

Development of E-Module for Construction Management Application Course Based on Building Information Modeling

Anisah, M. Agphin Ramadhan*, Syadila Nur Haniyyah

Building Engineering Education departement, Universitas Negeri Jakarta, 13220, Indonesia

Email: agphin@unj.ac.id

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Abstract

The rapid demands of technological development in the construction world require competent and skilled human resources to operate BIM-based software. One of the university's efforts to address this is by adopting Building Information Modeling in one of the lecture teaching materials, one of which is the Construction Management Application Course. The research and development aim to produce e-modules Building Information Modeling-Based Construction Management Application Course at the Building Engineering Education Study Program, Universitas Negeri Jakarta. The method used in this study is the Research and Development by using a 4D model. The 4D model consists of 4 systematic stages: define, design, development and Dissemination. Based on the validation results, the developed e-modules fall into the very feasible category with 82% of material experts and 93% of media experts. Limited trial results and Dissemination of N-gain values of 0.65 (moderate) and 0.75 (high) show learners' cognitive improvement. Along with the respondents' questionnaire results, the percentage of practicality was 90.2%, which falls into the Very Practical category. Based on the advantages processed, the Construction Management Application e-module regarding the procedures of making 4D and 5D simulations in 2-story house buildings using Autodesk Navisworks software is suitable as advanced teaching materials in the Construction Management Application course.

Keywords: autodesk, navisworks, information modelling, construction management, application, e-module

INTRODUCTION

In the construction world, one of the technologies that are being developed to face the industrial revolution 4.0 is implementing Building Information Modeling-based construction software. Building Information Modeling (BIM) is one of the rapidly developing technologies in the

Architecture, Electrical, and Construction (AEC) sector, which can display 3D visualization of the building life cycle starting from planning (pre-construction) to operational time. BIM is one of the fastest growing technologies in the AEC sector, which can display 3D visualization of a building's life cycle from planning or pre-

construction to operational. The use of BIM on construction projects can help users to know the condition and form of a project during the construction process (Ramadhan & Maulana, 2020) so that the construction process can be more effective and efficient according to needs. The advantages of using applications with BIM concepts compared to conventional software include accelerating project planning schedule by $\pm 50\%$, reducing human resources needs by 26.66% and saving workers' expenses by 52.25% (Berlian, 2016)

In Indonesia, the application of BIM is still low. Although practitioners and academics know about BIM, about 70%, but only 38%, have used and can operate BIM-based software, especially in 3D visualization and modelling (Hanifah, 2016). Implementing BIM challenges include the high cost of initial investments such as software licensing and specifications. The difficulty of changing workflows from 2D images into BIM systems, the lack of human resources who have competence and skills in the optimization of various BIM software (Liu et al., 2015; Telaga, 2018), as well as the lack of agency participation in providing training and motivation related to Building Information Modeling (Hutama & Sekarsari, 2019). To face these challenges, Direktorat Jenderal Bina Konstruksi 2019 issued several policies, one of which is to link and match the field of education with the field of construction services, which can be in the form of alignment and digitization of the curriculum with the construction industry. The existence of training and certification guided by professionals and applying BIM to the education curriculum is also one of the strategies to face these challenges (Telaga, 2018). Therefore, universities play an essential role in preparing competent human resources that can later compete globally in the world of digital construction. The efforts of universities in responding to this one of them is by starting to

plan a BIM-based curriculum and the adoption of BIM in one of the lecture teaching materials.

One of the courses in the Building Engineering Education Study Program of Universitas Negeri Jakarta that can adopt BIM in its teaching materials is the Construction Management Application course. This course is one of the elective courses that students significantly demand. The material studied in this course is about how to use (software) Main Manager and Microsoft Project that is not based on BIM and has not been integrated with other software. Therefore, there needs to be further teaching material development using BIM-based software that can integrate to visualize project scheduling and estimation over time. Learning BIM-based software is hoped to make effective, efficient construction management plans.

One BIM software that can be adopted in this course is Autodesk Navisworks. Autodesk Navisworks is software that reviews architectural, engineering and construction projects by integrating models and data used to control scheduling and cost with 4D and 5D simulations. One example of a 4D simulation is by combining scheduling data with 3D modelling, which results in a simulation of the construction stages of a building (Pitake & Patil, 2013). Meanwhile, 5D simulation can be done by combining scheduling data, cost estimation data, and 3D modelling to visualize the construction stage simulation with cost calculations at each stage. According to (Fadzil & Yahya, 2021), 4D simulation can make it easier to plan scheduling activities that can be communicated visually. During 5D simulation, it can facilitate cost prediction in each phase in consideration which is very helpful in the early stages of project implementation. With its various features, Autodesk Navisworks has several advantages, including making it easier to review project developments in real-time, speeding up the planning process, detecting clashes and making it

easier to coordinate further experts. Due to the advantages and relevance of the use of Autodesk Navisworks software with the material needs in the Construction Management Application Course, Autodesk Navisworks allows it to be implemented into one of the advanced teaching materials in the course (Laorent et al., 2019). It is expected to improve student competence and provide a more realistic learning atmosphere with 4D and 5D simulation animations that show the real-life cycle of the project.

Adopting BIM in one of the Construction Management Application course materials requires teaching materials to convey. Teaching materials used in construction management application courses in the academic year 2020-2021 in e-modules integrated with learning videos through links. However, from the results of the needs analysis survey conducted, 73.1% of 52 respondents stated that the teaching materials used today are still ineffective. At the same time, 86.5% stated that the teaching materials used were not attractive. So it has not been able to increase the motivation of students who learn. Therefore, exciting teaching materials are needed, interactive, communicative and easily accessible, to increase students' motivation and learning interest in optimizing BIM-based software in construction management application courses. It is also supported by open-ended questions on the needs analysis survey, which states that the teaching materials must follow technological developments and be adapted to distance learning circumstances. To increase understanding and support learners to learn independently.

The teaching materials used can be integrated with media. One of them is the integration of E-modules with the Learning Management System (LMS) as a platform to organize and facilitate communication in online learning. E-module is a self-taught material that

can be complemented by video, animation, and audio connected through link links to make learning more interactive and practical (Pratama& Fikriyah, 2021). According to (Andrey & Maulana, 2021), e-modules can be one solution to overcome low learning motivation from learners. Research conducted by Fausih & Danang (2014); Purnomo (2017) stated that e-modules that are systematically arranged could facilitate learners in understanding the material delivered to improve learners' learning outcomes. LMS is an information technology system designed to help manage the learning process virtually, easily accessible anywhere (Ramadhan et al., 2020). LMS also allows educators to form discussion spaces. It can also integrate the material with several other media formats so that learners can be more active and the material provided is easier to understand. According to research conducted by Cavus & Alhih (2014), it was found that LMS is one of the best media for managing, organizing and delivering materials so that the learning is enjoyable it increases students' learning interest. It was also supported by an initial needs analysis survey, which showed 98.1% of 52 respondents. Holding agreed that the teaching materials in the form of e-modules integrated with the LMS platform as one of the learning media in the Construction Management Application course.

Through e-modules packaged in Universitas Negeri Jakarta LMS platform, it is expected that learners can receive material on the creation of 4D and 5D simulations of construction management using Autodesk Navisworks software optimally. So that learners can understand and explore skills using Autodesk Navisworks software to the fullest. Based on the background stated above, research was conducted on developing an e-Module for construction management application course based on building information modelling.

METHOD

The method used in this study is Research and Development. This method is usually used to create and test the effectiveness of a product. The method used in this study is Research and Development and creating and testing the effectiveness of a product. In addition, this method is also used to validate and develop a product (Pratama & Fikriyah, 2021). The model used in this study, a 4D development model, consisting of 4 steps in the name of Define at this stage, carried out an initial needs analysis. Next is the design stage. At this stage is done the initial planning of product design is done. The development is carried out at this stage by conducting material and media validation tests and limited trials. While the last is Dissemination. The stage will be distributed on a limited basis, and the final packaging will be in the form of implementation on the LMS platform.

The research instrument used is a questionnaire with a Linkert scale that will be used to collect data when conducting material validation tests, media validation tests and test participants' responses. The instrument uses a good module indicator to measure the feasibility and practicality of e-modules. These indicators include accuracy, matching, sufficiency, readability, fluency, attractiveness, and impressions (Charlton & O'Brien, 2019). Data from the questionnaire results can then be calculated using the formula equation 1.

$$Percentage = \frac{total\ score}{maximum\ score} \times 100\% \quad (1)$$

The results of these calculations are further categorized using the following eligibility interpretation, if the percentage is 0-20 so, the criterion is very unworthy, 21-40 is not worth it,

41-60 is decent enough, 61-80 is proper, and 81-100 is very worthy.

The cognitive improvement of learners taken from pre-test and post-test data, the following formulas are presented in equation 2.

$$N - gain = \frac{score\ post - test - score\ pre - test}{maximum\ score - score\ pre - test} \quad (2)$$

The formula calculation results are further categorized using the following scale of cognitive improvement criteria. If the gain score is more than 0.7, so classification of effectiveness is high. While the gain score range from 0.3 to less than 0.7 as classification moderate, and then if grain score 0.7 and more got classified as high effectiveness. In the e-module, a practicality test is carried out using the following formulas, as shown in equation 3.

$$Practicality = \frac{\sum\ item\ score}{maximum\ score} \times 100\% \quad (3)$$

After calculating the formula, the data is categorized into practical categories. If the practical percentage of 0-20 gets into the impractical category, 21-40 and 41-60 are less and reasonably practical. While the practical percentage is 61-80 get the category practical and 81-100 in the efficient category (Arvinda, 2020).

All data analysis results will be used to improve the learning media products being developed so that the product can be used optimally to improve learners' competence, especially in construction management application courses. A flowchart of the development of the e-module is shown in Figure 1.

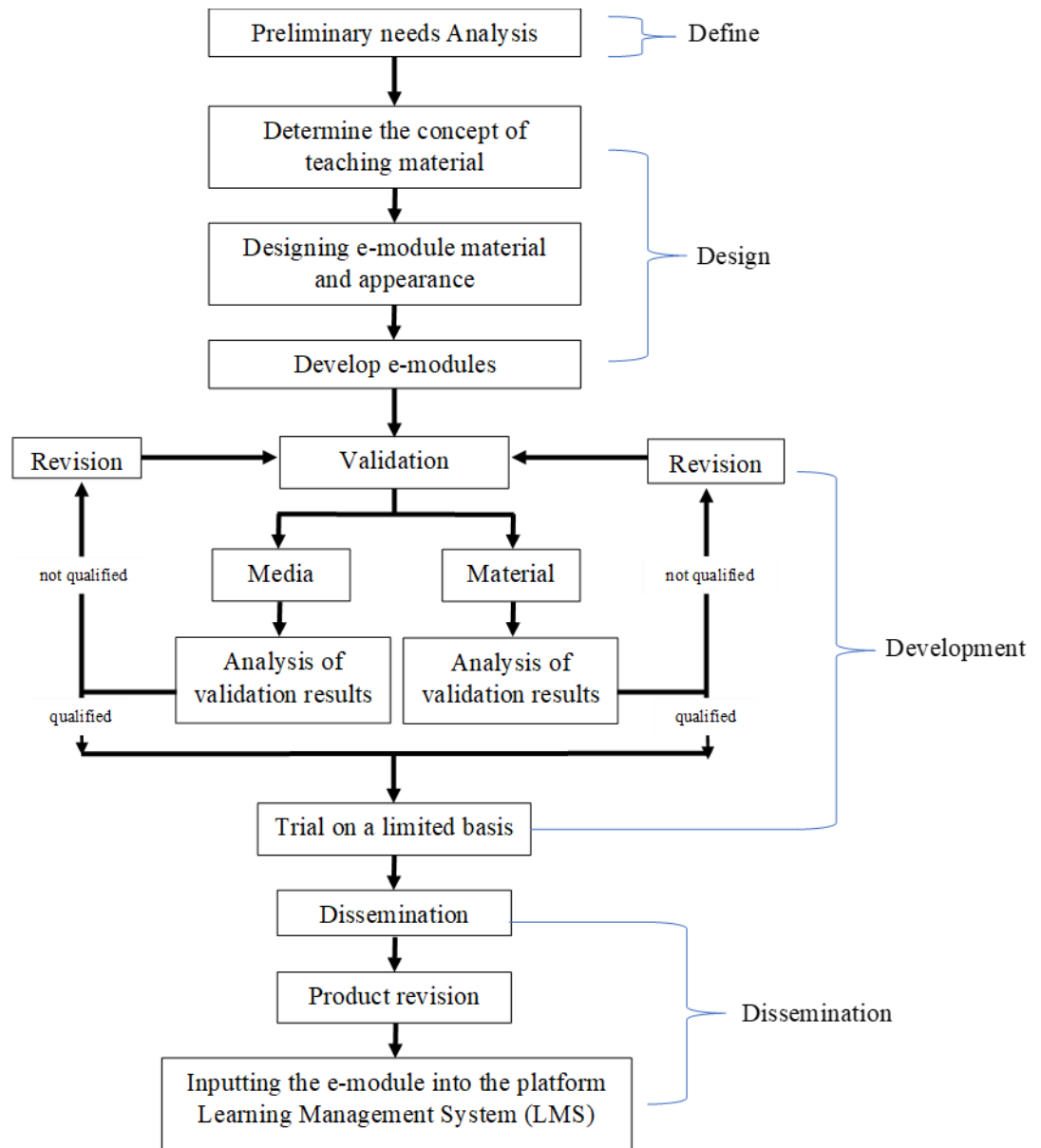


Figure 1. Flowchart development of e-module

Following the flowchart in Figure 1. above, this research begins with an initial needs analysis by distributing questionnaires to students who have taken and are taking the Construction Management Application course. Based on the data from the initial needs analysis that has been carried out, the concept of teaching materials to be developed will then be determined. After the

concept is formed, the design is carried out, followed by the development of teaching materials in content and appearance. This stage is included in the design stage. After the teaching materials have been developed, material experts and media experts will carry out validation tests. This limited trial was conducted on five students who have taken and are currently taking the

Construction Management Application course. After that, a limited trial was carried out, then dissemination was carried out, and revisions were made to the teaching materials under the input and suggestions obtained during the dissemination. After the teaching materials are said to be final or fixed, then the teaching materials will be inputted into the Learning Management System (LMS) platform that has been provided.

RESULT AND DISCUSSION

The product developed in this study is e-module Application Construction Management regarding creating 4D and 5D simulations in 2-story house buildings using Autodesk Navisworks software. This e-module contains three primary materials: preparation stage material and combines 3D models, 4D simulation making materials and 5D simulation materials until export animations. The e-module is also equipped with formative and practice tests to evaluate learners' learning outcomes. The e-module will be used as advanced teaching materials in the Construction Management

Application course, Faculty of Engineering, Jakarta State University. Before using this e-module, students are expected to have completed learning in the previous e-module about how to use the Microsoft Project and Mind Manager, which will be used to create detailed scheduling for further data integration in Autodesk Navisworks software.

Validation tests conducted by material experts obtained the average eligibility percentage from two validators, 82%, and falls into the very feasible category. At the same time, the results of validation tests by media experts obtained an average eligibility percentage of two validators of 93% and fell into the category of very feasible. The study found that the drawing module and volume of BIM-based building construction developed were declared very feasible based on the feasibility tests and got a beneficial category on the student opinion test, getting a percentage of 84.1%. Based on this, it can be indicated that the e-modules developed are very suitable for use as teaching materials in the Construction Management Application course.

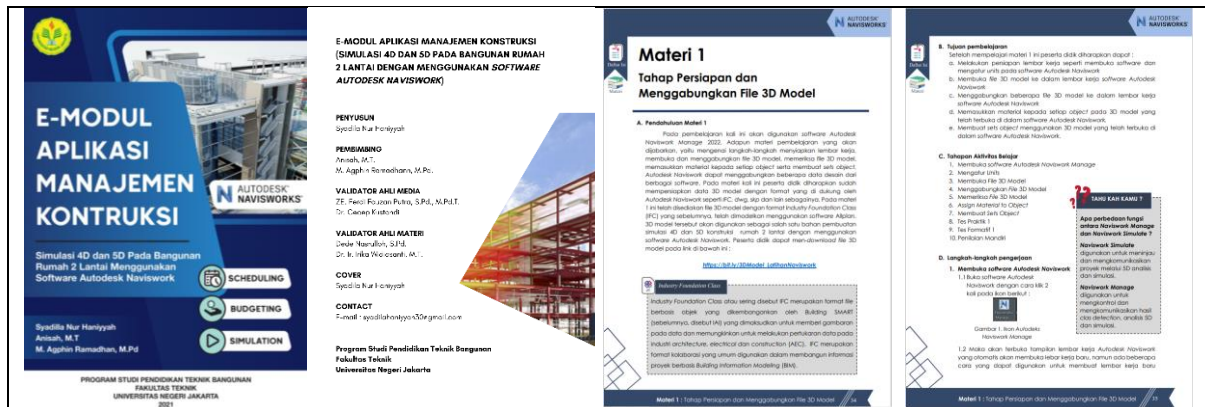


Figure 2. E-module Display

BIM products obtained by mastering one or more software should not be the focus of BIM education in the Construction Management Application course in universities. Lectures with BIM can encourage students to understand the role of BIM in different project phases so that they know why this tool is used, how to improve project performance and how it can be improved further (Lindblad, 2013). Lab-based task evaluation mechanism is also based on students' discussion of the process and further understanding of the tasks based on practice, not the results.

This section describes a detailed course design and instructional approach. There are a

team and individual evaluations throughout the semester. All lab-based assignments (one educational module) are carried out in teams (Kibble et al., 2016). Industry-led case studies are also conducted in teams. Individual evaluation is carried out through class discussions based on reading assignments, quizzes, and synthesis reports.

Meanwhile, based on limited trial results data and Dissemination, it is known that the developed e-modules can improve cognitive learners based on calculations from pre-test and post-test results data. Hamid et al. (2017) also showed that using e-modules can improve learning outcomes.

Table 4. Limited trial results

No.	Trial Participants	Pre-Test	Post-Test
1	Student 1	40	80
2	Student 2	50	80
3	Student 3	70	80
4	Student 4	70	100
5	Student 5	70	90
Average		60	86
N-Gain		0,65	
Category		Moderate	

Source: (Limited trial results data)

Table 5. Dissemination results

No.	Trial Participants	Pre-Test	Post-Test
1	Student 6	50	90
2	Student 7	100	100
3	Student 8	90	100
4	Student 9	80	100
5	Student 10	60	90
6	Student 11	80	80
7	Student 12	40	100
8	Student 13	100	100
9	Student 14	90	100
10	Student 15	70	90
Average		76	95
N-Gain		0,79	
Category		High	

From the trial participants' questionnaire responses, Dissemination obtained an average percentage result of 90.07% with a convenient category. The developed e-module can be practically used in the Construction Management Application course.

Based on respondents' records during limited trials and Dissemination, the advantages and disadvantages of e-modules developed. The advantages of e-modules include The display on the e-module is quite exciting and interactive. It is also supported by the results of response questionnaires on the appearance aspect of e-modules get, an average percentage of 90.42%, and the results of validation of media experts on the aspect of the face get an average percentage of 90%. E-modules are easy to access and use to support independent learning. E-modules have easily accessible characteristics and support independent learning, so they are very effective and efficient in distance learning. It is reinforced by the results of response questionnaires on aspects of use with an average percentage of 88.67%. Presented quite complete and under the purpose, supported by the results of material validation on the aspect of adequacy that get a percentage of 80%—helping improve new understanding and skills, particularly in the operation of Autodesk Navisworks software. The disadvantages of the e-module include Autodesk Navisworks software, which is used rather heavily and requires a high enough laptop specification. It can also be seen from 25 test participants and Dissemination that fills in pre-

test problems and installs software. Only 15 participants completed learning up to material 3. The articulation of sound in video tutorials is still not consistent, and also the duration of some video tutorials is still too short.

Materials with BIM versions developed in this e-module can be integrated with other courses such as Construction Management (MK), Cost Budget Plan (RAB) and Engineering Drawings 2. It is supported by Abdirad & Dossick (2016), who stated that skills in the use of BIM, collaboration and integration between various AEC disciplines have a synergistic effect in BIM learning. The development of BIM-based learning should cover a wide range of disciplines. However, the current actual condition of the material regarding the use of BIM-based software in construction management application courses has not been possible to be integrated with other courses as mentioned earlier. In the future, lecturers who master the courses can integrate BIM-based learning materials to create continuous learning using various software BIM-based construction to produce a complete project.

Developing this e-module goes through the definition, design, development and Dissemination stages. The validations carried out by material experts and media experts fall into the Very feasible category to be used as teaching materials in the Construction Management Application course, with a feasibility percentage of 82% from material experts and 93% from media experts. The developed e-module can improve students' cognitive abilities, which can

be seen from the results of the N-gain calculation, which results in 0.65 in the "Medium effectiveness classification and 0.79 in the High effectiveness classification. Aspects of appearance, presentation of materials and aspects of use obtained a practicality percentage of 90.7%, which is included in the convenient category. E-modules are used as advanced teaching materials in the Construction Management Application course, procedures for making 4D and 5D simulations in house buildings. Moreover, two floors use Autodesk Navisworks software in BIM.

BIM-based software learning is expected to make efficient construction management plans. BIM can help simulate various mechanical compositions for specific changes. It is also conducive to a more practical layout of the appropriate changes. The layout can be more efficient and cost-effective in finding the process design and project characteristics. The materials used in the construction of the project are the basic materials of the entire project. Whether the materials are selected correctly, and their use is reasonable can directly affect the quality of the project. Therefore, material control is the main link of the whole project. BIM technology analyzes the needs of comprehensive construction and project progress and provides the most reasonable choice of materials to ensure that the whole construction process is normal and effective (Dong, 2017). The application of BIM technology can record specific information and material sources and classify them according to

different material types as a basis for further engineering examinations.

For construction projects, BIM technology can quickly change in the electronic simulation of various construction methods to simulate construction. At the same time, it can be combined with various strengths and weaknesses in the simulation analysis, more consistent with the construction project process.

Simultaneously it can also be used to construct a demonstration of the reasoning program so that it is expected to be under the truth, thus ensuring the quality of housing construction projects. A prototype 4D model was implemented to overcome problems that arise in conventional planning methods and to incorporate practical site management features. This 4D model, which relates the 3D geometric model to the data schedule, consists of the activity schedule and the facility's 3D model of the site at any given moment. There are many potential benefits of a 4D modelling system, including facilitating site planning and management, predicting the occurrence of potential site problems, and site management practices. In addition, advances in computing technology are helping work in producing user-friendly, comprehensive and integrated site management tools. Thus the results of 4D visualization have strong potential in the planning and construction management process.

The development of electronic modules in the Construction Management Application course lies in the material developed. In previous

research, the material developed has not studied the use of BIM-based software. In contrast, the e-module developed this time contains material on how to use one bim-based software, namely Autodesk Navisworks software. In addition, the e-module developed today is also more interactive because several navigation features and Qr code equip it.

The difference between the scheduling process without and using Autodesk Navisworks software. Previously, in the process, we found an e-module on how to use Microsoft Project. The display of making scheduling using Microsoft Project software which contains many tasks, the duration of the work, the start of the creation is shown on the start and finish dates which are equipped with a barchart (Figure 3). On the other hand, Figure 4. shows the creation of a

scheduling using the Autodesk Navisworks software. The display contains the name of the job, the start date and the completion date of the work and is completed by a barchart on the left. If Autodesk Navisworks allows for data collaboration, so scheduling data can be imported directly from other software such as Primavera, Microsoft Project or created directly in the Autodesk Navisworks window. The software can be used as a follow-up job from the previous task. In addition, scheduling can be linked to a 3D model so that it can display animations of the construction process in real time. In addition to the differences in scheduling displays, there are also differences in the final results of student assignments from the practicality of using Autodesk Navisworks.

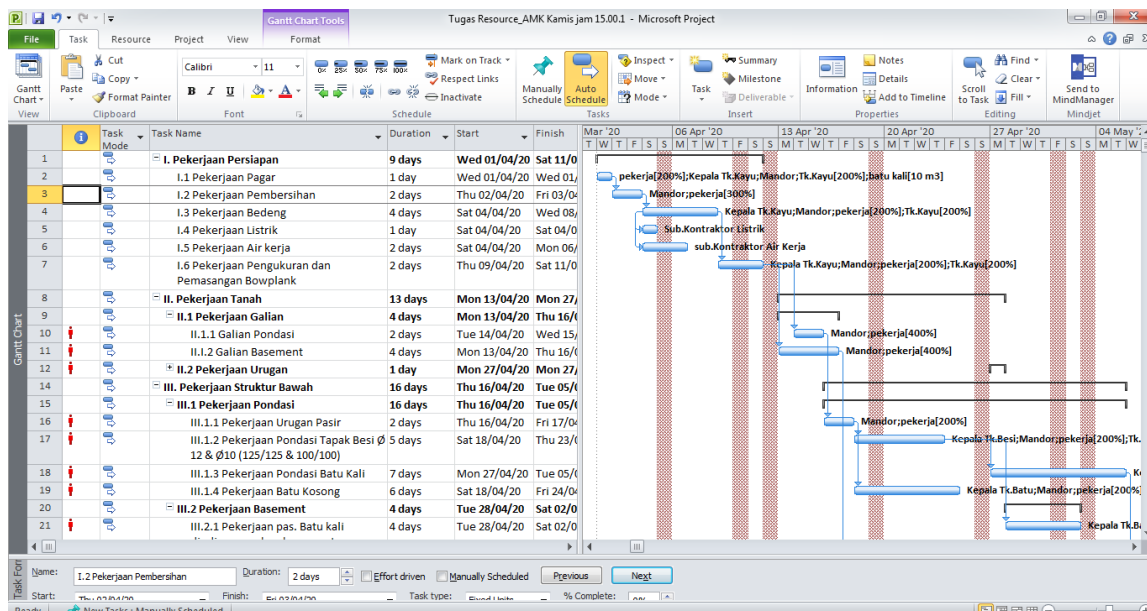


Figure 3. Scheduling view in Microsoft Project software

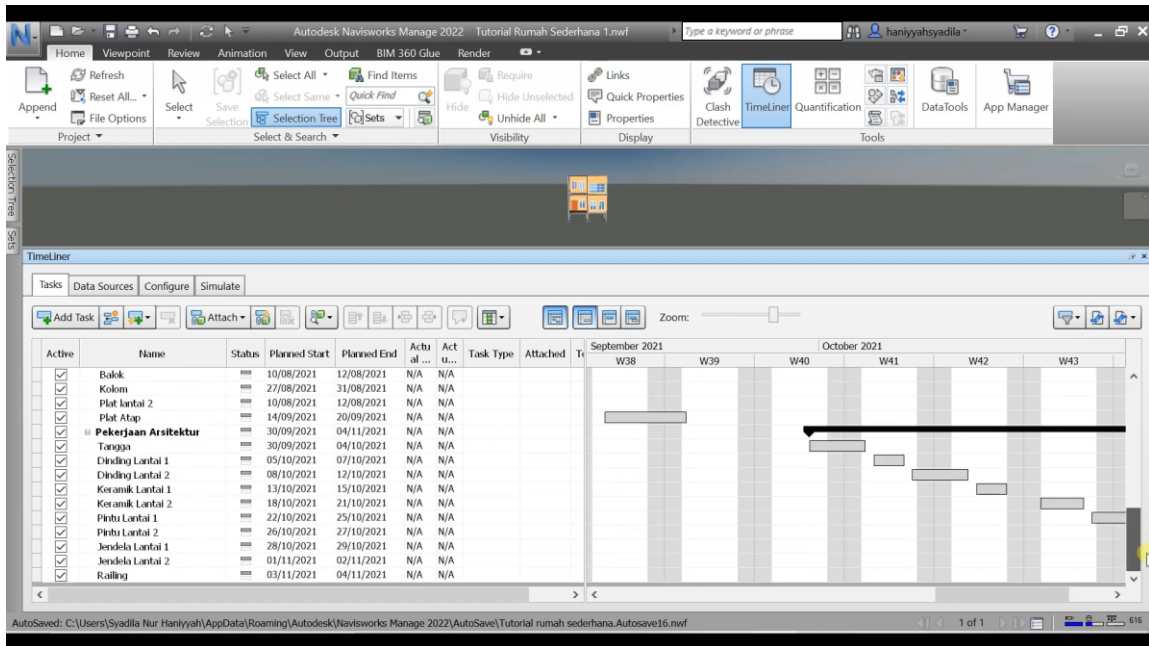


Figure 4. Scheduling view on Autodesk Navisworks

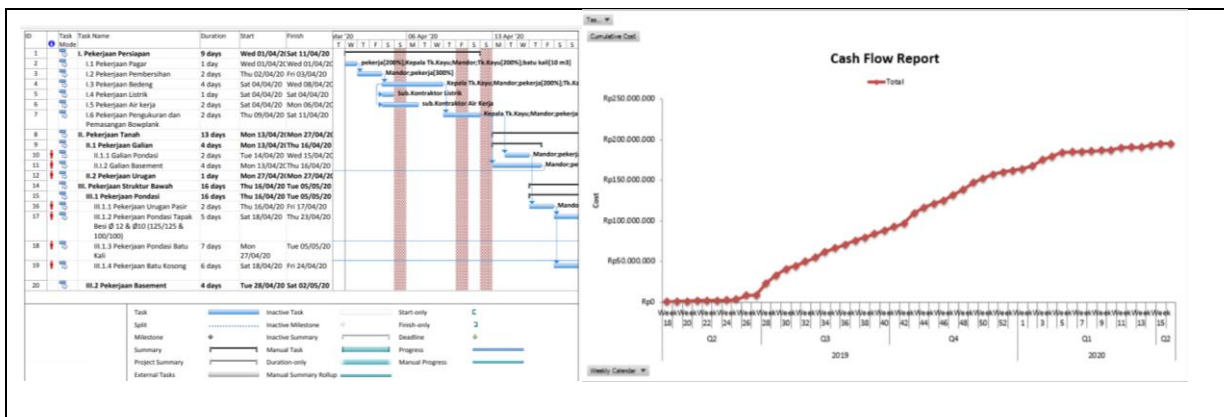
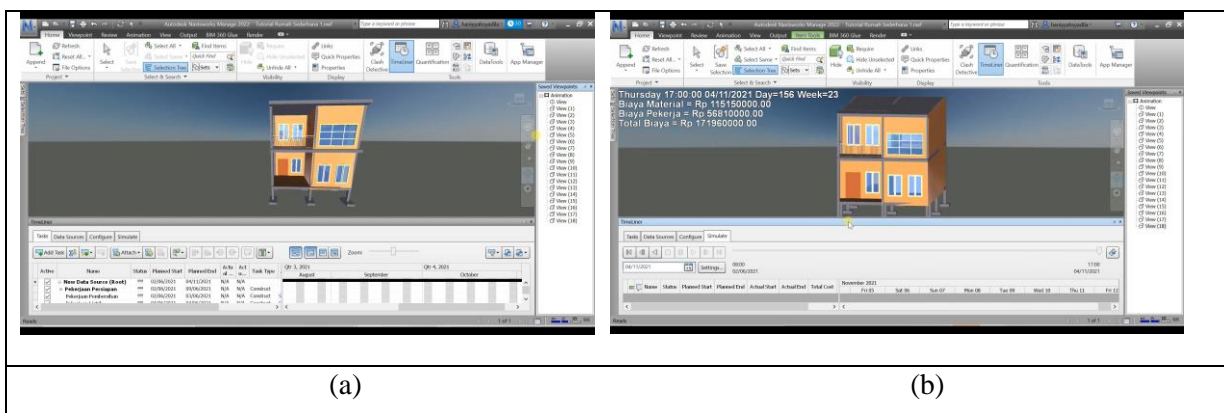


Figure 5. Student work before using Autodesk Navisworks software for design of simple home



(a)

(b)

Figure 6. Final results of student work using Autodesk Navisworks software for Home Design

The final work of using the Autodesk Navisworks program is scheduling and budgeting equipped with a bar chart, s curve and cash flow in mpp and pdf formats as shown in Figure 5. There is no visualization of the house drawing product yet. After using Autodesk Navisworks, students are required to produce a simulation animation that is equipped with scheduling and budgeting, while the output produced is in the form of a video in AVI format, as shown in Figure 6. The image on the left (a) of the house building is not yet proportional, but can be simulated again with a more detailed and complete schedule with financing. The right-hand side of the house (b) illustrates that the last schedule with the building is erect and fully proportional. The entire student's final work in construction and budget is predictable. The total cost of materials and labor for a simple house that has been erected is stated in the calculated time. Many construction projects are poorly designed as well as inconsistent timing and costs. Management can improve the quality of design and management practices that are supported in better time and cost management. Building Information Modeling is recognized to improve the planning and realization of a construction project via Autodesk Navisworks software (Jrade et al., 2015).

CONCLUSION

The product is a teaching material in the form of a Construction Management Application e-module regarding the procedure for making 4D and 5D simulations in a 2-story house building

using Autodesk Navisworks software integrated with the Learning Management System at the Universitas Negeri Jakarta. The development of this e-module goes through the stages of definition, design, development and Dissemination. The category is feasible for teaching material in the Construction Management Application course. The developed e-module can improve students' cognitive abilities in the classification of High Effectiveness. The Very Practical category includes aspects of appearance, presentation, material and use. The e-module is used as advanced teaching material in Construction Management Applications and procedures for making 4D and 5D simulations in house buildings, especially on the second floor, using Autodesk Navisworks software at BIM.

REFERENCES

- Abdirad, H. & Dossick, C. S. (2016). BIM curriculum design in architecture, engineering, and construction education: a systematic review. *Journal of Information Technology in Construction (ITcon)*, 21(17), 250-271.
- Cavus, N., & Alhih, M. S. (2014). Learning Management Systems Use in Science Education. *Procedia - Social and Behavioral Sciences*, 143, 517-520.
- Andrey, A., & Maulana, A. (2021). Pengembangan Bahan Ajar E-Modul Mata Kuliah Gambar Teknik Ii Di Prodi Pendidikan Teknik Bangunan. *Jurnal Pensil: Pendidikan Teknik*

- Sipil*, 10(3), 160-165.
- Arvinda, M. N. (2020). Pengembangan E-Modul Berbasis Scaffolding Dengan Modular Object Oriented Dynamic Learning Environment (Moodle) Pada Materi Momentum Impuls Dan Getaran Harmonis Kelas X SMA/MA.
- Berlian, C. A. (2016). Perbandingan Efisiensi Waktu, Biaya dan Sumber Daya Manusia Antara Metode BIM dan Konvensional (Studi kasus: Perencanaan Gedung 20 Lantai). *Jurnal Karya Teknik Sipil*, 5(2), 220-229.
- Charlton, S. G., & O'Brien, T. G. (Eds.). (2019). *Handbook of human factors testing and evaluation*. CRC Press.
- Dong, R. R. (2017). The application of BIM technology in building construction quality management and talent training. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(7), 4311-4317.
- Fadzil, A. I. M., & Yahya, M. Y. (2021). Pelaksanaan Sistem Pemodelan Maklumat Bangunan (BIM) Bagi Mengurangkan Kos Dalam Pengurusan Fasilitas. *Research in Management of Technology and Business*, 2(1), 892-904.
- Fausih, M., & Danang, T. (2015). Pengembangan media e-modul mata pelajaran produktif pokok bahasan "instalasi jaringan lan (local area network)" untuk siswa kelas xi jurusan teknik komputer jaringan di smk negeri 1 labang bangkalan madura. *Jurnal Unesa*, 1(01), 1-9.
- Hamid, M. A., Aribowo, D., & Desmira, D. (2017). Development of learning modules of basic electronics-based problem solving in Vocational Secondary School. *Jurnal Pendidikan Vokasi*, 7(2), 149.
- Hanifah, Y. (2016). Awareness dan Pemanfaatan BIM: Studi Eksplorasi. *Temu Ilmiah IPLBI 2016, August*, 49-54.
- Hutama, H. R., & Sekarsari, J. (2018). Analisa faktor penghambat penerapan building Information modeling dalam proyek konstruksi. *Jurnal Infrastruktur*, 4(1), 25-31.
- Jrade, A., & Lessard, J. (2015). An integrated BIM system to track the time and cost of construction projects: a case study. *Journal of Construction Engineering*, 2015(3), 1-10.
- Kibble, J. D., Bellew, C., Asmar, A., & Barkley, L. (2016). Team-based learning in large enrollment classes. *Advances in physiology education*, 40(4), 435-442.
- Laorent, D., Nugraha, P., & Budiman, J. (2019). Analisa Quantity Take-Off dengan Menggunakan Autodesk Revit. *Dimensi Utama Teknik Sipil*, 6(1), 1-8.
- Lindblad, H. (2013). Study of the implementation process of BIM in construction projects.
- Liu, S., Xie, B., Tivendal, L., & Liu, C. (2015). Critical barriers to BIM implementation in the AEC industry. *International Journal of Marketing Studies*, 7(6), 162.
- Pitake, S. A., & Patil, P. D. S. (2013). Visualization of construction progress by 4D modeling application. *International Journal of Engineering Trends and Technology (IJETT)*,

- 4(7), 3000-3005.
- Pratama, R. B., & Fikriyah, T. R. (2021). Pengembangan E-Modul Bemuatan Kearifan Lokal pada Pembelajaran Tematik di Kelas V SDN 2 Waruroyom. *Jurnal Kreatif: Jurnal Kependidikan Dasar*, 11(2), 127-136.
- Purnomo, L. A. (2017). Penerapan E-Modul Berbasis Problem Based Learning (PBL) Sebagai Upaya Peningkatan Hasil Belajar Siswa Pada Mata Pelajaran Gambar Konstruksi Bangunan Kelas XI TGB SMK Negeri 1 Sidoarjo. *Jurnal Kajian Pendidikan Teknik Bangunan*, 2(2/JKPTB/17).
- Ramadhan, M. A., & Maulana, A. (2020). Pemahaman Konsep BIM melalui Autodesk Revit bagi Guru SMK Teknik Bangunan se-Jabodetabek. *Wikrama Parahita: Jurnal Pengabdian Masyarakat*, 4(1), 47-52.
- Ramadhan, M. A., Maulana, A., Kusumarini, A., Apriliany, A., Haryani, M. P., Rismana, E., & Rizky, D. M. (2020). Pemanfaatan Learning Management System (LMS) Bagi Guru Smk Desain Pemodelan Dan Informasi Bangunan Di Kab/Kota Bekasi. *Sarwahita*, 17(02), 193–200.
- Telaga, A. S. (2018). A review of BIM (Building Information Modeling) implementation in Indonesia construction industry. *IOP Conference Series: Materials Science and Engineering*, 352(1).