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THE DEVELOPMENT OF A COMPETENCY FRAMEWORK FOR ARCHITECTURAL ENGINEERING GRADUATES: PERSPECTIVES BY THE CONSTRUCTION INDUSTRY IN INDONESIA

Rihab Wit Daryono[1*], Nur Hidayat[2], Muhammad Nurtanto[3], Athok Fu'adi[4]

[1]Department of Islamic Education, Ponorogo State Islamic Institute (Indonesia)

[2]Department of Civil Engineering and Planning Education, Yogyakarta State University (Indonesia)

[3]Department of Mechanical Engineering, Jakarta State Polytechnic (Indonesia)

[4]Islamic Education Management, Ponorogo State Islamic Institute (Indonesia)

**Corresponding author: rihabwit.daryono@iainponorogo.ac.id*

nurhidayat@uny.ac.id, mnurtanto23@untirta.ac.id, athok@iainponorogo.ac.id

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Abstract

The discrepancy between competence and real work in engineering graduates can be resolved with cooperation by the construction industry. Therefore, it is necessary to determine the appropriate and required architectural engineering competencies with the current demands and conditions of the construction industry. So, this study aims to analyze the determinants of competence and test the competency development model for architectural engineering graduates according to the needs of the construction industry. The research sample method is non-probability sampling using purposive sampling. The research sample consisted of 240 practitioners and trainers from 40 construction industry companies. The PLS-SEM technique was used to test the measurement and structural models (3 dimensions, 8 elements, 47 constructs/indicators, and 9 hypotheses). The competence of architecture graduates is determined by the dominant factor, namely Utilities and Building Construction (UBC1 & UBC2, λ = 89.90%), and Building Estimation and Costing (BEC7, λ = 73.30%) is the lowest factor. The ability of the structural model to explain architectural competency measurements is 36.20% in the moderate category. The predictive relevance value (Q2) explains 47.5% to 56.0% of the phenomena predicted in the field and explains the level of strength of the observed value in the structural model. Furthermore, 9 hypotheses from 8 dimensions have a positive and significant effect. The results of this study can be a recommendation for schools in the competency implementation model, and efforts to improve graduates' abilities and skills so that they can be absorbed by the construction industry and reduce unemployment.

Keywords – Architectural engineering, Competency, Construction industry, Students' graduates, Vocational education.

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1. Introduction

Vocational Education (VE) has an important role in preparing a workforce that is required to be able to follow the trend of competency development needed by the industrial world (Olazaran, Albizu, Otero & Lavía, 2019; Perusso & Baaken, 2020). The VE has the main mission to produce workers who have professional skills according to the demands of work competencies and have a good attitude to work (Beicht & Walden, 2019; Setyadi, Triyono & Daryono, 2021). In addition, VE graduates can continue to higher education and are expected to create jobs as independent entrepreneurs (Supriyadi, Indro, Priyanto & Surwi, 2020). The reality on the ground shows that the current existence of VE is considered to be lacking in preparing graduates as ready to work (Beicht & Walden, 2019; Draaisma, Meijers & Kuijpers, 2018; Nurtanto, Arifin, Sofyan, Warju & Nurhaji, 2020; Santoso, Sukardi, Prayitno, Widodo & Daryono, 2022; Setyadi et al., 2021). Improving the quality and competitiveness of resources for VE graduates can be promoted the revitalization of vocational high schools. Operationally, the revitalization of education at VE is realized through: first, increasing collaboration between VE and industry (Kesai, Soegiarso, Hardjomuljadi, Setiawan, Abdullah & Napitupulu, 2018; Olazaran et al., 2019). Second, the involvement and use of industry as a place for internships, work practices, and places to learn the management of the world of work (Ćudić, Alešnik & Hazemali, 2022; Perusso & Baaken, 2020). Third, the alignment of the VE curriculum, by the applied dual system model, both in determining work practice activities and learning through the teaching factory.

According to the results of a national labor force survey conducted by the Central Statistics Agency in Indonesia, in February 2021 the unemployment rate for VE was the highest among other education levels at 7.42%, when compared to August 2020, it increased by 0.16% points. The Central Statistics Agency in Indonesia 2021 revealed that the result data on the unemployment rate for VE graduates was still the highest compared to graduates of other education levels at 11.13%. Meanwhile, the average unemployment rate for several countries in 2021 shows that the unemployment rate in Indonesia is 5.90%, ranking 16th out of 32 countries. This fact shows that the role of vocational schools as educational institutions makes graduates unable to work according to their field of expertise. Thus, this fact indicates that there is a gap between the competencies of VE graduates and industry needs (Daryono, Yolando, Jaedun & Hidayat, 2020; Rosantono, Wijanarka, Daryono & Nurtanto, 2021).

To create the competency alignment between architectural engineering graduates, it is necessary to involve stakeholders and experts in the field of construction in planning and designing graduate competencies (Daryono et al., 2020; Hariyanto, Daryono, Hidayat, Prayitno & Nurtanto, 2022). In addition to the problem of limited employment opportunities due to the country's economic growth that has not met expectations, the high unemployment rate indicates a mismatch between supply and demand. Both are related to the quality and relevance of competence in the field of expertise between the workforce who graduated from VE and the needs of the industrial world (Ćudić et al., 2022; Kesai et al., 2018). The competency gap between what is reflected in graduates and the competency qualifications required by the industrial world can be reduced by aligning competencies and their relevance according to current needs according industry demands (Okolie, Nwajiuba, Binuomote, Osuji, Onajite & Igwe, 2020; Olazaran et al., 2019).

The perspective of construction industry practitioners as users of architectural engineering graduates is that graduates must have professionalism in work, and they must have competencies and skills that are in accordance with industry needs (Celadyn, 2020; Hariyanto et al., 2022; Taraszkiewicz, 2021). The demand of the industry is not an easy job because it requires good cooperation between schools and industry regarding the development of competencies taught in schools (Daryono, Rochmadi & Hidayat, 2021). This effort has been made by the Indonesian government and schools in compiling a curriculum that involves stakeholders, academics and construction industry experts (Surya & Mulyanti, 2020). The role of stakeholders is the main key in determining and implementing what competencies are taught in schools according to industry demands.

This data also reveals that to enter the world of work, VE graduates still face many challenges. According to (Daryono et al., 2020; Surya & Mulyanti, 2020), there are at least two challenges faced by VE graduates to enter the workforce. First, the curriculum and architectural engineering competencies are not relevant to the competencies demanded in the current construction industry, so the graduate competencies cannot meet the requirements according to industry needs. Second, is the lack of educational facilities and infrastructure at VE in vocational practice learning (Draaisma et al., 2018; Okolie et al., 2020; Olazaran et al., 2019). In addition, schools also need to better direct their graduates to become entrepreneurs, so that it can be one way out to reduce the unemployment rate of VE graduates. So the process of entrepreneurship development and business incubation for students and graduates of VE is very much needed.

The discrepancy between competence and actual work in architectural engineering graduates can be resolved by cooperation and retraining by the construction industry. However, it is rare for the industry to be willing to carry it out because training requires manpower, time, space, and costs so it is not profitable for the company. So, it is important to research architectural engineering competence against the demands and needs of the construction industry. Therefore, this study aims to analyze the determinants of competence and test the competency development model for architectural engineering graduates according to the needs of the construction industry. The results of the research will become input for the development of curriculum and competencies in the architectural engineering department at VE. So that it can increase the competence of graduates and the absorption of VE graduates in the construction service industry. The results of this study can become recommendations for schools in the competency implementation model, and efforts to increase the capabilities and skills of graduates so that they can be absorbed by the construction industry and reduce unemployment.

2. Literature Review

2.1. Basic Fields of Expertise (C1)

The basic fields of expertise subjects are binding substantive subjects that function as the main focus of the vocational program. In the architectural engineering department, competence is divided into several competency areas, namely: Basics and Technical Drawing (BTD), Building Construction Basics (BCB), Engineering Mechanics Statics (EMS), and Land Measurement Techniques (LMT). Basics and Technical Drawing (BTD) is one of the skill competencies that equip students with knowledge and skills in terms of drawing the basics of architectural buildings which includes: drawing pictures of plane shapes, pieces of a building, 2D and 3D projections, and introduction BIM software. Building Construction Basics (BCB) is a skill competency that equips students with the skills to implement and plan materials for a building, including woodwork, concrete, steel, soil, etc. (Li, Zhao & Zhou, 2019; Simpson & Bester, 2017; Taraszkiewicz, 2021). Engineering Mechanics Statics (EMS) is a skill competency that equips students with the skills to analyze and calculate the balance of forces, beams, moments, and other structural elements (Hariyanto et al., 2022; McCrum, 2017). Land Measurement Techniques (LMT) is a competency skill that equips students with field survey skills and tools such as theodolite and spirit level, performance measurement techniques, and staking out and making the results of field survey measurements (Daryono et al., 2020; Hariyanto et al., 2022).

2.2. Basic Skills Program (C2)

The basic skills program subjects are specific vocational content within the scope of skills competency. In the architectural engineering department, competence is divided into several areas of competence, namely: Building Estimation and Costing (BEC), Road and Bridge Construction (RBC), and Utilities and Building Construction (UBC). Building Estimation and Costing (BEC) is a competency skill that equips students with the skills to analyze the calculation of the volume of work in a building, present specifications for building construction materials, and make estimates and reports on building construction costs (Daryono et al., 2020; Gębczyńska-Janowicz, 2020; Hariyanto et al., 2022). Road and Bridge Construction (RBC) is a skill competency that equips students with the skills to present road and bridge classifications and to draw construction and road and bridge details (Gębczyńska-Janowicz, 2020; Zieliński, 2020). Utilities and Building Construction (UBC) is a skill competency that equips students with the skills to draw a floor plan, cut, view, and detail a building. Make isometric drawings of electrical installations, clean water, dirty water, and rain flows (Puškár, Vráblová & Czafík, 2022; Taraszkiewicz, 2021; Węcławowicz, 2021).

2.3. Skills Competency (C3)

The skills competency subjects are specific vocational content within the scope of the vocational field they are engaged in. Vocational competencies are prepared based on the vocational curriculum by schools and work competencies are according to industry needs by stakeholders. In this case, the vocational field in architectural engineering is the Software Applications and Building Interior (SAB) competency as the dominant graduate competency for architectural engineering (Gil-Mastalerczyk, 2022; Ratajczyk-Piątkowska & Piątkowska, 2020).

3. Method

3.1. Sample

This research is quantitative with a survey method approach. The research aims to analyze the determinants of competence and to test the competency development model for architectural engineering graduates according to the needs of the construction industry. The research was conducted in the province of Central Java, Indonesia about research by experts in the field of building construction. The characteristics of the research sample are shown in Table 1. Research respondents were selected based on purposive sampling in several fields of construction, namely the fields of buildings, roads, and bridges. This research is quantitative with a survey method approach. The research sample consisted of 240 practitioners and trainers from 40 construction industry companies.

Characteristics		Freq.	Characteristics		Freq.
Gender	Male	153	Specific sectors	Buildings	171
	Female	87		Roads	43
	Total	240		Bridges	26
Age range	25-30	56		Total	240
	>30-35	69	Profile of employer	Director	12
	>35-40	52		General Manager	14
	>40	63		Project Manager	19
	Total	240		Site Manager	26
Educational background	Diploma	77		Senior Engineer	33
	Bachelor	115		Senior Drafter/Detailer	34
	Master	38		Architect	70
	Doctor	10		Estimator	32
	Total	240		Total	240
Experience in construction (year)	<5	41	Construction services business	Limited liability company	71
	05-Okt	64		CV	108
	>10	135		Individual	61
	Total	240		Total	240

Table 1. Research respondents: construction expert

3.2. Research Instruments

The questionnaire contains competency indicators to be assessed by construction experts on the urgency of the 49 proposed competencies based on a 4-point scale: very important (4), important (3), moderately (2), and unrequired (1). In addition, it is also important to know and provide opportunities for experts to express their opinions regarding the current level of urgency of architectural competence required and the demands of graduates to be able to work in the construction industry. Then an open question was added: *"Are there any competency indicators that are still lacking according to the needs of the construction industry?"* if there are competencies that may not be included in closed questions. The construction of competency measurement is shown in Table 2.

No	Dimension	Elements	Construct	Indicators	References
1	Basic Fields of Expertise (C1)	Basics and Technical Drawing (BTD)	BTD1	Drawing sketch	(Gil-Mastalerczyk, 2022; Makowska, 2021; Puškár et al., 2022; Zieliński, 2020)
2			BTD2	Symbols, notations, and dimensions	
3			BTD3	Drawings and building details	
4			BTD4	Draw a 3D projection	
5			BTD5	Draw the projection using BIM software	
6		Building Construction Basics (BCB)	BCB1	Application of Tekla Structures	(Celadyn, 2020; Hariyanto et al., 2022; Li et al., 2019; Simpson & Bester, 2017; Taraszkiewicz, 2021)
7			BCB2	Health and safety in building work	
8			BCB3	Wood, concrete, and steel construction	
9			BCB4	Material planning in constr uction work	
10			BCB5	Implementation of building construction	
11			BCB6	Construction work inspection	
12		Engineering Mechanics Statics (EMS)	EMS1	Analyze the strength balance of the building	(Daryono, Ramadhan, Kholifah, Isnantyo & Nurtanto, 2023; Hariyanto et al., 2022; McCrum, 2017)
13			EMS2	Analyze the stress on the beam	
14			EMS3	Analyze structural elements	
15			EMS4	Analyze the moment of the building structure	
16			EMS5	Structural planning using SAP 2000	
17		Land Measurement Techniques (LMT)	LMT1	Field survey and measurement tools	(Daryono et al., 2020; Gil-Mastalerczyk, 2022; Hariyanto et al., 2022)
18			LMT2	Field measurement sketch	
19			LMT3	Water-pass and theodolite	
20			LMT4	Total station in building measurements	
21			LMT5	Total station in road measurement	
22			LMT6	Analyze measurement results	
23	Basic Skills Program (C2)	Utilities and Building Construction (UBC)	UBC1	Building plan drawing	(Burke & Parrish, 2018; Puškár et al., 2022; Taraszkiewicz, 2021; Węcławowicz, 2021)
24			UBC2	Building details	
25			UBC3	Stair construction drawing	
26			UBC4	Piping installation drawings	
27			UBC5	Water isometric drawing	
28			UBC6	Electrical installation drawings	
29		Building Estimation and Costing (BEC)	BEC1	Construction work materials	(Daryono et al., 2020; Gębczyńska-Janowicz, 2020; Hariyanto et al., 2022; Ratajczyk-Piątkowska & Piątkowska, 2020)
30			BEC2	Methods of calculating for construction materials	
31			BEC3	Determine the unit price of the building	
32			BEC4	The volume of construction work	
33			BEC5	Calculating the construction work budget	
34			BEC6	Time schedule progress	
35			BEC7	Ms. Project for construction cost estimation	
36		Road and Bridge Construction (RBC)	RBC1	Classification of roads and bridges	(Daryono et al., 2023; Matusik, 2020; Puškár et al., 2022; Zieliński, 2020)
37			RBC2	Road and bridge drainage	
38			RBC3	Drawing of road and bridge construction	
39			RBC4	Road and bridge construction details	
40			RBC5	Land Desktop for road planning	
41			RBC6	ArchiCAD and Revit Architecture for road and bridge construction planning	
42	Skills Competency (C3)	Software Applications and Building Interior (SAB)	SAB1	Interior and exterior materials and ornaments	(Gębczyńska-Janowicz, 2020; Gil-Mastalerczyk, 2022; Łątka & Michałek, 2021; Ratajczyk-Piątkowska & Piątkowska, 2020)
43			SAB2	Autocad for 2D and 3D	
44			SAB3	Revit Architecture and ArchiCAD for 3D	
45			SAB4	Artificial colors and lighting	
46			SAB5	3D rendering using Lumion and V-Ray	
47			SAB6	Interior design lay out	
48			SAB7	Interior design mockup	
49			SAB8	Interior and exterior materials and ornaments	

Table 2. Construction of competency measurement for architectural engineering graduates

3.3. Research Design and Hypothesis

In general, PLS-SEM aims to test whether the relationship and predictive effect between constructs. The consequence of using PLS-SEM is that testing can be carried out by ignoring several assumptions (non-parametric) and parameter estimation is carried out directly without the goodness of fit criteria requirements (Al-Fraihat, Joy, Masa'deh & Sinclair, 2020; Apriliani, Widihastuti, Daryono, Jaya & Rizbudiani, 2023). In this study, the PLS-SEM technique was used to test the structural model because of its great complexity with many constructs and indicators, there are 3 measurements, 8 constructs, 49 indicators, and 9 relationships. In addition, the coefficient of determination is used to estimate the accuracy of the model construct.

Based on the explanation of skill competencies in Basic Fields of Expertise (C1), Basic Skills Program (C2), Expertise Competencies (C3) that must be mastered by architectural engineering graduates according to the demands of the construction industry to work, this study formulates the following hypothesis: H1, H2, H3, H4. Competencies in BTD, BCB, EMS, LMT positively affect the Basic Fields of Expertise (C1) as competence demands on current architectural engineering graduates. H5, H6, H7. Competencies in BEC, RBC, UBC positively affect the Basic Skills Program (C2) as competence demands on current architectural engineering graduates. H8, H9. Competencies in C1 and C2 positively affect Skills Competency (C3/SAB) as competence demands on current architectural engineering graduates. The structural model in PLS-SEM in the path diagram of the relationship between construct variables and latent variables as a determinant of the competence of architectural engineering graduates is generally shown in Figure 1.

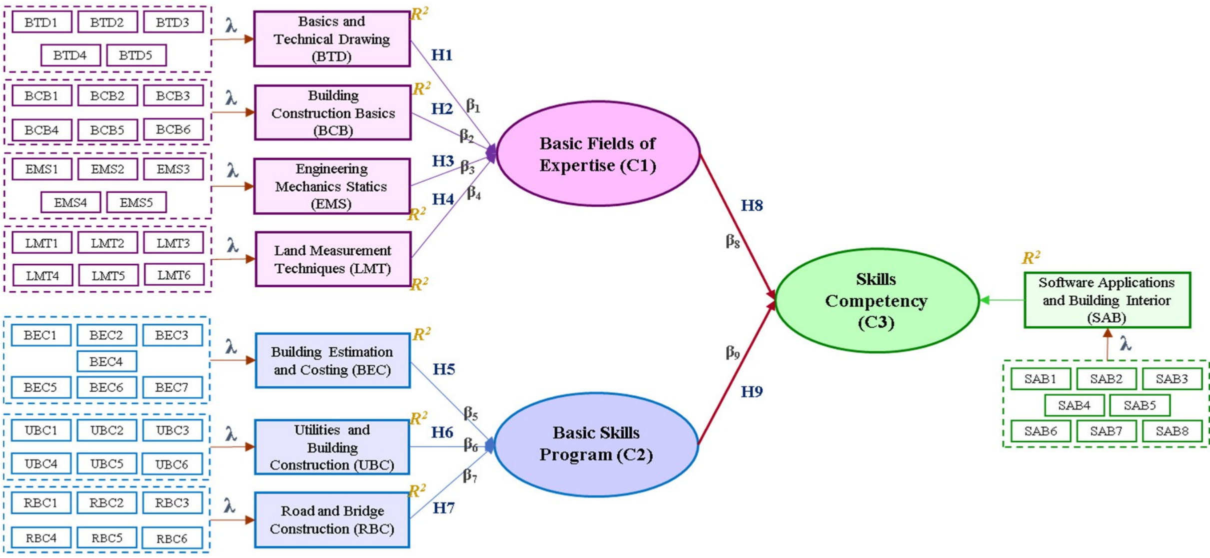

Figure 1. The research model framework

3.4. Data Analysis

Interpretation of measurement data based on evaluation of measurements and structural models. Evaluation of measurement model (Al-Fraihat et al., 2020; Daryono et al., 2023; Dash & Paul, 2021; Hair, Howard & Nitzl, 2020; Hariyanto et al., 2022; Supriyanto, Munadi, Daryono, Tuah, Nurtanto & Arifah, 2023): (1) Internal consistency reliability (>0.70): using the indicator of Cronbach's alpha (α), rho_A (φ), and Composite Reliability (δ). (2) construct validity: (a) convergent validity using the indicator of Factor Loading (λ >0.70) and AVE (≥0.50); and (b) discriminant validity using the indicator of Fornell-Larcker (each construct is greater than the correlation with another construct). Evaluation of structural model (Apriliani et al., 2023; Hair, Ringle, Gudergan, Fischer, Nitzl & Menictas, 2019; Hair, Howard & Nitzl, 2020; Khan, 2021; Law & Fong, 2020): effect size (f^2); coefficient of determination (R^2); predictive relevance (Q^2); path coefficient (β-$_{coefficient}$, ϱ-$_{value}$; and T-$_{statistics}$); and model's fit (SRMR ≤0.08; NFI >50%; and RMSTheta ≤0.12).

4. Findings

4.1. Preliminary Study

In the initial stage before evaluating the structural model, the evaluation of measurement is carried out first to ensure the convergent validity of the constructed model on each competency indicator. Convergent validity using the indicator of FL 0.70, if <0.70 then the indicator is eliminated from the constructed model. Based on the first run in the PLS Algorithm, totaling 49 indicators, 2 indicators failed on FL elimination <0.70. First, the Utilities and Building Construction (UBC) construct, namely the UBC4 indicator on the competence of presenting the specifications of piping installation, obtained a FL value of 0.659. The Building Estimation and Costing (BEC) construct, which is the BEC1 indicator of the competence of presenting the specifications of construction work materials, gets a FL value of 0.573. So, the two indicators are not included in the next stage, namely the evaluation of the structural model. Finally, there are 47 valid architectural engineering competency indicators for the evaluation of the measurement and structural model testing.

4.2. Construct Validity: Convergent Validity

Based on Table 3, the overall factor loading value for each indicator is >0.70 (0.730-BEC7 to 0.899-UBC1 & UBC2). The AVE value for each dimension has a value of >0.50 (0.599-SAB to 0.714-UBC). So it can be concluded that each indicator and dimension on the instrument has supported the convergent validity requirements. This means that the level of relationship between indicators and dimensions can be explained by 73.00% to 89.90%.

Based on the value of the loading factor coefficient, the most dominant statement indicators represent the successful competence of architectural engineering graduates namely UBC1 & UBC2 with the statements "Building plan drawing" and "Building details" on the Utilities and Building Construction (UBC) dimension of 89.90%. Meanwhile, the weakest indicator in measuring the success of architectural engineering graduate competencies is BEC7 with the statement "Ms. Project for construction cost estimation" in the organizational dimension of 73.30%.

No	Indicators	Construct	Convergent Validity		Internal Consistency Reliability			VIF <5.00
			FL (λ>0.70)	AVE (>0.50)	CA (α>0.70)	rho_A (φ>0.70)	CR (δ>0.70)	
1	Basics and Technical Drawing	BTD1	0.818	0.676	0.888	0.886	0.912	2.198
2		BTD2	0.834					2.432
3		BTD3	0.846					2.646
4		BTD4	0.797					2.174
5		BTD5	0.814					2.306
6	Building Construction Basics	BCB1	0.825	0.671	0.902	0.907	0.924	2.395
7		BCB2	0.792					2.178
8		BCB3	0.812					2.265
9		BCB4	0.806					2.181
10		BCB5	0.832					2.547
11		BCB6	0.846					2.757
12	Engineering Mechanics Statics	EMS1	0.797	0.654	0.868	0.870	0.904	2.124
13		EMS2	0.832					2.437
14		EMS3	0.810					2.301
15		EMS4	0.788					2.061
16		EMS5	0.818					2.142
17	Land Measurement Techniques	LMT1	0.781	0.656	0.895	0.898	0.920	2.09
18		LMT2	0.863					3.32
19		LMT3	0.789					2.353

No	Indicators	Construct	Convergent Validity		Internal Consistency Reliability			VIF <5.00
			FL (λ>0.70)	AVE (>0.50)	CA (α>0.70)	rho_A (φ>0.70)	CR (δ>0.70)	
20		LMT4	0.791					2.363
21		LMT5	0.781					2.117
22		LMT6	0.850					3.222
23	Utilities and Building Construction	UBC1	0.899	0.714	0.899	0.904	0.926	3.234
24		UBC2	0.899					3.385
25		UBC3	0.790					1.934
26		UBC5	0.828					2.170
27		UBC6	0.804					2.137
28	Building Estimation and Costing	BEC2	0.849	0.663	0.898	0.905	0.922	4.648
29		BEC3	0.894					4.583
30		BEC4	0.800					2.982
31		BEC5	0.745					1.751
32		BEC6	0.856					4.827
33		BEC7	0.730					1.972
34		RBC1	0.819					2.287
35	Road and Bridge Construction	RBC2	0.809	0.678	0.905	0.906	0.920	2.069
36		RBC3	0.839					2.688
37		RBC4	0.783					1.948
38		RBC5	0.823					2.317
39		RBC6	0.865					2.763
40	Software Applications and Building Interior	SAB1	0.739	0.599	0.904	0.907	0.923	1.939
41		SAB2	0.804					3.714
42		SAB3	0.751					1.886
43		SAB4	0.745					1.882
44		SAB5	0.749					1.906
45		SAB6	0.815					2.448
46		SAB7	0.776					2.273
47		SAB8	0.809					3.418

Table 3. Convergent Validity and Reliability

4.3. Construct Validity: Discriminant Validity

Based on the results PLS Algorithm in Table 4, the value of the Fornell-Larcker Criteria for each construct (BTD, BCB, BEC, EMS, LMT, RBC, SAB, UBC) is greater than the correlation with another construct. In the EMS construct, the FLC value is 0.809, which is greater than the correlation with another construct, namely EMS→LMT of 0.008, EMS→RBC of 0.027, EMS→SAB of 0.049, and EMS→UBC of 0.292. The value of cross-loading at the output of Table 4 ranges from 0.797 to 0.899 (>0.70). Because all indicators have a larger outer loading value with their construct compared to other constructs, this model has met the requirements of discriminant validity. The Heterotrait-Monotrait (HTMT) value obtained in the PLS Algorithm run is at least <0.9 (Al-Fraihat et al., 2020; Kurup, Li, Powell & Brown, 2019) so the discriminant validity testing of all constructs has certainly been fulfilled in measuring the competency of architectural engineering.

Indicators	BTD	BCB	BEC	EMS	LMT	RBC	SAB	UBC
BTD	0.822*							
BCB	0.152*	0.819*						
	0.170**							
BEC	0.226*	0.285*	0.814*					
	0.254**	0.313**						
EMS	0.181*	0.223*	0.126*	0.809*				
	0.204**	0.244**	0.175**					
LMT	0.054*	0.034*	0.127*	0.008*	0.810*			
	0.111**	0.082**	0.155**	0.094**				
RBC	0.237*	0.237*	0.064*	0.027*	0.078*	0.823*		
	0.264**	0.261**	0.123**	0.110**	0.105**			
SAB	0.125*	0.197*	0.333*	0.049*	0.710*	0.232*	0.774*	
	0.283**	0.193**	0.127**	0.324**	0.206**	0.223**		
UBC	0.255*	0.179*	0.111*	0.292*	0.188*	0.209*	0.300*	0.845*
	0.144**	0.220**	0.382**	0.117**	0.786**	0.260**	0.328**	

Note: *fornell-larcker; ** HTMT

Table 4. Discriminant validity: correlation matrix of fornell-larcker and HTMT

4.4. Internal Consistency Reliability

This measurement aims to estimate how much each construct can assess the latent variable, namely the demands of architectural competence. The value of each measurement is considered reliable and must be above 0.70. Based on the output PLS Algorithm of Table 3, it is found that all constructs have values α = 0.868 to 0.905, rho_A = 0.886 to 0.907, and C.R. = 0.904 to 0.926. This test concludes that all construct measurements get values >0.7. So, it can be said that all constructs for measuring the competence of architectural engineering graduate students have been reliable. The measurement of the evaluation model are shown in Figure 2.

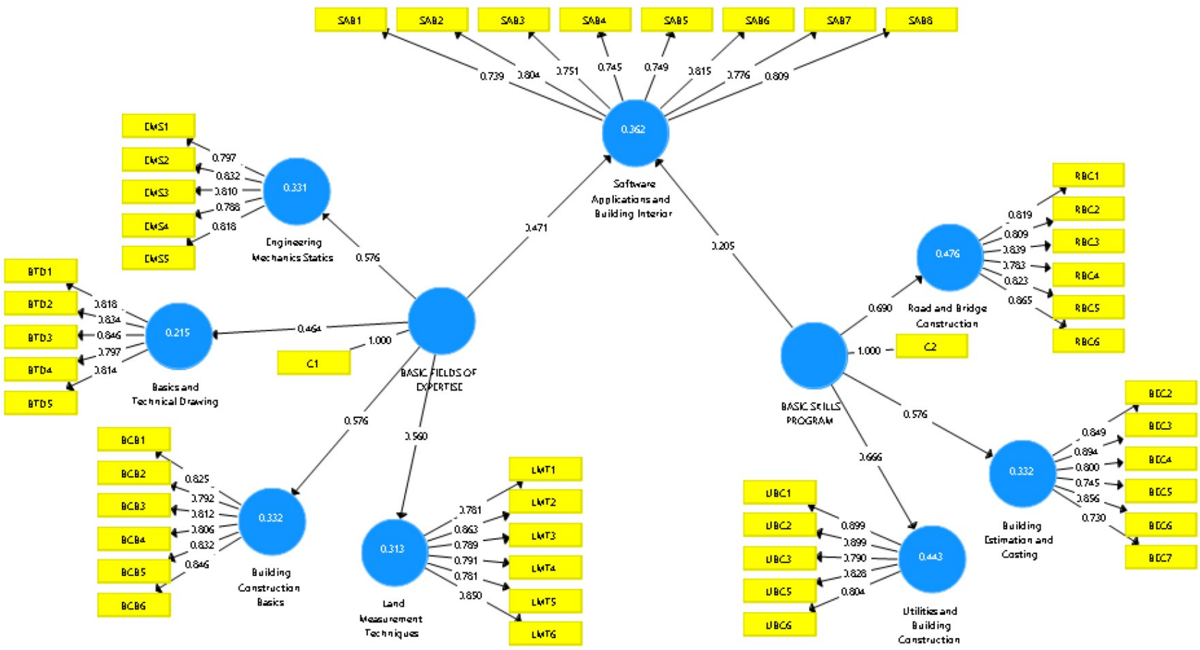

Figure 2. Evaluation of measurement model: PLS algorithm output

4.5. Collinearity Inner VIF Value and Effect Size F^2

One of the assumptions that must be met in the evaluation of structural model analysis is that there is no multicollinearity problem. That is a problem where there is a strong intercorrelation or correlation between indicators. Based on the output of Tables 3 on the results of the outer VIF, all indicators and constructs obtain VIF values <5.0 (1.751 to 4.827). This shows that there is no collinearity between indicators and constructs. Based on the results of the effect size value f^2 in Table 5 shows the relationship between C1→BTD and C1→SAB (C3) has a medium effect (<0.35), then C2 → SAB (C3) has a small effect (<0.15). A large effect is shown in the relationship between C1→BCB, C1→EMS, C1→LMT, C2→BEC, C2→RBC, and C2→UBC (>0.35).

4.6. Coefficient of Determination (R^2) and Predictive Relevance (Q^2)

The r-square value is a value that states how much the constructed variable can explain the variance of the competency demands of architectural engineering graduates. Based on Table 5, the r^2 value in the PLS Algorithm output obtained for all constructs ranged from 0.215 to 0.476, which means that each of the 8 constructs explained 21.5% to 47.6%. The determination factor concluded that all constructs contributed moderately to the competency demands of architectural engineering graduate students. Based on the SmartPLS blindfolding output, the Predictive Relevance (Q^2) value for the cross-validated communality construct ranges from 0.137 to 0.308 (>0.00) and the cross-validated redundancy construct ranges from 0.475 to 0.560 (>0.00). The predictive elevation value (Q^2) has 47.5% to 56.0% in explaining this level of strength.

	Effect Size (f^2)		R^2		Predictive Relevance (Q2)			
					Cross Communality		Cross Redundancy	
Construct/Path	Value	Effect Size	Value	Decision	Q^2 >0,35	Power	Q^2>0,35	Power
(C1) → BTD	0.274	Medium	0.215	Small	0.137	Moderate	0.502	Strong
(C1) → BCB	0.497	Large	0.332	Small	0.215	Moderate	0.534	Strong
(C1) → EMS	0.495	Large	0.331	Small	0.214	Moderate	0.475	Strong
(C1) → LMT	0.457	Large	0.313	Small	0.198	Moderate	0.516	Strong
(C2) → BEC	0.497	Large	0.332	Small	0.199	Moderate	0.517	Strong
(C2) → RBC	0.910	Large	0.476	Moderate	0.308	Strong	0.543	Strong
(C2) → UBC	0.796	Large	0.443	Moderate	0.304	Strong	0.560	Strong
(C1) → SAB	0.260	Medium	0.362	Moderate	0.208	Moderate	0.481	Strong
(C2) → SAB	0.049	Small						

Note: R^2 (0,190 weak; 0,333 moderate; and 0,670 substantial); f^2 (0,02 small*; 0,15 medium**; and 0,35 large***)

Table 5. The inner VIF value, effect size (F^2), R^2, and predictive relevance (Q^2)

4.7. Path Coefficient of Research Direct Hypothesis

Furthermore, the final step is testing the significance of the structural model to ensure that each construct has a positive and significant relationship to the measurement. The direction of the relationship is shown in the value of coefficients and its significance can be seen in T-$_{statistics}$ and the P-$_{value}$ (Table 6).

The output path coefficients for each construct range from 0.205 to 0.666. The construct of Basic Fields of Expertise (C1) has a direct BTD effect of 0.464, which means it has an increase of 46.4%. The positive direction is shown in the coefficients indicator which gets a positive value of 0.464. The significance value based on T-statistics is 5.760 (>1.960) and P-value 0.000*** which means that it is significant at the 1% level. So Basic Fields of Expertise (C1) → BTD positively has a direct and significant influence at the 1% level. The evaluation of structural model measurement is shown in Figure 3.

The bootstrapping output also includes histogram path coefficients that show the dispersion of the estimated values on all the studied variable constructs. For example, the histogram in Figure 3 shows the distribution of the path loading coefficients of all the variable constructs, namely Basic Fields of

Expertise (C1) → BTD, BCB, EMS, LMT, and Basic Skills Program (C2) → BEC, RBC, UBC, and Basic Fields of Expertise (C1) → SAB (C3) and Basic Skills Program (C2) → SAB (C3). This is a graphical way of displaying the same information as contained in a confidence interval.

Hypothesis	Path Coefficients	$\beta_{\text{-coefficients}}$	M	$T_{\text{-statistics}}$	$P_{\text{-values}}$	Decision
H1	(C1) → BTD	0.464	0.475	5.760	0.000***	Accepted
H2	(C1) → BCB	0.576	0.579	8.719	0.000***	Accepted
H3	(C1) → EMS	0.576	0.582	9.258	0.000***	Accepted
H4	(C1) → LMT	0.560	0.566	9.357	0.000***	Accepted
H5	(C2) → BEC	0.576	0.581	9.220	0.000***	Accepted
H6	(C2) → RBC	0.690	0.569	13.049	0.000***	Accepted
H7	(C2) → UBC	0.666	0.667	9.431	0.000***	Accepted
H8	(C1) → SAB (C3)	0.471	0.474	5.609	0.000***	Accepted
H9	(C2) → SAB (C3)	0.205	0.207	2.389	0.017**	Accepted

Note: T-statistics = | $\beta_{\text{-coefficients}}$ /STDEV|; **, *** indicate a significant relation at 5%, 1%

Table 6. Path coefficients on research hypotheses

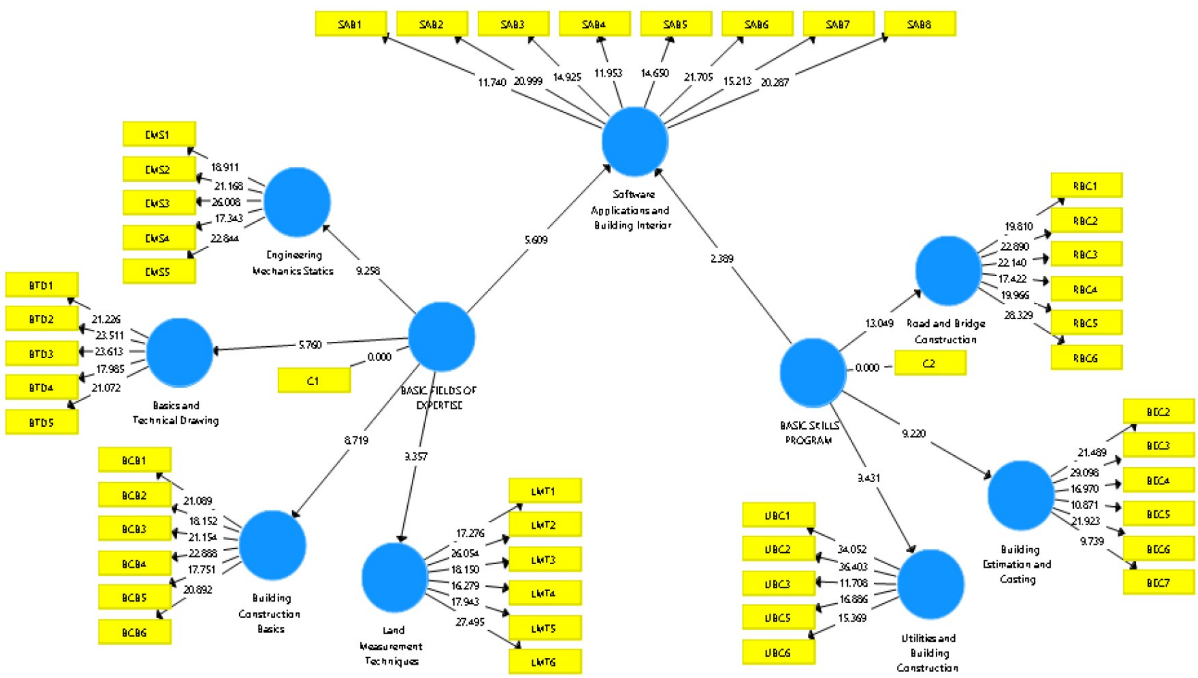

Figure 3. Evaluation of structural model: bootstrapping output

4.8. Model's Fit

For the model structure to meet the model fit criteria, it must meet the criteria for SRMR values <0.080, NFI >0.500, and RMS Theta <0.120. SRMR is a conclusion if there is a difference between the data being tested and the model. So, the indicators and constructs of competence have matched the model being tested because the SRMR value is 0.076 <0.080. The NFI value describes the overall model suitability level reaching 50.3% with the PLS algorithm output obtaining a value of 0.503 >0.500. RMS Theta has an output value of 0.076, where less than 0.120 indicates a suitable model for determining competency demands. So that all aspects of competence measured as competency benchmarks that must be mastered by architectural engineering graduate students have met the model fit criteria.

5. Discussion

The Basic Fields of Expertise (C1) skills consist of 4 competency elements, namely Basics and Technical Drawing (BTD), Building Construction Basics (BCB), Engineering Mechanics Statics (EMS), and Land Measurement Techniques (LMT). Elements of Basics and Technical Drawing (BTD) consists of 5 final indicators that measure architectural engineering competence, namely drawing sketches, drawing symbols, notations, and dimensions, drawing details of building construction, drawing 3D projections, and drawing projections using BIM software. This competency indicator is in line with the results of research by Gil-Mastalerczyk (2022), Makowska (2021), Hariyanto et al., (2022), and Puškár et al. (2022) on presenting types of sectional images and their drawing rules, then drawing projected (3D) images using BIM software. Elements of Building Construction Basics (BCB) construct consists of 6 final indicators measuring architectural engineering competence, namely application of Tekla Structures, health and safety in building work, wood, concrete, and steel construction, material planning in construction work, and implementation of building construction. The same results were obtained by Celadyn (2020), Li et al. (2019), Simpson and Bester (2017), and Taraszkiewicz (2021) regarding the introduction and application of Tekla Structures, the application of safety procedures in building construction work, and the examination of the results of construction work which can be compared with our research.

Elements of Engineering Mechanics Statics (EMS) consists of 5 indicators to measure architectural engineering competence, namely analyzing the strength balance of the building, analyzing the stress on the beam, analyzing structural elements, and analyzing the moment of the building structure. These results are consistent with several studies where researchers analyzed and calculated the balance of forces, analyzed and calculated the stress on the beam, and presented structural elements in competencies taught in architectural engineering, for example, Daryono et al. (2023), Hariyanto et al. (2022), and McCrum (2017). Elements of Land Measurement Techniques (LMT) consists of 6 final indicators measuring architectural engineering competence, namely field survey and measurement tools, field measurement sketch, water-pass and theodolite, total station in building measurements, total station in road measurement, and analyzing measurement results. These competency indicators support the research of Daryono et al. (2020), Gil-Mastalerczyk (2022), and Hariyanto et al. (2022) related to field surveys and tools before starting work, sketching measurements in the field, and analyzing and reporting measurement results.

The Basic Skills Program (C2) skills consist of 3 competency elements, namely Utilities and Building Construction (UBC), Building Estimation and Costing (BEC), and Road and Bridge Construction (RBC). The measurements on the Elements of Utilities and Building Construction (UBC) agree with the results obtained by Burke and Parrish (2018) and Taraszkiewicz (2021). This element consists of 5 indicators measuring architectural engineering competence, namely building plan drawing, building details, stair construction drawing, water isometric drawing, and electrical installation drawings. These results support other researchers for example, Puškár et al. (2022) and Węcławowicz (2021) are concerned with making a drawing of a building plan, making stairs construction drawings, and presenting the specifications of piping installation.

The Building Estimation and Costing (BEC) element consists of 6 indicators measuring architectural engineering competence, namely construction work materials, how to calculate building materials, determine building unit prices, the volume of construction work, calculate construction work budgets, time schedule progress, and Ms. Project. for estimating construction costs. This result corroborates the results obtained by Daryono et al. (2020), Gębczyńska-Janowicz (2020), Hariyanto et al. (2022), and Ratajczyk-Piątkowska and Piątkowska (2020) regarding buildings presenting the specifications of construction work materials, making technical analysis as a reference to determine the unit price of the building, and calculating the volume of building, road and bridge construction works. Elements of Road and Bridge Construction (RBC) consist of 6 indicators, namely classification of roads and bridges, road and bridge drainage, drawings of road and bridge construction, road and bridge construction details, Land Desktop for road planning, and ArchiCAD and Revit Architecture for road and bridge construction planning. These results support other researchers, for example, Daryono et al. (2023), Matusik (2020), Puškár et al. (2022), and Zieliński (2020) regarding presenting the classification of roads and bridges and drawing road and bridge plans which can be compared with the results of this study.

The Skills Competency (C3) skill consists of 1 competency element, namely Software Applications and Building Interior (SAB). The SAB element consists of 8 final indicators measuring architectural engineering competence, namely interior and exterior materials and ornaments, Autocad for 2D and 3D, Revit Architecture and ArchiCAD for 3D, and artificial colors and lighting. The next competency indicators are 3D rendering using Lumion and V-Ray, interior design lay out, interior design mockup, and interior and exterior materials and ornaments. These results are consistent with the results obtained by Łątka and Michałek (2021), and Ratajczyk-Piątkowska and Piątkowska (2020) regarding creating interior design drawings with artificial lighting and the introduction and application of Augmented Reality (AR) in construction and architectural projects involving placing 3D models.

Additional competencies by practitioners from the construction industry are competencies related to the use of computers in preparing reports, documents, and drawings of building construction as well as roads and bridges. In addition, students are required to master information technology and understand attitudes and ethics in working professionalism. The recruitment process for corporate vocational school graduates varies. Competencies that must be mastered by graduates are not only knowledge and skills in work but must have a professional attitude in work. Attitude competencies that must be possessed by graduates based on open questions from practitioners' assessments, namely self-confidence, being able to adapt, and being able to work with certain goals. This research also supports the results of research by Daryono et al. (2023) and Hariyanto et al. (2022) that graduate competencies must be able to work with specific goals, carry out work carefully and carefully, and be willing to learn new things.

There are high gaps in the construction industry in the absorption of graduates because there is only a small need for construction engineering and architectural engineering graduates, but the number of architectural engineering graduates is large. Schools need to consider the local conditions of the school area and students (Ikudayisi, Chan, Darko & Adedeji, 2023). Collaboration with construction companies is carried out to obtain the diversification of capabilities needed by the company so that schools can prioritize competencies that students need to master when they graduate. This is considering that the vocational school learning process is carried out in a limited period of 3 years. The competencies possessed by graduates are not fully suitable for working in various specific construction sectors, seen from the very small relevance value, especially regarding the use of spoken and written language in work, the use of various computer programs, ways, and attitudes of work, and organization. This shows that graduates experience difficulties in working in top-level construction companies.

Construction companies really need work attitude competence. Schools need to equip graduates with appropriate organizational and management structures in companies, work ethics, and job responsibilities. Apart from being introduced to students, learning also needs to be carried out by conditioning good work situations, so it is hoped that work ethics and Occupational Safety And Health (OSH) are not memorized or become habits of students and graduates. The knowledge competencies needed by construction companies are different for each level. The higher the level of the company, the more extensive and comprehensive knowledge must be owned. Knowledge competencies that graduates must have are computer and IT skills, such as making documents and presentations with Microsoft Office and drawing planning with AutoCAD, Lumion, Enscape, and V-Ray (Darwish, Kamel, S., & Assem, 2023; Özacar, Ortakcı & Küçükkara, 2023; Saleh, Abdelkader & Hosny, 2023).

The number of construction industry companies is far more numerous than planning and supervision companies, so that a large number of graduates from architectural engineering are needed, where schools with such programs are few. This needs to be considered by the Education Office in Indonesia and schools in developing learning curricula because it is possible that there is a shortage of workers with the skills needed in these companies. The results of research by Daryono et al. (2020) support the results of this study in that these results also encourage companies to use graduates other than vocational schools so that the absorption of graduates in the construction industry is low.

6. Conclusion

There is a gap between the competencies that must be possessed by graduates and the competencies that must be possessed by workers in the construction industry. This is because there are basic competencies that are not carried out in schools, besides that there are basic competencies that are not implemented. It is necessary to develop competencies ranging from planning to supervision carried out jointly between the Education Office in Indonesia, the construction industry in various fields and levels, and schools so that the competencies possessed by graduates are relevant to the competency needs in the construction industry.

Competencies that are suitable for the demands of the construction industry are used as a needs analysis in the preparation and development of school curricula. Furthermore, it is used as a reflection for teachers on the competencies that have been implemented so far in schools. Existing competencies are based on urgency and assessment by stakeholders, and experts in the construction field in the hope of finding high relevance to the competencies taught to students so that graduates will be ready to work according to the needs of the current construction industry. In addition, support from the construction industry is also very necessary for schools, in addition to aligning competencies and apprenticeship schools, this is due to the limited availability of the latest learning tools and facilities according to technological developments in the construction industry. So, the establishment of a sustainable relationship between schools and industry in the hope of reducing the unemployment rate for architectural engineering graduates.

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References

Al-Fraihat, D., Joy, M., Masa'deh, R., & Sinclair, J. (2020). Evaluating E-learning systems success: An empirical study. *Computers in Human Behavior*, 102, 67-86. https://doi.org/10.1016/j.chb.2019.08.004

Apriliani, F.D., Widihastuti, Daryono, R.W., Jaya, D.J., & Rizbudiani, A.D. (2023). The Influence of Fashion Knowledge, Fashion Selection Factor, and Dress Etiquette on Dress Look for Members of Dharma Wanita: PLS-SEM Analysis. *Jurnal Pendidikan Dan Pengajaran*, 56(1), 194-207. https://doi.org/10.23887/jpp.v56i1.53677

Beicht, U., & Walden, G. (2019). Transition to company-based vocational training in Germany by young people from a migrant background – the influence of region of origin and generation status. *International Journal for Research in Vocational Education and Training*, 6(1), 20-45. https://doi.org/10.13152/IJRVET.6.1.2

Burke, R.D., & Parrish, K. (2018). System Engineering Analysis Approach to Building Material Selection for Sustainable Buildings. *Construction Research Congress 2018* (655-663). https://doi.org/10.1061/9780784481301.065

Celadyn, W. (2020). Architectural education to improve technical detailing in professional practice. *Global Journal of Engineering Education*, 22(1), 57-63. Available at: http://www.wiete.com.au/journals/GJEE/Publish/TOCVol22No1.html

Ćudić, B., Alešnik, P., & Hazemali, D. (2022). Factors impacting university–industry collaboration in European countries. *Journal of Innovation and Entrepreneurship*, 11(1), 33. https://doi.org/10.1186/s13731-022-00226-3

Darwish, M., Kamel, S., & Assem, A. (2023). Extended reality for enhancing spatial ability in architecture design education. *Ain Shams Engineering Journal*, 14(6), 1-13. https://doi.org/10.1016/j.asej.2022.102104

Daryono, R.W., Ramadhan, M.A., Kholifah, N., Isnantyo, F.D., & Nurtanto, M. (2023). An empirical study to evaluate the student competency of vocational education. *International Journal of Evaluation and Research in Education (IJERE)*, 12(2). https://doi.org/10.11591/ijere.v12i2.22805

Daryono, R.W., Rochmadi, S., & Hidayat, N. (2021). Development and validation of video-based learning media to increase competency achievement in civil engineering education. *Journal of Physics: Conference Series*, 1833(012022), 1-10. https://doi.org/10.1088/1742-6596/1833/1/012022

Daryono, R.W., Yolando, A.P., Jaedun, A., & Hidayat, N. (2020). Competency of vocational schools required by construction industry in consultants' supervisor. *Journal of Physics: Conference Series*, 1456(2020), 1-10. https://doi.org/10.1088/1742-6596/1456/1/012057

Dash, G., & Paul, J. (2021). CB-SEM vs PLS-SEM methods for research in social sciences and technology forecasting. *Technological Forecasting and Social Change*, 173, 121092. https://doi.org/10.1016/j.techfore.2021.121092

Draaisma, A., Meijers, F., & Kuijpers, M. (2018). The development of strong career learning environments: The project 'Career Orientation and Guidance' in Dutch vocational education. *Journal of Vocational Education & Training*, 70(1), 27-46. https://doi.org/10.1080/13636820.2017.1392995

Gębczyńska-Janowicz, A. (2020). Virtual reality technology in architectural education. *World Transactions on Engineering and Technology Education*, 18(1), 24-28. Available at: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V18N1.html

Gil-Mastalerczyk, J. (2022). The importance of the relationship between religion and architecture through the lens of architectural education. *World Transactions on Engineering and Technology Education*, 20(1), 25-32. Available at: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V18N1.html

Hair, J.F., Howard, M.C., & Nitzl, C. (2020). Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. *Journal of Business Research*, 109, 101-110. https://doi.org/10.1016/j.jbusres.2019.11.069

Hair, J.F., Ringle, C.M., Gudergan, S.P., Fischer, A., Nitzl, C., & Menictas, C. (2019). Partial least squares structural equation modeling-based discrete choice modeling: An illustration in modeling retailer choice. *Business Research*, 12(1), 115-142. https://doi.org/10.1007/s40685-018-0072-4

Hariyanto, V.L., Daryono, R.W., Hidayat, N., Prayitno, S.H., & Nurtanto, M. (2022). A framework for measuring the level of achievement of vocational students competency of architecture education. *Journal of Technology and Science Education*, 12(1), 157-171. https://doi.org/10.3926/jotse.1188

Ikudayisi, A.E., Chan, A.P.C., Darko, A., & Adedeji, Y.M.D. (2023). Integrated practices in the Architecture, Engineering, and Construction industry: Current scope and pathway towards Industry 5.0. *Journal of Building Engineering*, 73, 1-10. https://doi.org/10.1016/j.jobe.2023.106788

Kesai, P., Soegiarso, R., Hardjomuljadi, S., Setiawan, M.I., Abdullah, D., & Napitupulu, D. (2018). Indonesia Position in The Globalization of Construction Industry. *Journal of Physics: Conference Series*, 1114, 012133. https://doi.org/10.1088/1742-6596/1114/1/012133

Khan, S.A.R. (2021). Assessing the eco-environmental performance: An PLS-SEM approach with practice-based view. *International Journal of Logistics Research and Applications*, 24(3), 303-321. https://doi.org/10.1080/13675567.2020.1754773

Kurup, P.M., Li, X., Powell, G., & Brown, M. (2019). Building future primary teachers' capacity in STEM: Based on a platform of beliefs, understandings and intentions. *International Journal of STEM Education*, 6(1), 1-14. https://doi.org/10.1186/s40594-019-0164-5

Łątka, J.F., & Michałek, J. (2021). Interdisciplinary methods in architectural education. *World Transactions on Engineering and Technology Education*, 19(1), 102-107. Available at: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V19N1.html

Law, L., & Fong, N. (2020). Applying partial least squares structural equation modeling (PLS-SEM) in an investigation of undergraduate students' learning transfer of academic English. *Journal of English for Academic Purposes*, 46, 100884. https://doi.org/10.1016/j.jeap.2020.100884

Li, S., Zhao, X., & Zhou, G. (2019). Automatic pixel□ level multiple damage detection of concrete structure using fully convolutional network. *Computer-Aided Civil and Infrastructure Engineering*, 34(7), 616-634. https://doi.org/10.1111/mice.12433

Makowska, B. (2021). Teaching freehand drawing on-line to architecture students. *World Transactions on Engineering and Technology Education*, 19(1), 41-47. Available at: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V19N1.html

Matusik, A. (2020). Role of teamwork formulas in educating Bachelor of Science graduates in architecture. *World Transactions on Engineering and Technology Education*, 18(3), 324-329. Available at: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V18N3.html

McCrum, D.P. (2017). Evaluation of creative problem-solving abilities in undergraduate structural engineers through interdisciplinary problem-based learning. *European Journal of Engineering Education*, 42(6), 684-700. https://doi.org/10.1080/03043797.2016.1216089

Nurtanto, M., Arifin, Z., Sofyan, H., Warju, W., & Nurhaji, S. (2020). Development of Model for Professional Competency Assessment (PCA) in Vocational Education: Study of the Engine Tune-Up Injection System Assessment Scheme. *Journal of Technical Education and Training*, 12(2), 34-45. https://doi.org/10.30880/jtet.2020.12.02.004

Okolie, U.C., Nwajiuba, C.A., Binuomote, M.O., Osuji, C.U., Onajite, G.O., & Igwe, P.A. (2020). How careers advice and guidance can facilitate career development in technical, vocational education, and training graduates: The case in Nigeria. *Australian Journal of Career Development*, 29(2), 97-106. https://doi.org/10.1177/1038416220916814

Olazaran, M., Albizu, E., Otero, B., & Lavía, C. (2019). Vocational education–industry linkages: Intensity of relationships and firms' assessment. *Studies in Higher Education*, 44(12), 2333-2345. https://doi.org/10.1080/03075079.2018.1496411

Özacar, K., Ortakcı, Y., & Küçükkara, M.Y. (2023). VRArchEducation: Redesigning building survey process in architectural education using collaborative virtual reality. *Computers & Graphics*, 113, 1-9. https://doi.org/10.1016/j.cag.2023.04.008

Perusso, A., & Baaken, T. (2020). Assessing the authenticity of cases, internships and problem-based learning as managerial learning experiences: Concepts, methods and lessons for practice. *The International Journal of Management Education*, 18(3), 1-12. https://doi.org/10.1016/j.ijme.2020.100425

Puškár, B., Vráblová, E., & Czafík, M. (2022). The concept of an intelligent building in architectural education. *World Transactions on Engineering and Technology Education*, 20(1), 19-24. Available at: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V18N1.html

Ratajczyk-Piątkowska, E., & Piątkowska, K. (2020). Three-dimensional and synchronous resolution of functional and spatial aspects in architectural design. *World Transactions on Engineering and Technology Education*, 18(1), 45-50. Available at: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V18N1.html

Rosantono, I.G., Wijanarka, B.S., Daryono, R.W., & Nurtanto, M. (2021). Analysis of the Influencing Factor of Vocational Education Students Career Decisions. *Jurnal Pendidikan Dan Pengajaran*, 54(3), 582-595. https://doi.org/10.23887/jpp.v54i3.37343

Saleh, M.M., Abdelkader, M., & Hosny, S.S. (2023). Architectural education challenges and opportunities in a post-pandemic digital age. *Ain Shams Engineering Journal*, 14(8), 1-12. https://doi.org/10.1016/j.asej.2022.102027

Santoso, A., Sukardi, T., Prayitno, S.H., Widodo, S., & Daryono, R.W. (2022). Design development of building materials lab for teacher education institutes on vocational and academic program. *Pegem Journal of Education and Instruction*, 12(4), 310-320. https://doi.org/10.47750/pegegog.12.04.32

Setyadi, M.R.A., Triyono, M.B., & Daryono, R.W. (2021). The influence of industrial work practices and workshop infrastructure facilities on work readiness of students. *Journal of Physics: Conference Series*, 1833(1), 012029. https://doi.org/10.1088/1742-6596/1833/1/012029

Simpson, Z., & Bester, J. (2017). Cognitive Demand and Student Achievement in Concrete Technology Study. *Journal of Professional Issues in Engineering Education and Practice*, 143(2), 04016022. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000307

Supriyadi, E., Indro, H.Y., Priyanto, E., & Surwi, F. (2020). Students' Evaluation on Teaching in Vocational and Technical Schools. *International Journal of Instruction*, 13(2), 621-636. https://doi.org/10.29333/iji.2020.13242a

Supriyanto, S., Munadi, S., Daryono, R.W., Tuah, Y.A.E., Nurtanto, M., & Arifah, S. (2023). The Influence of Internship Experience and Work Motivation on Work Readiness in Vocational Students: PLS-SEM Analysis. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, 5(1). https://doi.org/10.23917/ijolae.v5i1.20033

Surya, R.E.R., & Mulyanti, B. (2020). Competencies needed by civil engineering teachers in the digital era. *IOP Conference Series: Materials Science and Engineering*, 830(3), 1-7. https://doi.org/10.1088/1757-899X/830/3/032060

Taraszkiewicz, A. (2021). Freehand drawing versus digital design tools in architectural teaching. *Global Journal of Engineering Education*, 23(2), 100-105. Available at: http://www.wiete.com.au/journals/GJEE/Publish/TOCVol23No2.html

Węcławowicz, E. (2021). Teaching building surveying of valuable historical timber architecture. *Global Journal of Engineering Education*, 23(1), 49-54. Available at: http://www.wiete.com.au/journals/GJEE/Publish/TOCVol23No1.html

Zieliński, R. (2020). New technologies to support students in a BIM design course. *World Transactions on Engineering and Technology Education*, 18(3), 313-317. Available at: http://www.wiete.com.au/journals/WTE&TE/Pages/TOC_V18N3.html

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