PUBLISHED BY
JR
EDUCATION

Available online at http://ijite.jredu.id

International Journal of Information Technology and Education (IJITE) 5 (2S), (April 2026) 253 - 259

International Journal of Information Technology and Education (IJITE)

http://ijite.jredu.id

Implementation of Teaching Materials Using Building Modeling and Information Design Based on the Green Building Concept at State Vocational School 3 Tondano

Saruendo Winowatani[1]*, Parabelem Tinno Dolf Rompasi[1], Rolly Robert Oroh[1]

[1]Department of Technology and Vocational Education, Graduate Program, Universitas Negeri Manado, Indonesia

*Corresponding author: saruendowinowatan@gmail.com

ARTICLE INFO
Article history:
Received: February 27, 2026; Received in revised form: March 28, 2026; Accepted: April 22, 2026;
Available online: April 24, 2026;

ABSTRACT

This study aims to develop a model of teaching materials for the Building Information Modeling (BIM) subject integrated with the green building concept, in order to improve students' understanding and awareness of the principles of sustainability in building design. The background of this study is based on the need for teaching materials relevant to the development of the modern construction industry, especially the application of Building Information Modeling (BIM) and global demands for sustainable development. The research method used is Research and Development (R&D) with the Borg & Gall development model consisting of ten stages, starting from preliminary studies to product trials. The research subjects consisted of vocational high school students majoring in BIM and learning media. The instruments used included interviews, validation questionnaires, observation sheets, and comprehension tests. The results of the study indicate that the developed teaching material model meets the eligibility criteria in terms of content, presentation, language, and visual appearance based on expert validation results. Limited trials indicate an increase in students' understanding of the BIM concept and green building principles with N-Gain scores in the medium to high category. In addition, student responses to the teaching materials are very positive, indicating that this model is interesting, easy to understand, and relevant to the needs of the workplace. Thus, this teaching material model is suitable for use in DPIB learning and is recommended for implementation as part of strengthening technology- and sustainability-based curricula in vocational education.

Keywords: Building Information Modeling and Design, green building, R&D, Teaching Materials, Vocational High School.

INTRODUCTION

The current development of the construction sector requires not only the production of functional and aesthetic buildings but also environmental sustainability. Buildings are known to be one of the largest contributors to energy consumption, making the application of energy conservation principles crucial. The National Standardization Agency, through SNI 03-6196-2000, emphasizes that buildings must be designed with energy efficiency in mind through the management of lighting and ventilation systems, as well as the use of materials that support energy savings (BSN, 2011). This demonstrates that sustainability has become a national standard that is mandatory for all players in the construction industry, including in the education sector.

Developments in information technology and global awareness of environmental issues have driven significant changes in the construction sector. One key innovation that is rapidly developing is Building Information Modeling (BIM), a digital-based approach to the planning, design, construction, and management of buildings. BIM is a technology that enables the creation of digital models of a building's physical and functional location throughout its lifecycle and facilitates real-time cross-disciplinary collaboration (Eastman et al., 2011).

Research in architecture and construction education suggests that Green BIM needs to be integrated into the curriculum to ensure graduates have professional skills that meet global sustainability demands (Ahmed, 2025). Research by Ramadhani and Kurniawan (2020) shows that integrating BIM into building design learning at vocational schools (SMK) can improve students' digital design competencies and industrial work readiness. Meanwhile, Kurniawan and Rahman (2021) revealed that implementing green building principles in architectural design has a positive impact on design quality and building energy efficiency. This demonstrates that integrating BIM and green building concepts into learning has significant potential to improve the quality of vocational education in the construction sector.

These shifting industrial and educational paradigms demonstrate the need to develop structured and comprehensive learning materials that integrate BIM and green building principles. These models are expected to convey the basic concepts of BIM and sustainability conceptually and practically, facilitate project-based and simulation-based learning, explain the use of BIM for energy analysis and environmental impact evaluation, and prepare graduates with competencies relevant to industry needs (Nguyen et al., 2025). Without innovation in learning materials, engineering and architecture education has the potential to produce graduates who are ill-prepared to face the demands of the global construction industry, which is increasingly oriented toward energy efficiency and sustainability.

From a pedagogical perspective, developing relevant learning models is key to the successful implementation of innovative materials. Huda (2016) emphasized that effective learning models must be contextual, applicable, and capable of developing students' higher-order thinking skills. Vocational education in Indonesia, particularly Vocational High Schools (SMK), plays a strategic role in preparing work-ready human resources with competencies aligned with job market needs. Vocational education is designed to produce graduates with practical, adaptive, and relevant skills relevant to industrial

developments (Sudira, 2016). However, in reality, there is still a gap between the competencies of vocational high school graduates and the needs of the business and industrial world (DUDI), resulting in low graduate absorption rates in the job market (Yulianto & Sutrisno, 2019). This gap is also influenced by the suboptimal standards of partnership between schools and industry that can ensure the relevance of graduate competencies to the demands of the real world of work (Wibowo & Haryanto, 2020).

METHOD

This study employed a Research and Development (R&D) approach using the Borg and Gall development model. The R&D approach was used because this research aimed not only to describe phenomena but also to produce educational products and test their feasibility and effectiveness in learning (Borg & Gall, 2003; Sugiyono, 2019). The product developed was a Building Information Modeling and Design (DPIB) module/teaching material based on green building concepts that can be used by teachers and students in the DPIB subject at SMK Negeri 3 Tondano. Integrating green building concepts into vocational education is crucial for fostering sustainability awareness and the relevance of graduate competencies to the needs of the modern construction industry (UNESCO, 2017). The Borg and Gall model was chosen because it has systematic, structured, and relevant development stages for educational product development, from needs analysis to product dissemination (Borg & Gall, 2003).

The development procedure in this study followed the ten-stage Borg and Gall model. These ten stages are used as a reference in developing DPIB teaching materials based on green buildings so that the resulting products are truly valid, practical and effective (Borg & Gall, 2003).

RESULTS AND DISCUSSION

The research results indicate that the developed learning module is categorized as very feasible. This indicates that the substance, structure, language, and depth of the material align with the characteristics of vocational high school students and the needs of the DPIB expertise competency. The feasibility of this material is demonstrated by its alignment with learning outcomes (CP) and learning objectives (TP), the integration of the Green Building concept with building modeling competencies, and the completeness of learning components such as objectives, materials, exercises, projects, and evaluations. A research and development product is deemed feasible if it meets the aspects of content validity, construction validity, and suitability to user needs (Borg & Gall, 2003).

The integration of the Green Building concept into the module provides added value because students not only learn building modeling techniques but also understand the principles of sustainability, energy efficiency, water efficiency, the selection of environmentally friendly materials, and sustainable building design concepts. This aligns with the demands of the modern construction industry, which is geared towards sustainable construction.

The practicality of the learning material is assessed through student responses and observations during the learning process. Student responses are categorized as very good, meaning the learning

material is easy to use, engaging, and facilitates understanding. This practicality is also reflected in the increase in student learning activities, student involvement in discussions, and students' ability to complete green building design projects.

The effectiveness of the learning materials was analyzed by comparing pre-test and post-test results. The analysis showed a significant improvement in student learning outcomes after using the learning module. The higher average post-test score compared to the pre-test indicates that the developed learning materials were able to improve students' understanding of Green Building concepts and building modeling. This aligns with Sugiyono's (2016) opinion, which states that the effectiveness of a learning product can be seen from the improvement in learning outcomes after treatment is administered.

The t-test results showed a significant difference between pre-test and post-test scores, thus supporting the research hypothesis that Green Building-based learning materials effectively improve student learning outcomes. Furthermore, the N-Gain value was in the moderate to high category, indicating a substantial improvement in student learning outcomes. This finding is supported by Richard R. Hake (1998), who classified learning outcomes into low, medium, and high categories based on gain values.

The integration of Green Building concepts with Building Information Modeling (BIM) technology in the learning module makes a significant contribution to improving student competency. Students not only understand theoretical concepts, but are also able to apply these concepts in building modeling using AutoCAD, Revit, and SketchUp software.

CONCLUSION

The Green Building concept-based teaching materials developed have undergone needs analysis, design, development, expert validation, initial trials, main trials, and product revision. The results indicate that the teaching materials are highly suitable for use in the Building Information Modeling and Design (BIM) competency. The results of the DPIB student trials indicate that the teaching materials are easy to understand, systematic, and support BIM practice-based learning. Students were able to follow the learning steps, from the Green Building concept and building modeling to energy and material efficiency analysis using the BIM approach. The pre-test and post-test analysis results indicate a significant improvement in student learning outcomes after using the developed teaching materials. Statistical tests (normality test, homogeneity test, and paired sample t-test) showed that there was a significant difference between the pre-test and post-test scores. The N-Gain value was in the quite effective category, which indicated that the teaching materials were effective in improving students' understanding of the Green Building concept and the application of BIM. This teaching material not only improved students' technical competence in building modeling, but also instilled awareness of sustainable development, energy efficiency, the use of environmentally friendly materials, and reducing environmental impacts in building planning. Thus, the teaching materials supported the achievement of vocational education goals that were in line with the principles of sustainable development.

REFERENCES

Abdirad, H., & Dossick, C. S. (2016). BIM curriculum design in architecture, engineering, and construction education: A systematic review. Journal of Professional Issues in Engineering Education and Practice, 142(3), 04015012.

Ahmed, N. (2025). Constructing an implementation plan for integrating green BIM into undergraduate architecture programs. Scientific Reports, 15(1), 1–22.

Ahn, Y. H., Pearce, A. R., Wang, Y., & Wang, G. (2019). Drivers and barriers of sustainable design and construction: The perception of green building experience. International Journal of Sustainable Building Technology and Urban Development, 10(1), 1–13.

Alshammari, M. T. (2020). Curriculum implementation and teacher challenges. International Journal of Learning, Teaching and Educational Research, 19(3), 1–20.

Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. Leadership and Management in Engineering, 11(3), 241–252.

Badan Standardisasi Nasional. (2011). SNI 03-6196-2000: Konservasi Energi pada BangunanGedung. Jakarta: BSN.

Barison, M. B., & Santos, E. T. (2010). BIM teaching strategies: An overview of the current approaches. Proceedings of ICCCBE, 1–10.

Billett, S. (2011). Vocational education: Purposes, traditions and prospects. Springer.

Borg, W. R., & Gall, M. D. (2003). Educational research: An introduction (7th ed.). Boston, MA: Allyn & Bacon.

Direktorat Jenderal Pendidikan Vokasi. (2021). Strategi link and match pendidikan vokasi dengan dunia usaha dan dunia industri (DUDI). Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Direktorat PSMK. (2018). Kurikulum SMK Program Keahlian Teknik Konstruksi dan Properti. Jakarta: Kemdikbud.

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). BIM handbook: A guide to building information modeling (2nd ed.). Wiley.

Emzir, (2012). Metodologi Penelitian Pendidikan Kuantitatif dan Kualitatif.

Fullan, M. (2007). The new meaning of educational change (4th ed.). Teachers College Press.

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: An introduction (8th ed.). Boston, MA: Pearson.

Green Building Council Indonesia. (2019). GREENSHIP Rating Tools for New Building v1.2.Jakarta: GBCI.

Hamzakadı, A., & Turkdogan, O. (2019). Integrated study of building information modeling (BIM) with green buildings for a sustainable environment. Environmental Research and Technology, 2(3), 123–130.

International Energy Agency. (2019). Global status report for buildings and construction. IEA.

Kementerian PUPR. (2020). Panduan Teknis Bangunan Gedung Hijau.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? Contemporary Issues in Technology and Teacher Education, 9(1), 60–70.

Kibert, C. J. (2016). Sustainable construction: Green building design and delivery (4th ed.). Hoboken, NJ: John Wiley & Sons.

Kurniawan, T., & Rahman, A. (2021). Implementasi prinsip green building dalam desain arsitektur. Jurnal Arsitektur dan Perencanaan,

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. Improving Schools, 19(3), 267–277.

Lozano, R., Lukman, R., Lozano, F. J., Huisingh, D., & Lambrechts, W. (2013). Declarations for sustainability in higher education: Becoming better leaders. Journal of Cleaner Production, 48, 10–19.

Maulina, M., & Yoenanto, N. H. (2022). Optimalisasi program link and match sebagai upaya meningkatkan relevansi lulusan SMK dengan dunia usaha dan dunia industri. Jurnal Akuntabilitas Manajemen Pendidikan, 10(2), 215–226.

Mulder, M. (2017). Competence-based vocational and professional education. Springer International Handbook of Education, 1–26.

Nguyen, T. D., Nguyen, H. T., & Le, Q. T. (2025). Bridging the gap: Enhancing BIM education for sustainable design integration. Computers, 14(11), 463.

Ornstein, A. C., & Hunkins, F. P. (2018). Curriculum: Foundations, principles, and issues (7th ed.). Pearson.

Prosser, C. A., & Quigley, T. H. (1949). Vocational education in a democracy. American Technical Society.

Putri, R. E., & Slamet, A. (2021). Kemitraan SMK dengan dunia usaha dan dunia industri dalam meningkatkan kompetensi peserta didik. Jurnal Pendidikan Vokasi, 11(1), 85–94.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74.

Sacks, R., & Pikas, E. (2013). Building information modeling education for construction engineering and management. Construction Management and Economics, 31(11), 1240–1256.

Santos, R., Costa, A. A., & Grilo, A. (2017). Bibliometric analysis and review of building information modelling literature published between 2005 and 2015. Automation in Construction, 80, 118–136.

Scherer, R., Tondeur, J., Siddiq, F., & Baran, E. (2019). The importance of attitudes toward technology for pre-service teachers' technological, pedagogical, and content knowledge. Computers & Education, 128, 13–29.

Sterling, S. (2010). Learning for resilience, or the resilient learner? Towards a necessary reconciliation in a paradigm of sustainable education. Environmental Education Research, 16(5–6), 511–528.

Sudira, P. (2016). TVET abad XXI: Filosofi, teori, konsep, dan strategi pembelajaran vokasional. Yogyakarta: UNY Press.

Sugiyono. (2016). Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D. Bandung: Alfabeta.

Thomas, J. W. (2000). A review of research on project-based learning. Autodesk Foundation.

UNESCO. (2017). Education for sustainable development goals: Learning objectives.

UNESCO. (2015). Unleashing the potential: Transforming technical and vocational education and training.

Volk, R., Stengel, J., & Schultmann, F. (2014). Building information modeling (BIM) for existing buildings—Literature review and future needs. Automation in Construction, 38, 109–127.

Wheelahan, L. (2015). Not just skills: What a focus on knowledge means for vocational education. Journal of Curriculum Studies, 47(6), 750–762.

Wijaya, H. (2019). Pendidikan berbasis green building di SMK: Tantangan dan strategi. Jurnal Inovasi Pendidikan Teknik Bangunan.

Wibowo, A., & Haryanto. (2020). Implementasi kerja sama SMK dan dunia industri dalam pelaksanaan praktik kerja industri. Jurnal Pendidikan Teknologi dan Kejuruan, 17(2), 189–198.

Wong, J. K. W., & Zhou, J. (2015). Enhancing environmental sustainability over building life cycles through green BIM. Automation in Construction, 57, 156–165.

Wu, W., & Issa, R. R. A. (2014). BIM education and recruiting. Journal of Professional Issues in Engineering Education and Practice, 140(2), 04013014.

Wu, P., Jin, R., Xu, Y., & Li, Y. (2021). The integration of BIM and green building for sustainable development: A systematic review. Sustainability, 13(4),

Yulianto, A., & Sutrisno. (2019). Relevansi kompetensi lulusan SMK dengan kebutuhan dunia industri. Jurnal Pendidikan Vokasi, 9(1), 1–10.

Zhang, J., Liu, Y., & Wang, X. (2017). Building Information Modeling (BIM) for green buildings: A critical review and future directions. Automation in Construction, 80, 106–116.

Zhang, J., Schmidt, K., & Li, H. (2016). BIM and sustainability education: A conceptual framework. Sustainability, 8(8), 1–15.

Zukna, I., & Sassi, K. (2024). Prospek sistem pendidikan vokasi di Indonesia abad-21.