An empirical study to evaluate the student competency of vocational education

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ABSTRACT

The low work readiness of vocational education (VE) graduates is caused by a mismatch of competencies with job demands. The unemployment rate for VE graduates is increasing due to low competency mastery and job absorption. The purpose of this study is to determine the competency needs of architectural engineering graduates according to the current demand for the construction industry. The research sample consisted of 193 respondents consisting of VE teachers and practitioners from the construction industry in Indonesia. The Covariance-Based Structural Equation Modeling (CB-SEM) analysis is used for the evaluation of the structural models of architectural engineering competency demands. The results of the analysis test using Confirmatory Factor Analysis (CFA) show that the construct validity of the evaluation model is in a good category. The evaluation model testing met the statistical criteria of goodness of fit. The model substantially explains 89.75% of the various competencies that must be mastered by architectural engineering graduates and suitable for use in Indonesia and other countries.

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1. INTRODUCTION

The development of science, technology, and information is very rapid which requires effective and efficient education [1], [2]. Education is an effort to grow and develop the potential possessed by students to become quality human resources [3], [4]. Competition makes the industry must have a strategy that can increase its competitiveness of the industry [5]–[7]. The competition in the vocational education (VE) curriculum is structured according to the suitability and needs of the industry and takes into account the development of students and the suitability of the type of work, social environment, national development needs developments in science, technology, and culture [8], [9]. Completion or improvement of education, especially VE is a form of harmonizing the development of the industry, technology, arts, and culture.

One of the visible problems is the limited employment opportunities due to the country's economic growth that has not met expectations, then the high unemployment rate for VE students [5], [9], [10], especially architectural engineering, indicates a competency gap between supply, and demand [6], [7], [11]. Rapid changes in the world of work as a result of the globalization of the world of work and the revolution in technology and various other scientific disciplines require anticipation and evaluation of the competencies needed by the world of work [12], [13]. Evaluation is also important so that the world of higher education is not separated from the real world of work that exists in society. For this reason, VE must be responsive to changes that occur both locally and globally [8], [10]. To anticipate these changes, the VE program must be reviewed periodically to make adjustments in a direction that is more relevant to the situation and conditions.

Observations and interviews were conducted in the department of architectural engineering in Central Java, Indonesia. This department learns about construction and property technology work, especially in the implementation of construction and building planning. But in reality, from the programs that have been implemented in the world of education, there are several problems encountered so there is a mismatch between the education unit and the industrial construction. There are many graduates who have not found jobs and jobs that are not in accordance with their areas of expertise. Furthermore, the discrepancy in the content of competency material in schools with the demands of graduates' competence in the industry.

Furthermore, in the context of developing and implementing the curriculum, it is still limited to the school. There are several obstacles, namely the competencies needed by the industry have not been implemented in schools, and learning that emphasizes hard and soft skills simultaneously has not been maximized. Furthermore, schools have not maximized the application of all vocational competencies in learning theory and vocational practice. Such a curriculum is developed only from the school without involving industry to shape the material taught in the learning that will run. Curriculum development has not run optimally by involving all stakeholders including teachers, counselors, school committees, principals, and industry in the form of work meetings. So that the lack of school relations with the world of work causes the absorption of vocational graduates to work according to their fields to be very low.

This is as the results of research conducted by Daryono *et al.* [14] revealed that there is still a link and match gap between schools and industry so that it recommends several competencies of architectural engineering graduates including personality competencies, basic knowledge, and work skills. Furthermore, research by Wijayanti and Jaedun [15] revealed the development of architectural engineering technology in the world of work, especially in the construction industry which is recommended to be implemented in VE, it is necessary to support the curriculum and competencies according to the standards and requirements needed in the industry [7], [14]. Some of these standards, for example, are content standards, graduate competency standards, and standards for the world of work. Through the curriculum developed, it is hoped that VE can produce graduates who are professional and have competitive careers as workers in accordance with their fields of expertise. The curriculum in schools has a character that leads to the formation of vocational competencies contained in productive programs that are reliable and work in accordance with their fields of expertise which are based on normative and adaptive scientific bases to support vocational competencies that must be achieved. It is important for each educational unit to improve quality and design the best program so that it has an impact on graduates who are ready to work.

Therefore, very important to research competency evaluation to explore competency needs according to the demands and current standards in the construction industry. The purpose of this study is to determine the competency needs according to the demands of the world of work and the urgency of competence by industry needs and standards. Through this research, it is hoped that schools will be able to determine the urgency of current competencies in architectural engineering. As an evaluation of the development and preparation of the curriculum on architectural engineering competence. Furthermore, for the construction industry, sustainable collaboration can be established in the development of competencies and school curricula. This research is expected to be able to provide an evaluation to produce input to produce competencies that are by industry needs so that it can increase the absorption of architectural engineering students' graduates.

2. RESEARCH METHOD

The research was conducted by conducting a survey in vocational education in Central Java of Indonesia and the construction service industry regarding the competencies that must be mastered for vocational school graduates in the architectural engineering department. The total sample was 193 respondents, consisting of 129 practitioners and trainers from 84 organizations in building construction companies and 64 VE teachers, from 11 VE in Central Java, Indonesia. Classification of construction service companies based on the main field of work, namely the building sector which consists of buildings, roads, bridges, and factory/workshops. Furthermore, the characteristics of the type of construction service business, the form of construction service business, employer profile, and organization category.

The use of Covariance-Based Structural Equation Modeling (CB-SEM) to estimate structural models based on strong theoretical studies to test the causality relationship between constructs and latent variables and measure the feasibility of the model and confirm it according to empirical data [3], [16]. The CB-SEM is used to analyze the relationship of the structural model which measures the dimensions between architectural engineering competency factors that must be mastered by students and the competencies required by the current construction industry [3], [17]. Research is supported with the help of the Amos 22.00 program. Data were obtained from vocational school teachers, practitioners, and trainers in the construction industry who filled out a questionnaire through the Google Form. Conducting confirmatory factor analysis (CFA) testing to ensure model fit. The first stage is testing factor analysis by considering descriptive statistical analysis, data normality, multicollinearity between variable data, and data reduction. The upper threshold value for multicollinearity results is <0.90 [3], [16]. The steps used in this research method are checking whether the data meets multivariate normality or not. The reliability test used the construct reliability (CR >0.70 and AVE >0.50) [16], [18]. The evaluation model test using the CFA method aims to test the structural model between theory and empirical data [19].

3. RESULTS

Preliminary study testing was conducted to ensure that the data were normally distributed and multicollinearity analysis met each of the measurement constructs. After these two assumptions are met, then proceed with CFA testing to ensure Internal consistency reliability, and construct validity in the evaluation of measurement and structural architectural engineering competency models. The five competency items offered from the 35 competency items were determined to be invalid because they did not meet the normality assumption on the skewness and kurtosis values and the multicollinearity value. Competencies that do not meet the assumptions are five points, namely: GT3, KJJ1, EBK1, KUG4, and PKK1. All competency items that passed the preliminary analysis totaled 30 items reaching data normality (skewness and kurtosis values>1.96) [3], [20]. Furthermore, multicollinearity analysis revealed that the 10 competency measurement constructs had an intercorrelation matrix value between 0.252 to 0.756 (<0.90). These results indicate that the discriminant validity of each aspect of competence is acceptable. The overall instrument reliability results are in the acceptable category (CR values between 0.841 to 0.950 and AVE between 0.624 to 0.932).

3.1. Evaluation of structural model

This study examines and ensures the construct validity of two evaluation models to evaluate the graduates competencies according to the industry demands. The CFA test to prove and ensure the suitability and validity of the two models offered, covering 30 items of competency for architectural engineering graduates. Further testing of CFA is based on the univariate normality and multicollinearity analysis that have been met. Figure 1 and 2 represent two models for testing the validity of architectural engineering competencies according to the assessments of VE teachers, practitioners, and trainers in the industry.

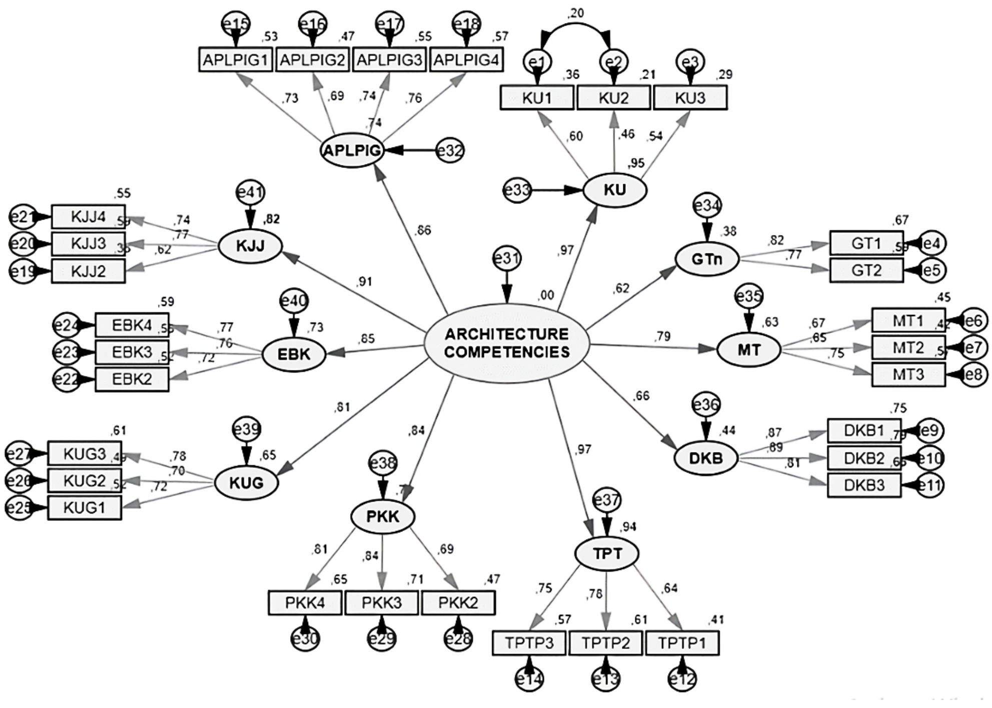

Figure 1. First order model for evaluating the competency demands of architectural engineering education

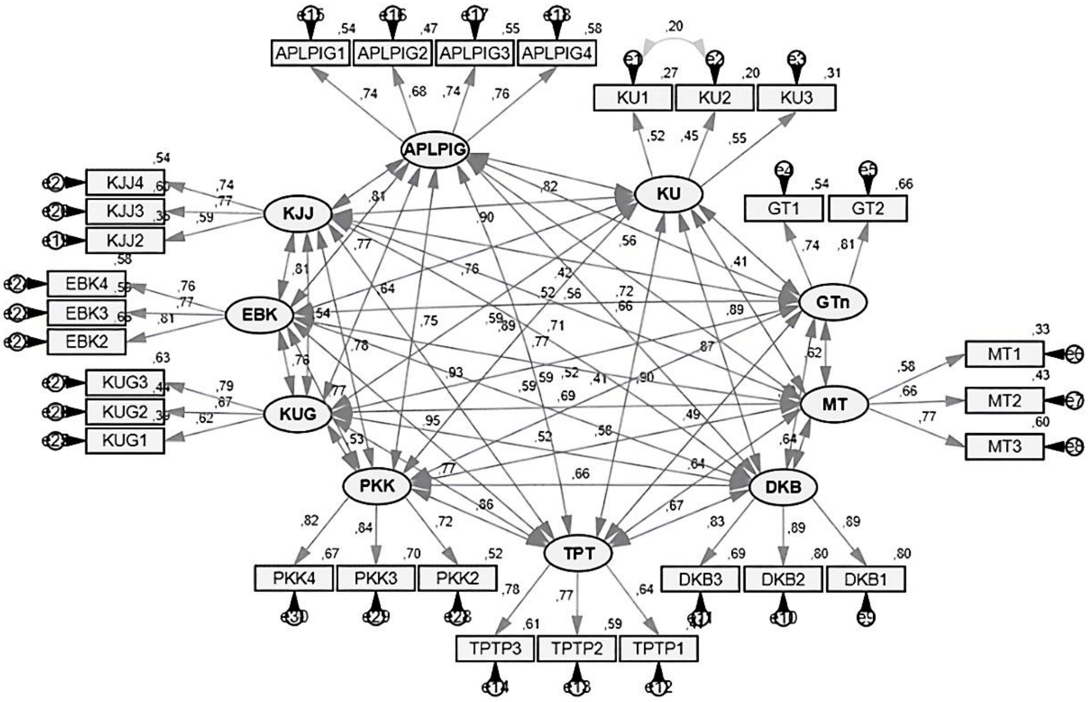

Figure 2. Second order model for evaluating the competency demands of architectural engineering education

All model fit criteria from the goodness of fit parameter used for the assessment determination have met all existing threshold values. The first and second-order measurement model for evaluating student competence produces a suitable and acceptable fit parameter value, p-value, RMSEA (≤0.08); IFI, CFI, and TLI (≥0.90) qualifies as a fit model [16], [19]–[21]. The results of the second-order evaluation model test hypothesized very well based on the GoF criteria so the model is accepted as presented in Table 1. The analysis can be concluded that both models have met the construct validity test to evaluate competence and can be used to be applied in schools on the implementation of graduate competencies. The NFI value shows a value of 0.894 in the first order and 0.901 in the second order. This model substantially explains 89.75% of the various competencies that must be mastered by architectural engineering graduates.

Table 1. The results of two order models for evaluating the competence of architectural engineering students

Model fit criteria	Parameter goodness of fit	Threshold value	1st-order output	GF (1) MG (2)	2nd-order output	GF (1) MG (2)
Absolute fit measures	GFI	≥0.90	0.896	2	0.901	1
	AGFI	≥0.90	0.859	2	0.860	2
	RMSEA	≤0.08	0.014	1	0.011	1
	RMR	≤0.10	0.015	1	0.014	1
Incremental fit measures	IFI	≥0.90	0.996	1	0.998	1
	TLI	≥0.90	0.994	1	0.997	1
	CFI	≥0.90	0.995	1	0.997	1
	NFI	≥0.90	0.894	2	0.901	1
	RFI	≥0.90	0.867	2	0.870	1
Parsimonious fit measures	PGFI	>0.50	0.668	1	0.639	1
	PNFI	>0.50	0.713	1	0.684	1
	PCFI	>0.50	0.794	1	0.757	1

GF=Good fit, MG=Marginal fit

3.2. Hypothesis test: With the criteria t-value and p-value

The results of hypothesis testing obtained t-value >1.96 and p-value <0.05, which indicates that the hypothesis is significant with the specified category. The sign of significance (***) indicates the p-value is less than 0.001. The value meets the criteria when the standard loading estimate (γ) is more than 0.5. Based on

Table 2, the hypothesis to determine the validity of the evaluation model developed to measure the achievement of student competencies is acceptable, because the t-value and p-value of all competency aspects meet the criteria in the constructed test and convergent validity.

Table 2. The validity test of the evaluation model to measure student competency achievement

Construct		Construct validity				Convergent validity	
		First-order		Second-order		First-order	Second-order
Item	Estimate	t_{value}	p_{value}	t_{value}	p_{value}	Estimate (γ)	
KU1	1.000					0.521	0.500
KU2		5.902	***	5.543	***	0.500	0.529
KU3		4.109	***	5.922	***	0.574	0.603
GT1	1.000					0.736	0.763
GT2		6.880	***	8.191	***	0.816	0.785
MT1	1.000					0.500	0.613
MT2		5.544	***	8.372	***	0.665	0.660
MT3		5.765	***	9.608	***	0.781	0.766
DKB1	1.000					0.890	0.977
DKB2		13.767	***	14.018	***	0.865	0.886
DKB3		10.069	***	13.459	***	0.658	0.826
TPTP1	1.000					0.560	0.500
TPTP2		7.731	***	10.602	***	0.854	0.783
TPTP3		7.960	***	10.414	***	0.760	0.762
APLPIG1	1.000					0.755	0.752
APLPIG2		7.626	***	9.805	***	0.784	0.693
APLPIG3		9.858	***	10.324	***	0.727	0.730
APLPIG4		10.426	***	10.907	***	0.767	0.763
KJJ2	1.000					0.813	0.516
KJJ3		10.256	***	9.719	***	0.754	0.777
KJJ4		10.073	***	8.607	***	0.751	0.818
EBK2	1.000					0.636	0.500
EBK3		10.498	***	7.578	***	0.577	1.000
EBK4		10.119	***	7.630	***	0.798	0.629
KUG1	1.000					0.713	0.229
KUG2		6.181	***	4.910	***	0.831	0.701
KUG3		7.536	***	4.981	***	0.824	0.815
PKK2	1.000					0.808	0.500
PKK3		10.867	***	10.050	***	1.000	0.814
PKK4		10.283	***	9.938	***	0.723	0.840

4. DISCUSSION

The General Competencies (KU) consists of three final indicators measuring architectural engineering competence, namely: have independence and responsibility in carrying out their job duties; have a curiosity to develop their skills on an ongoing basis; and hough to deal with work pressure, can work productively, and is beneficial to the work environment. The Basics and Technical Drawing (GT) consists of two final indicators competence, namely: drawing rules of symbols, notations, and dimensions on engineering drawings; drawing a pictorial (3D) projection. This competency indicator is in line with the results of research by Gil-Mastalerczyk [22]; Puškár, Vráblová, and Czafík [23]; and Zieliński [24] about technical drawing skills in concept drawing competencies and a basic drawing of building techniques.

The Basic Building Construction (DKB) consists of three final indicators measuring architectural engineering competence with the same results obtained by several researchers [25]–[28], namely i) Presenting the specifications and characteristics of wood, concrete, steel; ii) Carry out building construction work; and iii) Planning the use of materials and tools for construction work. The Engineering Mechanics Statics (MT) consists of three final indicators, namely: i) Calculating the balance of forces and the beam; ii) Calculation of moment, latitude, and normal forces in the application of building structures; and iii) Introduction and application of SAP 2000 software for structural planning. The results support previous studies [29], [30] on the evaluation of creative problem-solving abilities in building structure work competencies through interdisciplinary problem-based learning. The Land Measurement Techniques (TPT) consists of three final indicators, namely i) Carry out the operation of the water-pass and theodolite tools; ii) Performing measurement techniques and staking out; and iii) Performing maintenance techniques and checking the type of optics. These indicators of the competence of land measurement techniques support the results of the previous literatures [14], [30].

The Road and Bridge Construction (KJJ) consists of three final indicators measuring architectural engineering competence, namely presenting types of road and bridge drainage; and drawing views, sections, and details of roads and bridges (AutoCAD). In addition, other competencies are in line with research findings by previous researchers [14], [23], [24], namely introduction and application of the Land Desktop application to create a cross-section of the road, and introduction and application of BIM software (Revit Architecture and ArchiCAD) for road and bridge construction planning. The Building Estimation and Costing (EBK) consists of three final indicators competence. These results support research by several researchers [29], [31], namely making progress from time schedule to determine accumulated work progress; application Microsoft Project to calculate the estimated cost of the building; and making reports on building, road, and bridge construction work. The results of the Utilities and Building Construction (KUG) construct are from the literature by [23], [28], [32]. This competency consists of three final indicators competence, namely i) Making detailed drawings of buildings (foundations, columns, beams, sloof, plates, roof trusses); ii) Making isometric drawings of clean and dirty water installations; and iii) Making electrical installation drawings (AutoCAD). In addition, evidence from the literature by Zieliński [24]; Ratajczyk-Piątkowska and Piątkowska [33] can be compared with our results.

The Software Application and Interior Design of Buildings (APL-PIG) consists of four final indicators measuring architectural engineering competence. These results confirm the results obtained by previous researches [14], [24] which found that the main competencies of architectural engineering graduates include presenting data on interior design work needs: i) Determining the interior decoration materials or ornaments and interior finishing materials; ii) Introduction and application of BIM software other than AutoCAD and Sketchup, namely Revit Architecture, ArchiCAD, and Tekla Structures; iii) Introduction and application to 3D rendering software, namely Lumion, Enscape, and V-Ray. The next competency indicators that are in line with evidence from the literature [22], [33] are drawing the acoustic design of the room and checking the results of the 3D rendering, can be compared with our results. The Entrepreneurship (PKK) consists of three final indicators measuring architectural engineering competence, namely: make product/service prototype; carry out product inspections in accordance with product criteria/operational standards; and creating media based on market segmentation promotion.

5. CONCLUSION

The contributions of this research are diverse and provide both theoretical and practical contributions. The first contribution is to reveal 10 aspects and 30 points of competence that must be mastered by students to work according to current construction industry standards. Evidence of construct validity and estimation of instrument reliability is acceptable. The second contribution is to reveal and confirm the level of construct validity in two multidimensional evaluation models to evaluate the competence of architectural engineering graduates. The third contribution is the performance evaluation model developed.

The evaluation model shows a strong predictive power to measure the competencies of architectural engineering graduates. This model substantially explains 89.75% of the various competencies that architectural engineering graduates must possess to work in the construction industry. Thus, the school can evaluate the mastery of student competencies and equip competencies to be ready to work. Adjustment of work competencies needs to be carried out in schools according to the needs of the work world. So that efforts to improve the quality of the competence of architectural engineering graduates through vocational education and the availability of graduates to work can be increased. Increase the achievement of competencies by the competencies expected by the industry.

REFERENCES

[1] N. W. A. Majid, S. Fuada, M. K. Fajri, M. Nurtanto, and R. Akbar, "Progress report of cyber society v1.0 development as a learning media for Indonesian society to support EFA," *International Journal of Engineering Pedagogy*, vol. 10, no. 4, pp. 133–145, Jul. 2020, doi: 10.3991/ijep.v10i4.13085.

[2] Z. Simpson and J. Bester, "Cognitive demand and student achievement in concrete technology study," *Journal of Professional Issues in Engineering Education and Practice*, vol. 143, no. 2, Apr. 2017, doi: 10.1061/(ASCE)EI.1943-5541.0000307.

[3] V. L. Hariyanto, R. W. Daryono, N. Hidayat, S. H. Prayitno, and M. Nurtanto, "A framework for measuring the level of achievement of vocational students competency of architectural education," *Journal of Technology and Science Education*, vol. 12, no. 1, pp. 157–171, Mar. 2022, doi: 10.3926/JOTSE.1188.

[4] V. Sima, I. G. Gheorghe, J. Subić, and D. Nancu, "Influences of the industry 4.0 revolution on the human capital development and consumer behavior: A systematic review," *Sustainability (Switzerland)*, vol. 12, no. 10, p. 4035, May 2020, doi: 10.3390/SU12104035.

[5] Z. Arifin, M. Nurtanto, W. Warju, R. Rabiman, and N. Kholifah, "The TAWOCK conceptual model at content knowledge for professional teaching in vocational education," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 9, no. 3, pp. 697–703, Sep. 2020, doi: 10.11591/ijere.v9i3.20561.

[6] R. W. Daryono, S. Rochmadi, and N. Hidayat, "Development and validation of video-based learning media to increase competency achievement in civil engineering education," *Journal of Physics: Conference Series*, vol. 1833, no. 1, p. 012022, Mar. 2021, doi: 10.1088/1742-6596/1833/1/012022.

[7] M. Olazaran, E. Albizu, B. Otero, and C. Lavía, "Vocational education-industry linkages: intensity of relationships and firms' assessment," *Studies in Higher Education*, vol. 44, no. 12, pp. 2333–2345, Dec. 2019, doi: 10.1080/03075079.2018.1496411.

[8] F. Mutohhari, S. Sutiman, M. Nurtanto, N. Kholifah, and A. Samsudin, "Difficulties in implementing 21st century skills competence in vocational education learning," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 10, no. 4, pp. 1229–1236, Dec. 2021, doi: 10.11591/ijere.v10i4.22028.
[9] H. Yudiono, Soesanto, and Haryono, "An industrial competency-based curriculum alignment model," *World Transactions on Engineering and Technology Education*, vol. 16, no. 1, pp. 18–22, 2018.
[10] C. Hofmann, X. Müller, A. Krauss, and K. Häfeli, "Transition from low-threshold vocational education and training to work in Switzerland: Factors influencing objective and subjective career success," *International Journal for Research in Vocational Education and Training*, vol. 8, no. 2, pp. 136–159, Jun. 2021, doi: 10.13152/IJRVET.8.2.1.
[11] A. Santoso, T. Sukardi, S. H. Prayitno, S. Widodo, and R. W. Daryono, "Design development of building materials lab for teacher education institutes on vocational and academic program," *Pegem Journal of Education and Instruction*, vol. 12, no. 4, pp. 310–320, Oct. 2022, doi: 10.47750/pegegog.12.04.32.
[12] P. Kesai, R. Soegiarso, S. Hardjomuljadi, M. I. Setiawan, D. Abdullah, and D. Napitupulu, "Indonesia position in the globalization of construction industry," *Journal of Physics: Conference Series*, vol. 1114, no. 1, p. 012133, Nov. 2018, doi: 10.1088/1742-6596/1114/1/012133.
[13] M. Nurtanto, H. Sofyan, P. Pardjono, and S. Suyitno, "Development model for competency improvement and national vocational qualification support frames in automotive technology," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 9, no. 1, pp. 168–176, Mar. 2020, doi: 10.11591/ijere.v9i1.20447.
[14] R. W. Daryono, A. P. Yolando, A. Jaedun, and N. Hidayat, "Competency of vocational schools required by construction industry in consultants' supervisor," *Journal of Physics: Conference Series*, vol. 1456, no. 1, p. 012057, Jan. 2020, doi: 10.1088/1742-6596/1456/1/012057.
[15] M. Wijayanti and A. Jaedun, "The relevance of civil engineering graduate's competences to work in construction industry," *Jurnal Kependidikan: Penelitian Inovasi Pembelajaran*, vol. 3, no. 1, pp. 81–94, Jul. 2020, doi: 10.21831/jk.v3i1.18115.
[16] R. Hidayat, S. N. A. Syed Zamri, and H. Zulnaidi, "Exploratory and confirmatory factor analysis of achievement goals for Indonesian students in mathematics education programmes," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 14, no. 12, Oct. 2018, doi: 10.29333/ejmste/99173.
[17] L. D. Prasojo, A. Habibi, A. Mukminin, Sofyan, B. Indrayana, and K. Anwar, "Factors influencing intention to use web 2.0 in Indonesian vocational high schools," *International Journal of Emerging Technologies in Learning*, vol. 15, no. 5, pp. 100–118, Mar. 2020, doi: 10.3991/ijet.v15i05.10605.
[18] M. N. Waffak, P. Sukoco, FX. Sugiyanto, E. Arifianti, J. Setiawan, and R. W. Daryono, "Developing a Basketball Learning Model Using the Teaching Game for Understanding (TGfU) Approach to Improve the Effectiveness of HOTS in Elementary Schools," *Physical Education Theory and Methodology*, vol. 22, no. 3, pp. 21–29, Dec. 2022, doi: 10.17309/tmfv.2022.3s.03.
[19] A. Hanif, A. F. Siddiqi, and Z. Jalil, "Are computer experience and anxiety irrelevant? Towards a simple model for adoption of e-learning systems," *International Journal of Engineering Pedagogy*, vol. 9, no. 5, pp. 112–125, Nov. 2019, doi: 10.3991/ijep.v9i5.11488.
[20] M. Zare and N. Nastiezaie, "The relationship between distributed leadership and work self-efficacy with the mediating role of academic optimism of the teacher," *The New Educational Review*, vol. 58, no. 4, pp. 169–178, Dec. 2019, doi: 10.15804/tner.19.58.4.13.
[21] A. W. Fadiji and V. Reddy, "Learners' educational aspirations in South Africa: The role of the home and the school," *South African Journal of Education*, vol. 40, no. 2, pp. 1–13, May 2020, doi: 10.15700/saje.v40n2a1712.
[22] J. Gil-Mastalerczyk, "The importance of the relationship between religion and architecture through the lens of architectural education," *World Transactions on Engineering and Technology Education*, vol. 20, no. 1, pp. 25–32, 2022, [Online]. Available: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V20N1.html.
[23] B. Puškár, E. Vráblová, and M. Czafík, "The concept of an intelligent building in architectural education," *World Transactions on Engineering and Technology Education*, vol. 20, no. 1, pp. 19–24, 2022, [Online]. Available: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V20N1.html.
[24] R. Zieliński, "New technologies to support students in a BIM design course," *World Transactions on Engineering and Technology Education*, vol. 18, no. 3, pp. 313–317, 2020, [Online]. Available: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V18N3.html.
[25] W. Celadyn, "Architectural education to improve technical detailing in professional practice," *Global Journal of Engineering Education*, vol. 22, no. 1, pp. 57–63, 2020, [Online]. Available: http://www.wiete.com.au/journals/GJEE/Publish/TOCVol22No1.html.
[26] S. Li, X. Zhao, and G. Zhou, "Automatic pixel-level multiple damage detection of concrete structure using fully convolutional network," *Computer-Aided Civil and Infrastructure Engineering*, vol. 34, no. 7, pp. 616–634, Jul. 2019, doi: 10.1111/mice.12433.
[27] Z. Simpson and J. Bester, "Cognitive Demand and Student Achievement in Concrete Technology Study," *Journal of Professional Issues in Engineering Education and Practice*, vol. 143, no. 2, Apr. 2017, doi: 10.1061/(ASCE)EI.1943-5541.0000307.
[28] A. Taraszkiewicz, "Freehand drawing versus digital design tools in architectural teaching," *Global Journal of Engineering Education*, vol. 23, no. 2, pp. 100–105, 2021, [Online]. Available: http://www.wiete.com.au/journals/GJEE/Publish/TOCVol23No2.html.
[29] V. L. Hariyanto, R. W. Daryono, N. Hidayat, S. H. Prayitno, and M. Nurtanto, "A framework for measuring the level of achievement of vocational students competency of architecture education," *Journal of Technology and Science Education*, vol. 12, no. 1, pp. 157–171, Mar. 2022, doi: 10.3926/jotse.1188.
[30] D. P. McCrum, "Evaluation of creative problem-solving abilities in undergraduate structural engineers through interdisciplinary problem-based learning," *European Journal of Engineering Education*, vol. 42, no. 6, pp. 684–700, Nov. 2017, doi: 10.1080/03043797.2016.1216089.
[31] A. Gębczyńska-Janowicz, "Virtual reality technology in architectural education," *World Transactions on Engineering and Technology Education*, vol. 18, no. 1, pp. 24–28, 2020.
[32] E. Węcławowicz, "Teaching building surveying of valuable historical timber architecture," *Global Journal of Engineering Education*, vol. 23, no. 1, pp. 49–54, 2021, [Online]. Available: http://www.wiete.com.au/journals/GJEE/Publish/TOCVol23No1.html.
[33] E. Ratajczyk-Piątkowska and K. Piątkowska, "Three-dimensional and synchronous resolution of functional and spatial aspects in architectural design," *World Transactions on Engineering and Technology Education*, vol. 18, no. 1, pp. 45–50, 2020, [Online]. Available: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V18N1.html.

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