PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

MULTIMÍDIA INTERATIVA PARA MELHORAR A COMPREENSÃO DOS CONCEITOS DOS ESTUDANTES NO CURSO DE ENGENHARIA

INTERACTIVE MULTIMEDIA TO ENHANCE STUDENTS' UNDERSTANDING OF CONCEPTS IN ENGINEERING DRAWING COURSE

MULTIMEDIA INTERAKTIF UNTUK MENINGKATKAN PEMAHAMAN KONSEP MAHASISWA PADA MATAKULIAH GAMBAR TEKNIK

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RESUMO

O Desenho Técnico é uma das disciplinas obrigatórias ensinadas no Departamento de Engenharia Mecânica da Indonésia. Este curso visa dotar os alunos de conhecimentos e habilidades básicas em desenho. Esse estudo objetivou desenvolver mídia de aprendizagem na forma de multimídia interativa, determinar o nível de viabilidade da multimídia resultante e testar a eficácia da multimídia para melhorar a compreensão dos alunos sobre os conceitos básicos do desenho técnico. Por esse motivo, esta pesquisa utilizou um projeto de P&D com um modelo 4D para produzir e testar a eficácia de produtos multimídia. O teste de validade do produto foi realizado por 2 especialistas, um em material e outro em mídia. Quanto ao teste de efetividade, foi realizado o projeto de pesquisa pré-teste pós-teste de um grupo, envolvendo 28 alunos do Programa de Estudos em Educação em Engenharia Mecânica da Universidade de Educação Ganesha, em Bali, Indonésia. Os resultados mostraram que os especialistas em materiais e os especialistas em mídia concordaram que os resultados multimídia desse desenvolvimento eram apropriados para serem usados como materiais de ensino no processo da aula. Além disso, o teste de eficácia também mostrou que a multimídia desenvolvida foi eficaz para aumentar a compreensão dos alunos sobre os conceitos básicos do desenho técnico. O uso de multimídia interativa pode aumentar a motivação e a independência dos alunos na aprendizagem, aumentando assim a compreensão dos conceitos ensinados no curso de Desenho de Engenharia.

Palavras-chave: *desenvolvimento, multimídia interativa, compreensão de conceitos, Desenhos de engenharia*.

ABSTRACT

Engineering Drawing is one of the compulsory courses in the Department of Mechanical Engineering in Indonesia. This course aims to equip students with basic understanding and skills in drawing. In this case, this study aimed to develop learning media in the form of interactive multimedia determining the level of eligibility of the developed multimedia, and testing the effectiveness of the developed multimedia in enhancing students' understanding of the basic concepts of engineering drawings. For this reason, this study used an R&D design with the 4D model to produce and test the effectiveness of the developed multimedia. The product validity test was carried out by two experts, namely one material expert and one media expert. The effectiveness test, one-group pretest-posttest design was carried out by involving 28 students of the Mechanical Engineering Education study program at Universitas Pendidikan Ganesha, Bali, Indonesia. The results showed that both material and media experts agreed that the developed multimedia was suitable for teaching equipment in the lecture process. The effectiveness test also showed that multimedia developed effectively increased students' understanding of the basic concepts of engineering drawings. The use of interactive multimedia could improve students' motivation and independence in learning, thus increasing their understanding of the Engineering Drawing course concepts.

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Keywords: *development, interactive multimedia, understanding of concept, engineering drawings*.

ABSTRAK

Gambar Teknik merupakan salah satu matakuliah wajib yang diajarkan dalam jurusan Teknik Mesin di Indonesia. Matakuliah ini bertujuan untuk membekali mahasiswa dengan pemahaman dan keterampilan dasar dalam menggambar. Tujuan penelitian ini adalah mengembangkan media pembelajaran dalam bentuk multimedia interaktif mengetahui tingkat kelayakan multimedia yang dihasilkan, dan menguji efektivitas multimedia dalam meningkatkan pemahaman konsep dasar mahasiswa tentang gambar teknik. Untuk itu, penelitian ini menggunakan desain R&D dengan model 4D untuk menghasilkan dan menguji efektivitas produk multimedia. Uji validitas produk dilakukan oleh 2 orang ahli masing-masing sebagai ahli materi dan ahli media. Sedangkan untuk uji efektivitas, desain penelitian One group pretes-posttest dilakukan dengan melibatkan 28 orang mahasiswa program studi Pendidikan Teknik Mesin di Universitas Pendidikan Ganesha Bali, Indonesia. Hasil penelitian menunjukkan bahwa ahli materi dan ahli media setuju bahwa multimedia hasil pengembangan ini layak digunakan sebagai bahan ajar dalam proses perkuliahan. Selain itu, uji efektivitas juga menunjukkan bahwa multimedia ini efektif dalam meningkatkan pemahaman konsep dasar mahasiswa tentang gambar teknik. Penggunaan multimedia yang interaktif dapat meningkatkan motivasi dan kemandirian belajar mahasiswa, dengan begitu pemahaman konsep mereka terhadap suatu materi juga akan meningkat.

Kata kunci: *pengembangan; multimedia interaktif; pemahaman konsep; gambar teknik.*

1. INTRODUCTION:

Engineering Drawing is a compulsory course in the mechanical engineering study program in Indonesia. In general, it discusses the procedures for drawings under the ISO standards, including basic rules in drawing, reading, and interpreting images (Narayana *et al*., 2006). For engineering graduates, the ability to read engineering drawings is the most important requirement in any profession (Reddy, 2008). This is because such a kind of drawing serves as a communication language to express ideas in the form of images to be easily understood even though the real objects have not been existed or have never been made yet.

Engineering Drawing course that is commonly applied generally gives students less opportunity to understand and master the basic engineering drawing concepts. In this course, students' understanding of the concept of engineering drawing is one of the essential aspects they must master to have good skills in drawing (Narayana, 2006; Rohman *et al*., 2019; Białkiewicz, 2019; Żychowska, 2019). Learning patterns with project-based approaches require them to have more psychomotor than cognitive skills (Prasetya, *et al*., 2019). As a result, students will experience difficulties developing basic thinking patterns towards the higher ones in engineering images.

The constructivist approach is widely applied in the current learning process (Juanda, 2011). In constructivist theory, learning is the result of students' construction and interaction with their learning environment. Direct experience can provide higher memory effectiveness, compared to what is provided by indirect experience (Khaidir, 2016). Thus, the more concrete the lesson material the students learn, the more the experience they get; the more abstract what they study, the less the background they get.

Success in the learning process significantly determines the same in achieving educational goals (Setiawan *et al*., 2018). Engaging learning can give an impression and direct experience to students and motivate them to learn specific material. Miarso (2004), Sulistianingsih, and Carina (2019) also stated that a way to support the success of the learning process is developing multimedia utilizable to support learning activities in the classroom.

Practical and innovative learning media can be one of the main factors in successfully achieving learning goals (Nopriyanti and Sudira, 2015; Setiawan *et al*., 2018; Diner *et al*., 2020; Yulianti *et al*., 2020; Widodo, *et al*., 2020). Entering the digital era and the rapid development of information and communication technology (ICT) as it is today, the use of instructional media in the form of multimedia is becoming more innovative (Mayer, 2001; Prasetya, *et al*., 2018; Sukenda, *et al*., 2019). Simply put, multimedia can be interpreted as a combination of several medium such as texts, images, videos, and audio presented in an integrated way (Zhen, 2016). Rohman *et al*. (2019) and Samat and Aziz (2020) stated that multimedia learning is a combination of texts, images, graphics, sound, and video in an integrated way to improve the quality of learning in

the classroom.

Various studies showed that interactive multimedia used effectively could improve the quality of learning and student learning outcomes (Juanda, 2011; Husein *et al*., 2015; Ramli *et al*., 2019; Gunawan *et al*., 2020; Samat and Aziz, 2020). It also allows students to improve their ability to think, problem-solving, create, and construct the knowledge they have (Zheng and Zou, 2006; Rohman *et al*., 2019). In general, the benefits that can be obtained through the use of interactive multimedia are the learning process can run more interesting, more interactive, and more efficient in term of time spending (Husein *et al*., 2015; Zhen, 2016; Saprudin and Hamid, 2018; Rohman 2020; Imansari *et al*., 2020).

Research conducted by Sutarno and Desi (2012); Zainuddin *et al*., (2018); Adhitama *et al*., (2018); Ayob and Adnan (2019) found that the increase in mastery of the concept of students who took part in interactive multimedia-aided learning was significantly higher compared to students who took part in learning with conventional media. Furthermore, research conducted by Zheng and Zou (2006) and Gunawan (2011) also shows that the utilization of interactive multimedia has also been shown to increase the ability of students to draw conclusions and solve problems.

Observations made by researchers on the implementation of engineering drawing learning gained several results, including (1) student learning outcomes in engineering drawing subjects had not yet optimal; (2) most of the students still had difficulty in understanding basic concepts and material of engineering drawing; (3) the learning methods used were less appropriate and tended to use the assignment- or project-centered learning approach; (4) the way on which the material delivered still used the teacher-centered learning approach; and (5) no interactive multimedia was available in engineering drawing learning process.

The description above indicates that the limitations in the delivery of the material, less appropriate learning methods and less exciting learning media caused the students to lack understanding of the concepts and the material being studied. Therefore, this research aimed to (1) develop learning multimedia for engineering drawing course; (2) determine the feasibility of the multimedia products produced; and (3) test the effectiveness of the product in improving the students' ability to understand concepts in the Engineering Drawing course.

2. MATERIALS AND METHODS:

This research took place in the Mechanical Engineering Education study program, Faculty of Engineering and Vocations, Ganesha University of Education, Bali, Indonesia, as an R&D study with the 4D model (Thiagarajan *et al*., 1974). It was chosed the 4D development model for being widely used in learning media for educational purposes. This research aimed to develop interactive multimedia to be more feasible and sufficient to support Engineering Drawing lectures. There are 4 main stages in the 4D development model, namely Define, Design, Develop, and Disseminate. Figure 1 shows the development flow using the 4D model.

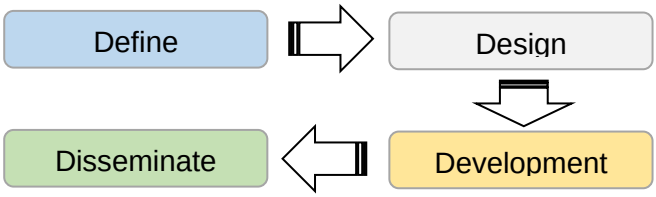

***Figure 1**. Flowchart of the 4D Model Development*

The first stage, Define, aims to identify problems and analyze curriculum, student characteristics, concepts/ learning materials, and media. The second stage, Design, is for making learning designs and multimedia designs to be developed. The third stage, namely development, aims to arrange the initial form (prototype) of products. Researchers in this third stage also need to conduct validation tests, trials, and product revisions. The fourth stage, the last, namely Disseminate, means the distribution and implementation of multimedia products in groups of students to support learning in the Engineering Drawing course.

The instruments used to collect data were questionnaires and tests. The questionnaires were used to determine the feasibility level of the resulting multimedia. In this study, the questionnaires consisted of 2 types: a questionnaire filled out by a material expert and the other by a media expert. The test instrument is used to test the effectiveness of using multimedia in improving student understanding of concepts. This test consisted of 20 multiple choice questions and 2 essay questions that must be done by students (Appendix 1).

The data obtained were then analyzed in the form of descriptive and inferential analyses. Descriptive analysis is used to describe the results

of the validation of the feasibility of multimedia products by a material expert and a media expert so that it can be seen as the eligibility level of the resulting multimedia. A material expert is someone who is an expert in the field of engineering drawing. The material expert in this study acted as a validator regarding the learning media content being developed. A media expert is someone who is an expert and has experience in the field of learning media. The media expert in this study acted as a validator of the media being developed. The two experts who worked as multimedia validators in this study were senior lecturers at Universitas Pendidikan Ganesha, Bali, Indonesia. Meanwhile, the inferential analysis was used to determine the effectiveness of using multimedia in improving students' understanding of concepts in the engineering drawing course before and after using multimedia (pretest-posttest).

Table 1 shows the eligibility criteria of multimedia, as determined by the material expert and the media expert:

***Table 1**. Product Eligibility Criteria*

Average	Category
3.26 – 4.00	Eligible
2.51 – 3.25	Somewhat eligible
1.76 – 2.50	Less eligible
1.00 – 1.75	Not eligible

Adapted from Arikunto (2002)

The students involved in this research were those from the Department of Mechanical Engineering Education, Universitas Pendidikan Ganesha, Bali, Indonesia. A total of 28 students, all male with ages ranging from 19 to 21 years and currently taking Engineering Drawing courses, were taken as the study sample. The involvement of these students was through their consent to be involved in research and data collection as scientific purposes. Besides, researchers have also obtained permission from teaching lecturers and the Department of Mechanical Mechanical Engineering Education at Universitas Pendidikan Ganesha, Bali, Indonesia. The involvement of the 28 students in this study was conducted to test the effectiveness of the multimedia products being developed. Therefore, after knowing the feasibility level of the product, a pretest-posttest one-group research design was carried out.

A one-group pretest-posttest design was conducted to determine the effectiveness of multimedia in improving students' understanding of the Engineering Drawing course concept.

O_1	X	O_2

(Source: Sugiyono, 2011)

Notes:

O_1: Pretest (before using interactive multimedia)
X: Interactive multimedia utilization
O_2: Posttest (after using interactive multimedia).

3. RESULTS AND DISCUSSION:

The process of developing multimedia products is carried out in 4 stages according to the 4 D development model, namely: Define, Design, Development, and Disseminate as follows:

3.1 Define

The defined step aims to analyze the needs in the engineering drawing course. The results of the needs analysis conducted in this study indicate that there were problems in learning Engineering Drawing, including 1) this course was quite challenging to understand by most students. This difficulty could be seen from (1) the low level of their understanding; (2) the use of learning media was still rare and also less uniform between one student and another, and; (3) students' low interest in reading or student motivation. Some of these problems, of course, caused the learning process could not be optimized. Thus, the development of learning media in interactive multimedia became one solution to the problem.

3.2 Design

The Design stage is carried out to design the development of textbooks that will be developed. Therefore, this stage is carried out by formulating the main ideas and designs in multimedia development for the engineering drawing course. The multimedia design that will be developed in this study can be seen in Figure 2.

3.3 Development

The product generated in this research was multimedia, in the form of interactive digital books. It was created in .exe format using the help of Flipbook Maker software. It was then packaged into a digital book that combined various kinds of contents such as texts, images, graphics, animations, audios, and videos. This digital book could be opened or run on a computer or laptop. It was quite easy to use by students without having special training. Its presence could increase students' interest in reading or motivate them to learn the Engineering Drawing course.

As an illustration, Figure 3 shows the

resulting multimedia display. This multimedia was more interesting because of the flip effect on the e-book when moving between pages. On the other hand, interactive effects could be seen with audios and videos in the e-book to support the delivery of material to students. The use of multimedia was not too difficult because of the navigation buttons provided, such as bookmarks, zoom-in, zoom-out, search, and others that could facilitate the readers.

This developed multimedia also goes through a validation test conducted by the material expert and the media expert in its development. This was done to determine the eligibility of multimedia before used as a learning medium by students. Table 2 and Table 3 below show the results of validation tests by material experts as well as media experts.

***Table 2**. Validation by material expert*

Scoring aspects	Score	Category
Content completeness	3.65	Eligible
Conformity between material and learning objectives	3.47	Eligible
Systematic delivery of material	3.56	Eligible
Average	3,56	Eligible

***Table 3**. Validation by media expert*

Scoring aspect	Score	Category
Multimedia display	3,78	Eligible
Use of language	3,60	Eligible
Interactive effect	3,66	Eligible
Average	3,68	Eligible

Validation conducted by the material expert showed that the developed multimedia was categorized as eligible with an average score of 3.56 (see Table 2). However, there were also some notes to improve the product. The material expert, to improve the product, suggested the addition of material to various lines, question exercises at the end of the chapter, and discussion on the chapter of Intersection.

Based on the assessment, the media expert said that multimedia was in the category of eligible with an average score of 3.68 (see Table 3). However, the video content was found to be incomplete, and some texts were overly large, thus need the addition of more content and the adjustment of the text size.

The development of interactive multimedia is an effort to optimize the role and function of information and computer technology (ICT) in the learning process (Elfeky and Masadeh, 2016; Rohman *et al*., 2019; Syawaludin, *et al.,* 2019). In ICT-based learning, the learning process carried out by lecturers and students can be more accessible, more practical, and also efficient. Therefore, students can maximize their learning outcomes.

The step next to the validation test and the product revision tested the effectiveness of the multimedia to improve students' conceptualization of engineering drawings. For this reason, a one-group pretest-posttest design with a *t*-test analysis was carried out. Table 4 and Figure 4 shows the results of the pretest and posttest conducted on 28 students.

The pretest and posttest scores above provide some descriptions, as shown in Table 5:

***Table 5**. Data description*

Score	Range	Min.	Max.	Mean	SD
Pretest	30	40	70	54.54	6.9
Posttest	12	76	88	82.75	3.1

Notes: Range: Difference between the maximum and the minimum scores; Min: Minimum score; Max: Maximum score; Mean: Mean score; SD: Standard Deviation

Furthermore, before *t*-test analysis, a normality test was needed to see whether the pretest and posttest scores were normally distributed. The data normality test in this study was carried out by Shapiro-Wilk analysis. Table 6 shows the results of the test with the help of SPSS 22.0.

Based on Table 6, the pretest and posttest data obtained Shapiro-Wilk values of 0.934 and 0.938, respectively, with sig. values of 0.077 and 0.099, respectively. Because the two sig values were greater than 0.05, it could be concluded that the data of the two data were normally distributed.

After the data was normally distributed, hypothesis testing was performed to see whether there was a significant difference between the pretest and posttest scores (before and after the use of interactive multimedia). In this study, hypothesis testing was done using the paired sample *t*-test, the results of which can be seen in

Table 7.

Table 7 shows that the value of sig. was 0.00, lower than 0.05. Thus, it could be observed that there was a significant difference between the pretest and posttest scores, indicating that the use of interactive multimedia in the learning process of Engineering Drawing could improve students' understanding of the concepts of the lecture materials.

This developed multimedia was in an interactive digital form used in the Engineering drawing course. It was made using Flipbook Maker software and packaged in soft files that could be run on computers or laptops. This interactive multimedia development followed the 4D model development path consisting of four main steps: Define, Design, Development, and Disseminate.

The resulting multimedia has been tested through a validation test and a trial to determine its eligibility and effectiveness. Based on the results, both material and media experts declared that it was categorized as eligible and offered some notes or revisions for its improvement. Besides, to determine its effectiveness in improving students' understanding of concepts, one-group pretest-posttest design was conducted on 28 students. The results showed a sig value of 0.000, less than 0.05, meaning that interactive multimedia was effective or had a significant effect on the student test scores (*pretest-posttest*).

There is an increase in student learning outcomes after using interactive multimedia, indicating that the use of interactive multimedia has a significant effect on student understanding of concepts in engineering drawing courses. The use of interactive multimedia allows students to study independently and adequately, the material they need both at home and on campus (Mayer, 2001; McLain, 2018; Adhitama, *et al*., 2018; Imansari, *et al*., 2020).

The use of interactive multimedia helps students to receive or understand the material presented (Munir, 2013; Sudarman *et al*., 2019; Rohman *et al*., 2019; Samat and Aziz, 2020; Widodo, *et al*., 2020). Interactive learning media supported by a variety of contents such as images, graphics, audio, and videos will make abstract materials clearer (Hwang, *et al*., 2018; Ramli *et al*., 2019; Diner *et al*., 2020, Imansari *et al*., 2020), thus increasing students' interest in reading and learning independently. The learning process with the help of interactive multimedia will enhance students' understanding of the materials being studied.

3.4 Disseminate

Based on the feasibility and effectiveness test, it is known that the multimedia product developed has a decent category and is also useful in improving students' conceptual understanding in the engineering drawing course. Thus, this interactive multimedia can be disseminated for broader use among students, especially in the Department of Mechanical Engineering Education, Ganesha University of Education, Bali, Indonesia.

4. CONCLUSIONS:

1. The results of validation tests by the material expert and the media expert showed that the resulting multimedia products were categorized as feasible. From the material aspect, the product feasibility level got a value of 3.56, and from the media, aspect got 3.68.
2. The effectiveness test, involving 28 students, showed that interactive multimedia effectively improved students' understanding of concepts in engineering drawing courses. This can be seen from the *t*-test analysis (paired sample *t*-test) with the Sig. 0.000 which indicated that there was a significant increase in student pretest and posttest scores before and after the use of interactive multimedia.
3. The findings in this study indicated that information and communication technology could help the learning process become easier. The use of multimedia in learning provides students with opportunities to play a more active role and provide more meaningful learning experiences. Therefore, as educators, lecturers are required to be able to provide innovative learning media for students.

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6. REFERENCES:

1. Adhitama, Sujadi and Pramudya. (2018). Discover the pythagorean theorem using interactive multimedia learning. *Journal of*

Physics: Conf. Series 1008, 1-8.

2. Arikunto, S. (2002). Prosedur Penelitian: Suatu Pendekatan Praktik. Jakarta: Rineka Cipta.
3. Ayob, A. and Adnan, N.S. (2019). The Effects of Virtual Text and Graphic Integration Based on Interactive Multimedia Towards Students' Achievement in Summary Writing. *International Journal of Innovation, Creativity and Change*, 8(4), 328-338.
4. Białkiewicz, A. (2019). Propaedeutics of teaching drawing to architects. *Global Journal of Engineering Education*, 21(2), 115-120.
5. Diner, L., Utami, S. E., Kurniati, E., and Widayanti, M. J. A. (2020). Efforts to Increase Listening Ability Through Interactive Multimedia on Dokkai Learning in Japanese Language Education Program of UNNES. *International Journal of Innovation, Creativity and Change*, 10(12), 69-84.
6. Elfeky, A.I.M. and Masadeh, T.S.Y, (2016). The effect of mobile learning on student's achievement and conversational skills. *International Journal of Higher Education*, 5, 20-31.
7. Gunawan, Mashami, R. A., and Herayanti, L. (2020). Gender Description on Problem-Solving Skills in Chemistry Learning Using Interactive Multimedia. *Journal for the Education of Gifted Young*, 8(1), 571-589.
8. Gunawan. (2012). Penggunaan Simulasi Interaktif untuk Meningkatkan Penguasaan Konsep Mahasiswa pada Konsep Mekanika. *Jurnal Kependidikan*, 2(1), 25-30.
9. Husein, S., Herayanti, L.,, Gunawan. (2015). Pengaruh Penggunaan Multimedia Interaktif Terhadap Penguasaan Konsep dan Keterampilan Berpikir Kritis Siswa pada Materi Suhu dan Kalor. *Jurnal Pendidikan Fisika dan Teknologi,* 1(3), 221-225.
10. Hwang, G.-J., Tu, N.-T., and Wang, X.-M. (2018). Creating Interactive E-Books through Learning by Design: The Impacts of Guided Peer-Feedback on Students' Learning Achievements and Project Outcomes in Science Courses. *Educational Technology and Society*, 21 (1), 25–36.
11. Imansari, N., Dalu, Z. C. A., Sulistianingsih and Ratnawati, D. (2020). Multimedia-Based Teaching Materials at College Level: Expert and Student Assessment. *Talent Development and Excellence,*12(2s), 3660-3669.
12. Juanda, E. A. (2011). Media Pembelajaran Berbasis Multimedia Interaktif Untuk Meningkatkan Pemahaman Dasar-Dasar Mikrokontroler. *Jurnal Ilmu Pendidikan*, 17, (6), 439-444.
13. Khaidir, C. (2016). Development of Constructivism-Based Numerical Method Textbook at IAIN Batusangkar. *Ta'dib*, 19(1), 67-82.
14. Mayer, R. E. (2001). *Multimedia learning*. New York: Cambridge University Press.
15. McLain, T. R. (2018). Integration of the Video Response App Flip Grid in the Business Writing Classroom. *International Journal of Educational Technology and Learning,* 4(2), 68-75.
16. Miarso, Y. (2004). *Menyemai Benih Teknologi Pendidikan*. Kencana.
17. Munir. (2013). *Multimedia: Konsep dan Aplikasi dalam Pendidikan.* Bandung: Alfabeta.
18. Narayana, K.L., Kannaiah, P., Reddy, K.V. (2006). *Machine Drawing: Third Edition*. New Delhi: New Age International (P) Ltd.
19. Nopriyanti and Sudira, P. (2015). Pengembangan Multimedia Pembelajaran Interaktif Kompetensi Dasar Pemasangan Sistem Penerangan dan Wiring Kelistrikan di SMK. *Jurnal Pendidikan Vokasi,* 5(2), 222-235.
20. Prasetya, D.Y., Suparmin and Johan, A.B. (2019). Application of project based learning learning models to improve student learning results techniques of manufacturing images of vocational school students. *Jurnal Taman Vokasi*, 7(1), 82-84.
21. Prasetya, D.D., Wibawa, A.P. and Hirashima, T. (2018). An Interactive Digital Book for Engineering Education Students. *World Transactions on Engineering and Technology Education*, 16 (1), 54-59.
22. Ramli, H., Said, T. S., Hazman, M. N. B., Malek, S. N. A. and Hussin, R. (2019). The Development and Evaluation of an Interactive Multimedia Module for the Topic of Art Elements of the Visual Art Education Subject. *International Journal of Innovation, Creativity and Change*, 10(6), 246-258.
23. Reddy, K. V. (2008). Textbook of Engineering Drawing: Second Edition. BS Publications.
24. Rohman, M. (2020). Analisis Motivasi Belajar Mahasiswa pada Pembelajaran Gambar

Teknik Berbasis Multimedia. *Jupiter (Jurnal Pendidikan Teknik Elektro),* 5 (1), 8-13.

25. Rohman, M., Sudjimat, D.A., Sugandi, M. and Nurhadi, D. (2019). Developing an Interactive Digital Book to Improve the Technical Drawing Abilities of Mechanical Engineering Students. *Global Journal of Engineering Education,* 21(3), 239-244.
26. Samat, M.S. and Aziz, A.b.A. (2020). Indigenous Student's Perception of Multimedia Learning as an Approach for Enhancing Reading Comprehension Skills. *Open Journal of Science and Technology,* 3(1), 8-16.
27. Saprudin and Hamid, F. (2018). Efektivitas Penggunaan Multimedia Interaktif Materi Kalor Berorientasi Peta Kompetensi Siswa Sekolah Menengah Atas. *Titian Ilmu: Jurnal Ilmiah Multi Sciences*, 10(1), 29-38.
28. Setiawan, D. A., Wahjoedi and Towaf, S. M. (2018). Multimedia Interaktif Buku Digital 3D pada Materi IPS Kelas IV Sekolah Dasar. *Jurnal Pendidikan: Teori, Penelitian dan Pengembangan,* 3(9), 1133-1141.
29. Sudarman, Riyadi, R. and Astuti, R. F. (2019). Development of Interactive Learning Multimedia to Increase Understanding of Basic Skills Teaching Procedures. *Advances in Social Science, Education and Humanities Research, vol. 432,* 132-136.
30. Sugiyono. (2011). *Metode Penelitian Kualitatif Kuantitatif dan R&D*. Bandung: Alfabeta.
31. Sukenda, Anjani, M. and Yustim, B. (2019). Learning Media for Biology Subject Based on Multimedia in Junior High School Level. *Universal Journal of Educational Research* 7(4A), 43-51.
32. Sulistianingsih, A.S. and Carina, A. (2019). Developing Interactive E-book as Material Technology Coursebook by Flipbook Maker Software. *Journal of Education and Practice,* 10(24), 11-17.
33. Sutarno and Desi. (2011). The Use of Interactive Multimedia in Magnetic Field Learning to Improve Students' Generic Science Thinking Skills. *Journal Exacta,* 9(1), 60- 66.
34. Syawaludin, A., Gunarhadi and Rintayanti, P. (2019). Enhancing Elementary School Students' Abstract Reasoning In Science Learning Through Augmented Reality-Based Interactive Multimedia. *Jurnal Pendidikan IPA Indonesia*, 8(2), 289-298.
35. Thiagarajan, S., Semmel, D.S and Semmel, M.I. (1974). *Instructional Development for Training Teachers of Exceptional Children: a Sourcebook*. Washington D.C.: National Center for Improvement of Educational System.
36. Widodo, W., Sudibyo, E., Suryanti, Sari, D.A.P., Inzanah and Setiawan, B. (2020). The Effectiveness of Gadget-Based Interactive Multimedia in Improving Generation Z's Scientific Literacy. *Jurnal Pendidikan IPA Indonesia,* 9(2), 248-256.
37. Yulianti, D., Wiyanto, Rusilowati, A. and Nugroho, S. E. (2020). Development of Physics Learning Teaching Materials Based on Science Technology Engineering and Mathematics to Develop 21st Century Learning Skills, *Periódico Tchê Química*, vol. 34, 711-717.
38. Zainuddin, Hasanah, A.R., Salam, M. A., Misbah and Mahtari, S. (2019). Developing the interactive multimedia in physics learning. *Journal of Physics: Conf. Series 1171,* 1-5.
39. Zhen, Z. (2016). The Use of Multimedia in English Teaching. *US-China Foreign Language*, 14(3), 182–189.
40. Zheng, R. and Zhou, B. (2006). Recency Effect on Problem Solving in Interactive
41. Multimedia Learning. *Educational Technology and Society*, 9 (2), 107-118.
42. Żychowska, M.J. (2019). Teaching Drawing to a New Generation of Engineers Architects. *World Transactions on Engineering and Technology Education*, 17 (1), 60-65.

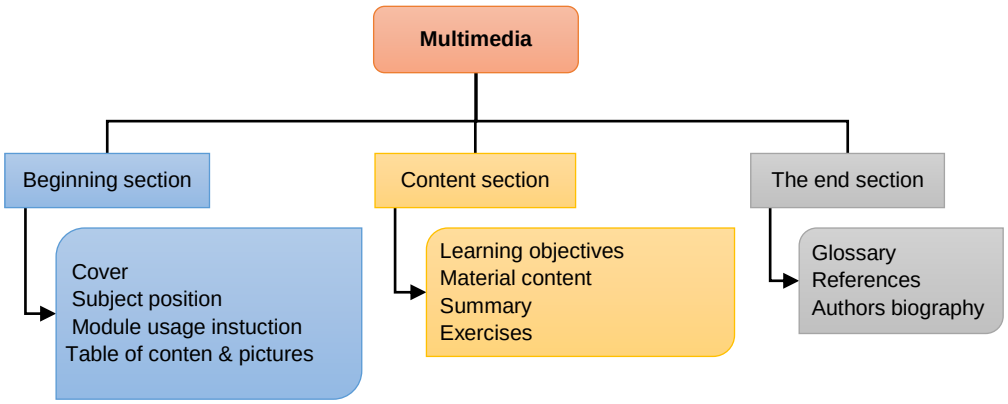
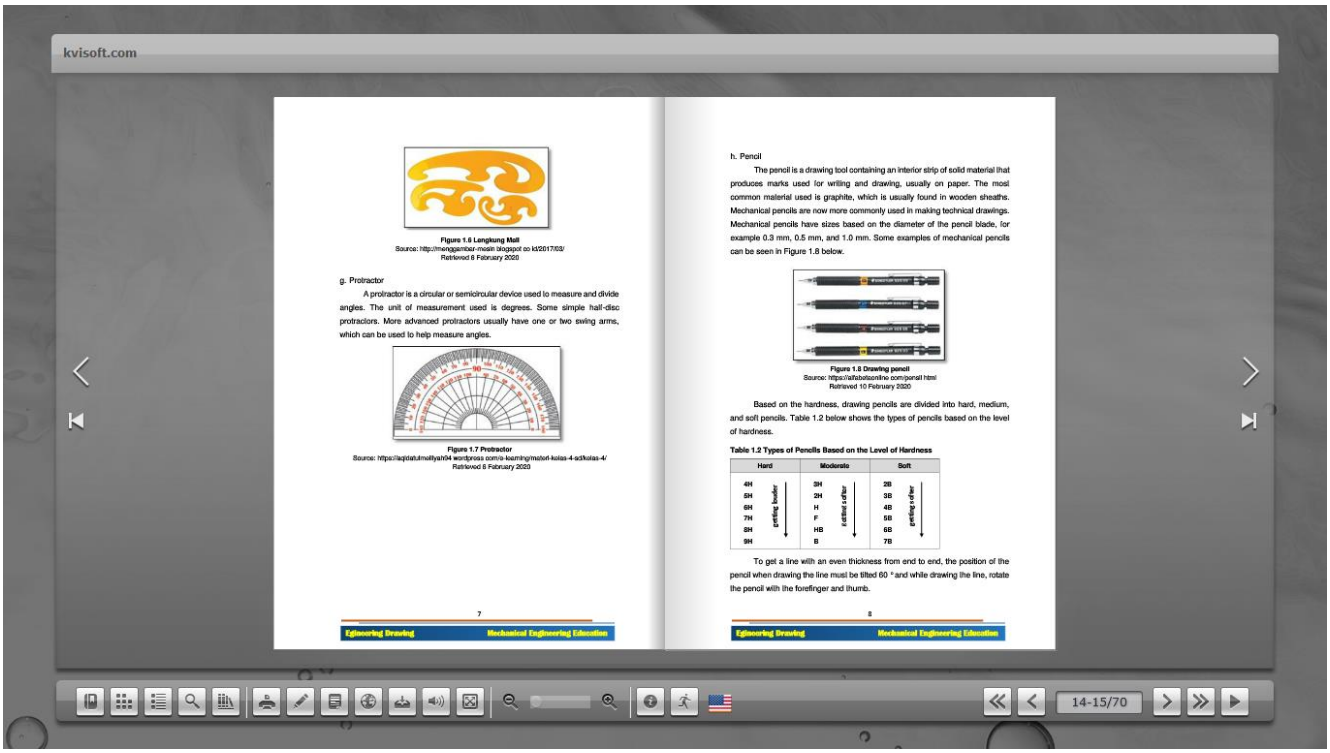


Figure 2. *The developed multimedia design*



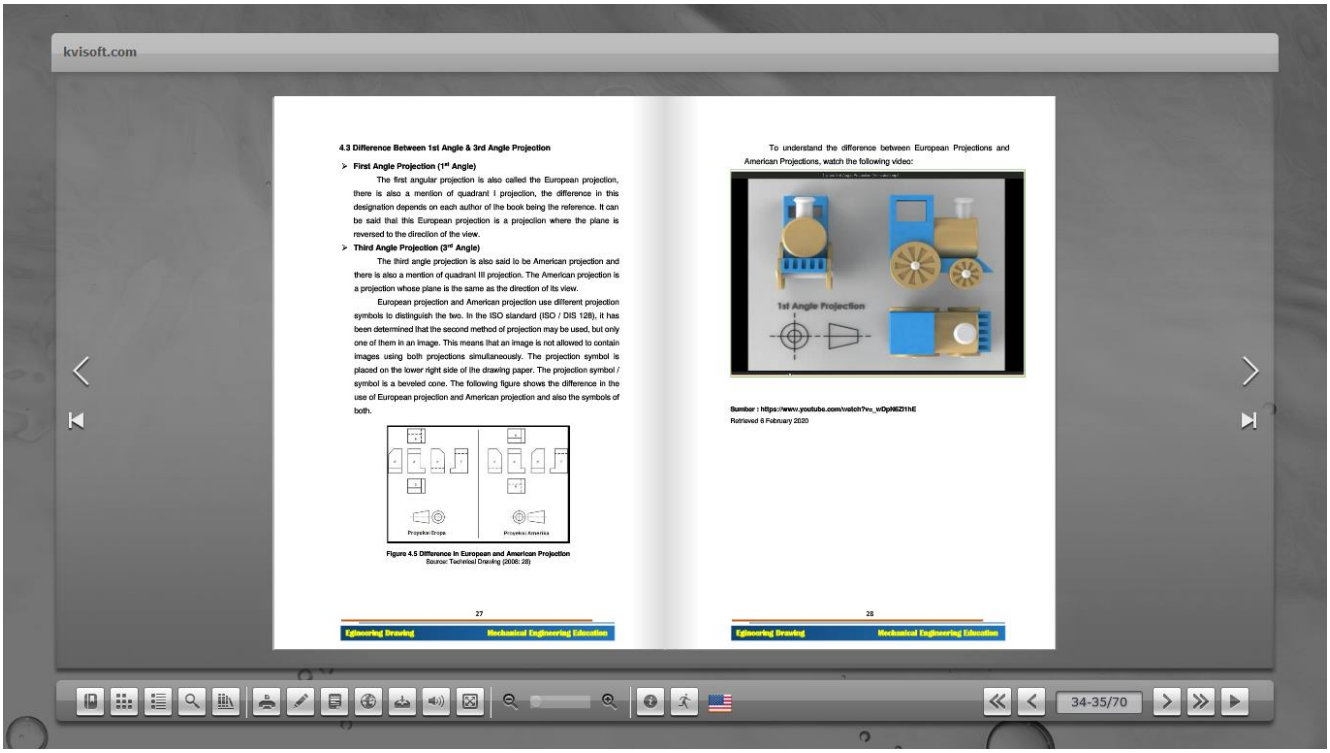


Figure 3. *The developed multimedia displays.*

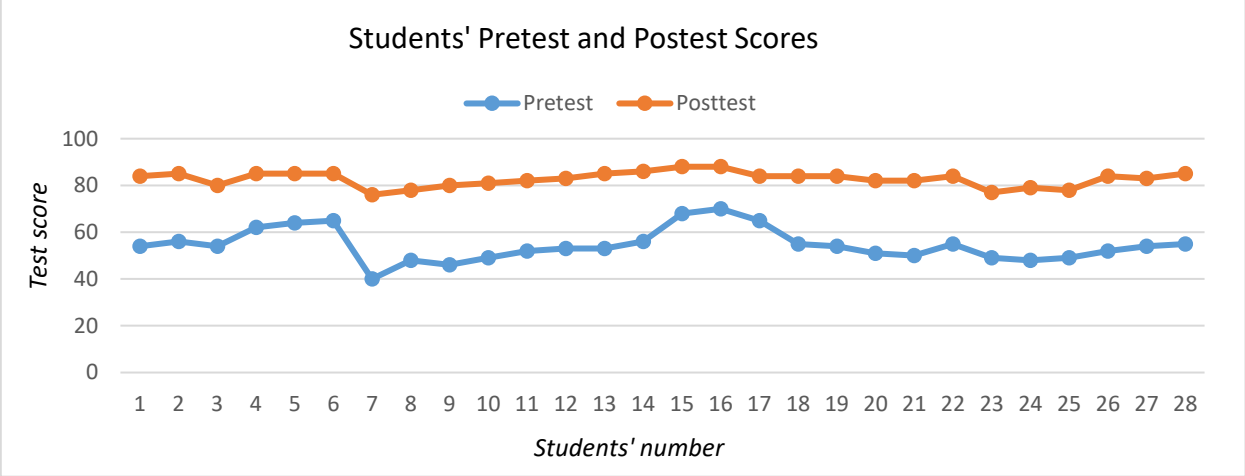


Figure 4. *Chart of students' pretest and posttest scores*

Table 4. *Students' pretest and posttest results*

No	Pretest	Posttest	No	Pretest	Posttest
1	54	84	15	68	88
2	56	85	16	70	88
3	54	80	17	65	84
4	62	85	18	55	84
5	64	85	19	54	84
6	65	85	20	51	82
7	40	76	21	50	82
8	48	78	22	55	84
9	46	80	23	49	77
10	49	81	24	48	79
11	52	82	25	49	78
12	53	83	26	52	84
13	53	85	27	54	83
14	56	86	28	55	85

Table 6. *Results of the normality test of pretest and posttest data*

Test of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Score	Statistic	df	Sig.	Statistic	df	Sig.
Learning_outcome	Pretest	.202	28	.005	.934	28	.077
	Posttest	.191	28	.010	.938	28	.099

Notes: df: the degree of freedom; Sig.: Significance; a. Lilliefors Significance Correction

Table 7. *Results of the paired sample* t*-test*

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest - Posttest	-28.214	4.717	.891	-30.043	-26.385	-31.652	27	.000

Notes: Std. Deviation: Standard Deviation; df: the degree of freedom; Sig.: Significance

APPENDIX 1

Validating questionnaire

VALIDATION SHEET FOR MATERIAL EXPERT

No.	Assessment Aspects	Scoring scale			
		4	3	2	1
A.	**Content completeness**				
1.	The depth level of discussion of material in multimedia has met the demands of the curriculum				
2.	The completeness of the material is following the level of student development				
3.	The content of the material has presented the competencies that students must master				
B.	**Conformity between material and learning objectives**				
4.	The packaging of material in multimedia has been following the scientific approach in the field of mechanical engineering				
5.	The material in the multimedia has been presented coherently and correctly				
6.	The contents of the material in multimedia can help students achieve learning goals				
C.	**Systematic delivery of material**				
7.	The development of material in multimedia has referred to the mechanical engineering study program curriculum				
8.	Presentation of material has been carried out systematically to achieve learning objectives				
9.	Presentation of the material has been done in a way that is easy for students to understand				
	TOTAL SCORE				

Suggestions for Improvement and Conclusions

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Bali, ……. 2019
Material expert

(_____)

VALIDATION SHEET FOR MEDIA EXPERT

No.	Assessment Aspects	Scoring scale			
		4	3	2	1
A. Multimedia display					
1.	The use of fonts and colors in multimedia has attracted the attention of students				
2.	The media design is following the material in the engineering field				
3.	Images in multimedia can be seen clearly				
B. Use of language					
4.	The use of language in multimedia is clear and easily understood by students				
5.	The language used is following the student's level of thinking				
6.	The language used has stimulated student curiosity and motivation to learn the content				
C. Interactive effect					
7.	Multimedia is easy to operate by students				
8.	The interactive effect of the flip on multimedia can attract students' attention and increase their learning motivation				
9.	Additional audio and video in multimedia is presented in good quality				
	TOTAL SCORE				

Suggestions for Improvement and Conclusions

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Bali, ……. 2019
Media expert

(_____)

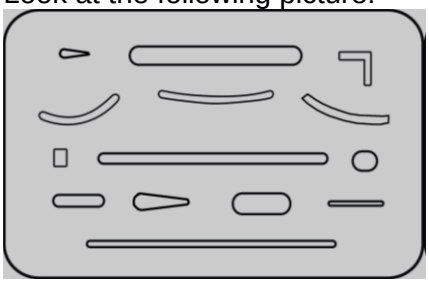
Student Test Instruments

Choose the correct answer!

1. Conveying the intentions of the designer appropriately to other parties in terms of process planning, manufacturing, inspection, and product / component assembly, is a function of engineering drawings as ....
   A. storage
   B. delivery of idea
   C. delivery of information
   D. development

2. A uniformity that has been mutually agreed with the aim of avoiding misunderstanding in technical communication is called ....
   A. image size
   B. standardization of engineering drawings
   C. Image etiquette
   D. engineering drawing projection

3. Look at the following picture!



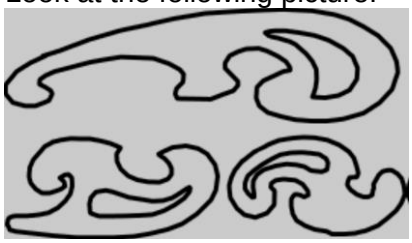
   The function of the drawing equipment is ....
   A. to make a curved line or semicircle
   B. to make a straight line on the drawing paper
   C. to create work symbols on working drawings
   D. to make the image to be deleted precisely and not to remove another image

4. The A4 drawing paper size according to the ISO system is ....
   A. 297 x 210 mm
   B. 277 x 210 mm
   C. 397 x 210 mm
   D. 420 x 297 mm

5. The A3 drawing paper size according to the ISO system is ....
   A. 287 x 210 mm
   B. 277 x 210 mm
   C. 594 x 420 mm
   D. 420 x 297 mm

6. The left side of the border for all sizes of drawing papers according to the ISO system is ....
   A. 10 mm
   B. 15 mm
   C. 20 mm
   D. 30 mm

7. Look at the following picture!



   The function of the drawing equipment above is ....
   A. to make straight lines on the drawing paper
   B. to create curved lines that couldn't be drawn with a compass
   C. to create work symbols on working drawings
   D. to make the image to be deleted precisely and not to remove another image

8. The number before the letter on a 2B pencil indicates the level of ....
   A. hardness
   B. accuracy
   C. softness
   D. thickness

9. The number before the letter on a 2H pencil indicates the level of ....
   A. accuracy
   B. coloring
   C. hardness
   D. thickness

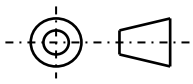
10. To describe the workpiece axis, the line type used is.....
    A. thick line
    B. real/continuous line
    C. thin etched lines
    D. double etched line

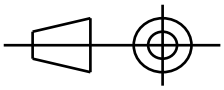
11. To describe the measuring line of an object, the type of line used is.....
    A. thick line
    B. real/continuous line
    C. continuous thin line
    D. double etched line

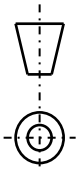
12. Image headers or etiquettes are usually placed on ....
    A. bottom right side
    B. bottom left side
    C. upper left side
    D. center right side

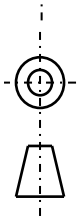
13. The following are included in the etiquette, except....
    A. the name of the drawer
    B. line thickness
    C. image title
    D. the name of institution

14. The European projection symbol is indicated by the following figure ....

    A. 

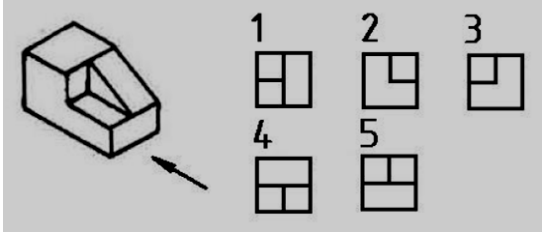
    B. 

    C. 

    D. 

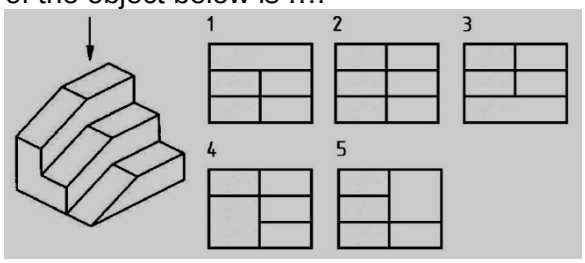
15. If A4 paper size is 210 x 297 mm, then A2 paper size is ….
    A. 297 x 420 mm
    B. 420 x 594 mm
    C. 420 x 841 mm
    D. 595 x 841 mm

16. Look at the following picture! The correct front view of the object from the arrow direction is ….



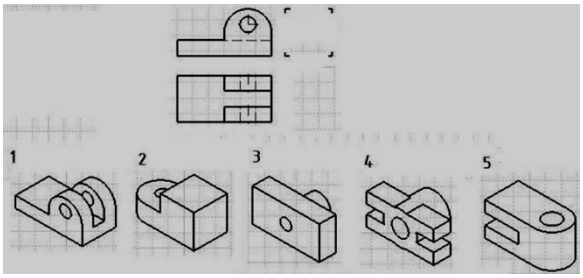
    A. 1
    B. 2
    C. 4
    D. 5

17. Look at the following picture. The top view of the object below is ….



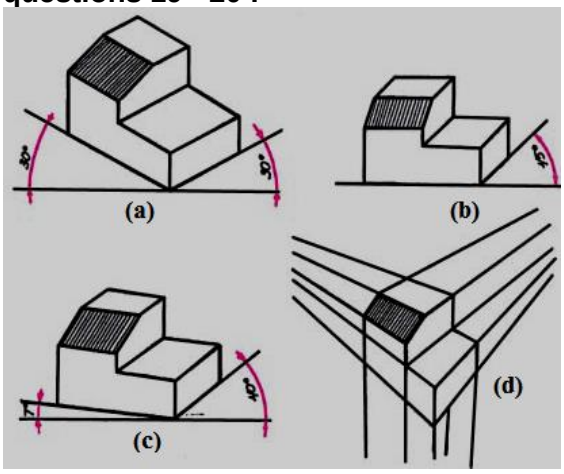
    A. 1
    B. 2
    C. 3
    D. 4

18. The correct 3D image from the 2D image below is ….



    A. 1
    B. 2
    C. 3
    D. 4

Look at the picture below to answer the questions 19 - 20 !

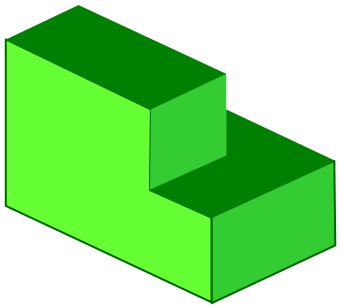


19. Figure (a) is a type of projection, namely....
    A. perspective
    B. isometric
    C. dimetric
    D. oblique

20. Figure (b) is a type of projection, namely....
    A. perspective
    B. isometric
    C. oblique
    D. orthogonal

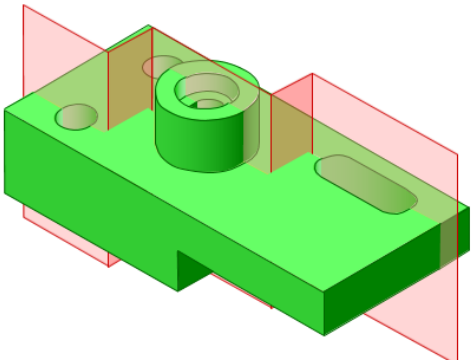
Student worksheets:

1. Look at the following 3-dimensional object!



Make a projection image of the object that shows top, front, and side views!

2. Look at the following object!



Make a projected image of the cut object above, showing the top-front views!