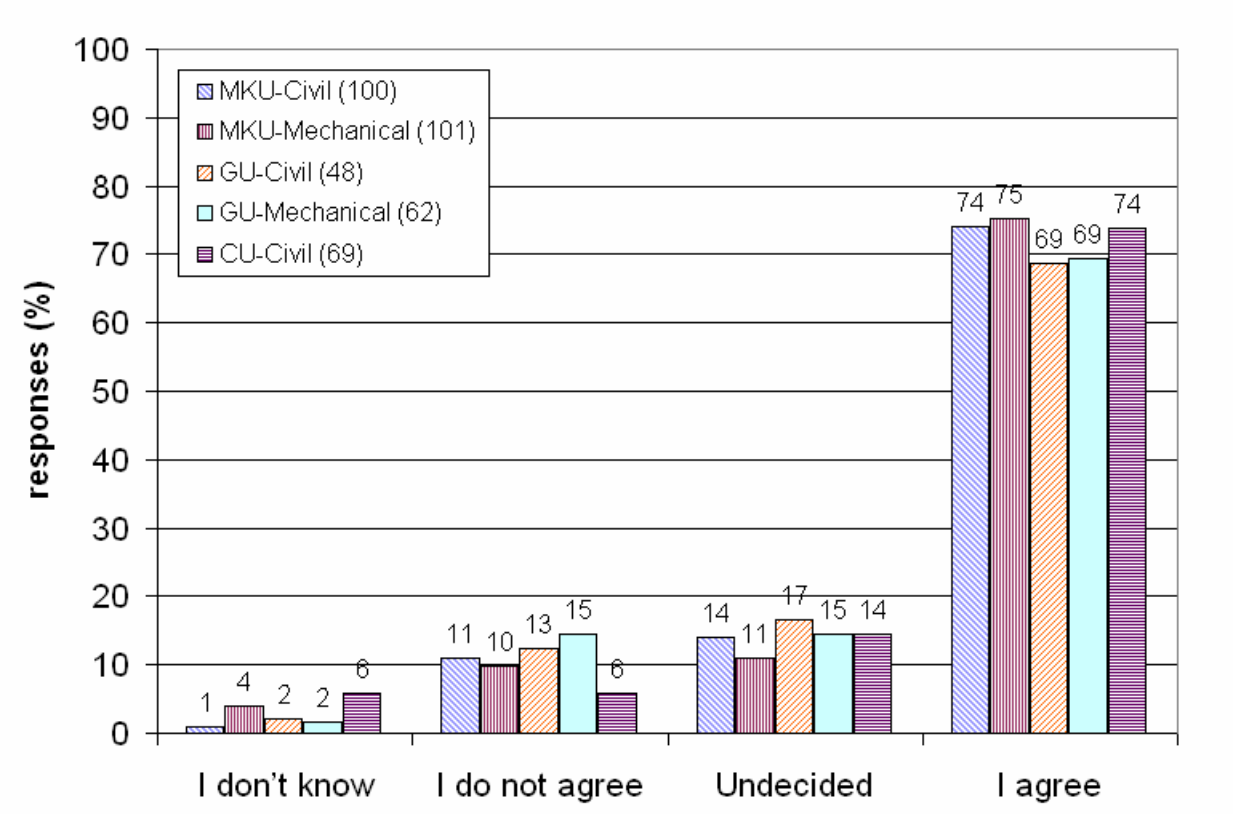

Fig. 8. Student responses to question 11: Instructor guidance is necessary for the effective use of animations.

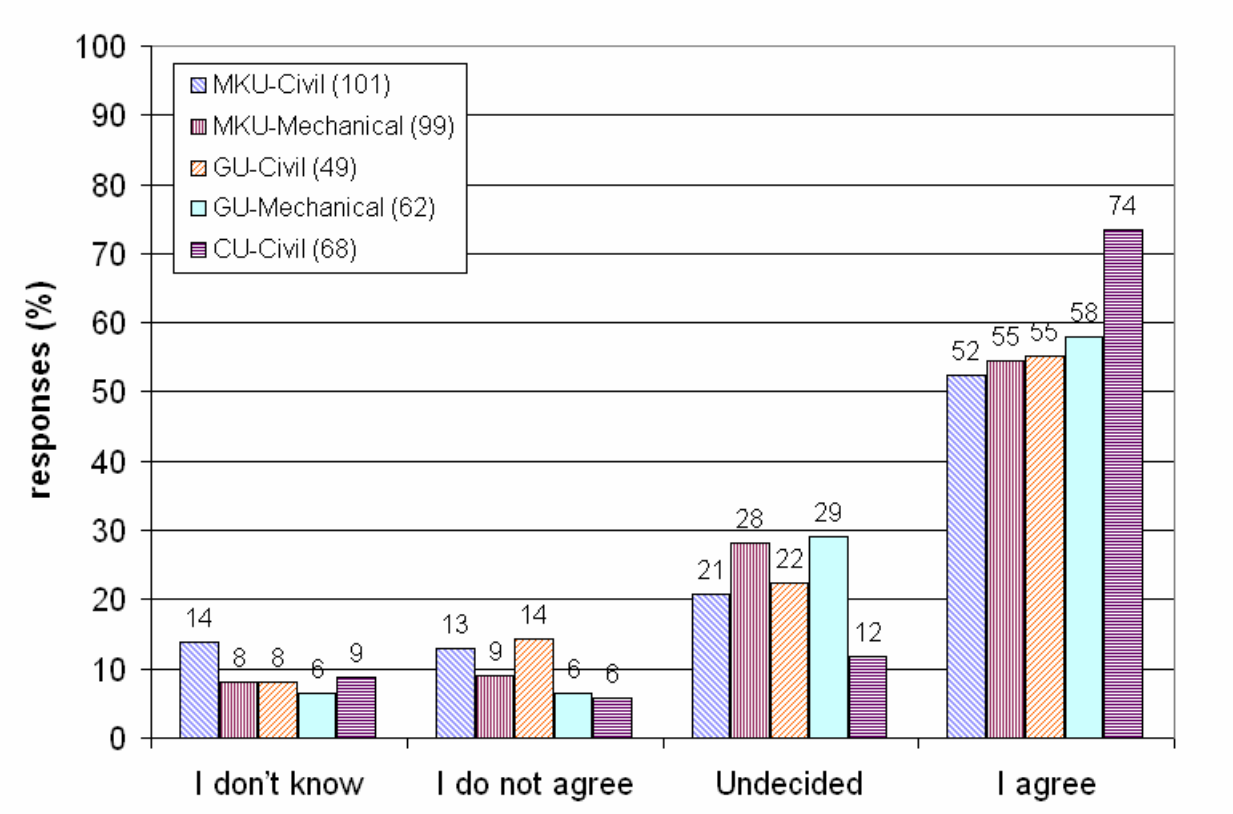

Fig. 9. Student responses to question 12: I better understood causality relations in this class.

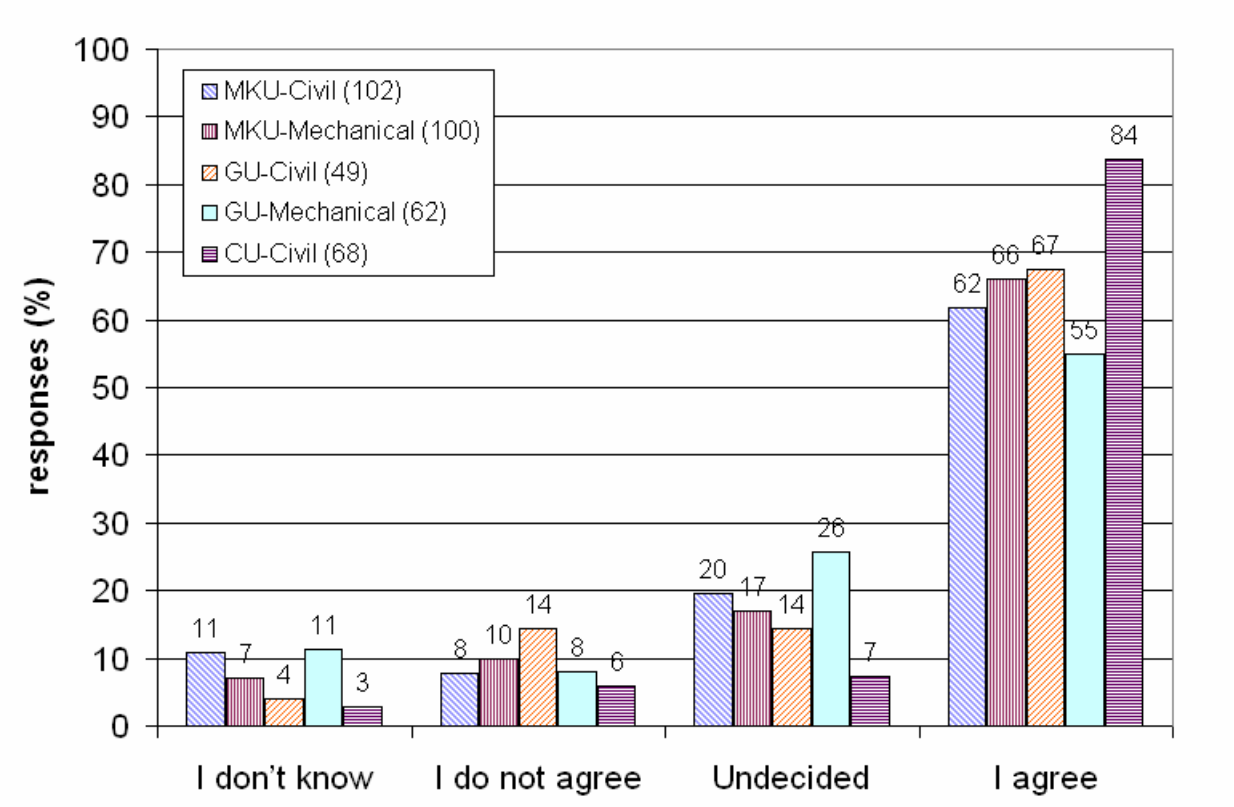

Fig. 10. Student responses to question 14: The animations have contributed to the development of my ability to critically analyze a problem and analytical thinking.