**Competency Framework: Measurement the competency achievement of architectural engineering students in Indonesia needed by the construction industry**

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**Abstract.** The purpose of this study is to test the validity and reliability of the instrument for measuring student achievements in architectural engineering education in Indonesia. The cluster random sampling technique was used to determine the number of students consisting of 103 vocational education students.. This research data is in the form of quantitative, then analyzed to obtain descriptive statistical values, multicollinearity, normality, data reliability, then tested with the EFA and CFA using Amos 22. EFA test is intended to reveal factors that can be formed from instruments that have been established for measurement of achievements of vocational student competencies. The CFA approach reaffirms and validates instruments for measuring the level of competency achievement. Overall the Cronbach Alpha value in the very high category is 0.956. EFA shows ten factors with 10 items so that it consists of 30 competency items. Each item shows a satisfying loading factor with a value of 0.474 to 0.987. CFA analysis obtained values (χ2/df) = 1.36, Probability level = 0.00, IFI = 0.93, TLI = 0.91, CFI = 0.93, RMSEA = 0.06. The developed instrument is suitable to be used to measure the level of mastery of vocational students` competencies in the department of architectural engineering in Indonesia.

1. **Introduction**

The quality of human resources is the key to the competitiveness of a nation to determine who can develop in global competition and maintain survival. Innovative, creative, technology literate, and having multiple intelligences are the hallmarks of superior HR [1]. The issue of manpower is always related to human resources, therefore the quality of human resources needs to be improved and developed to obtain a competent workforce have high morale will maintain the industry and strengthen the country's economy [2]. The World Economic Forum states that one of Indonesia's shortcomings is the 65th skill pillar of 141 countries. The pillar includes an index of the current and future components of the workforce skills that is still low so as to make Indonesia's competitiveness decline [3]. Furthermore, INSEAD data 2019, Indonesia was ranked 67th in 125 world countries. This also shows that the provision of human resources to improve the competitiveness of educational skills is still weak. The assessment index is influenced by vocational and technical skills that are still weak, including middle-level skills, employability, and relevance of the education system to the economy [4].

Such conditions can be concluded that the Indonesian state does not yet have quality human resources [5].The role of the construction sector contributes to national development in the form of buildings and infrastructure and facilities to support the growth and development of state infrastructure in realizing a just and prosperous society [6]. The increasing number of the construction sector makes Indonesia the construction market in the ASEAN country [7]. Indonesia has the largest construction market compared to neighboring countries. The need for a professional workforce increase will be affected by the rise in the construction market until 2025 [8].

The world of work continues to change creating new challenges for employers and employees. In preparing vocational student graduates in accordance with industry needs and the development of technology is one of the objectives to achieve vocational education. So students must be equipped with competencies according to the needs of the industrial world [9, 10].Educational development based on community needs will produce competent graduates [11]. Vocational Schools are organized to prepare students for work after completing vocational education [12].The one of the basic goals for vocational education can be successful, namely by increasing students' skills [13].If after graduating students can work immediately, then the opportunity for unemployment in Indonesia will be reduced. According to the Central Statistics Agency report, the Open Unemployment Rate in VE has scored 10.42% ranked first among other education in the last 5 years [14].

In the research of [15] states that there are several four premise factors that contribute to increasing the employment rate of vocational education graduates, including professional teachers, industry-equivalent curriculum, leadership spirit, and link and match. The first factor as a cause of absorption of Building Engineering graduates is the low teaching and learning process. The teaching and learning process of vocational schools that have not maximized the learning of soft skills and hard skills together, the school emphasizes the learning of hard skills only for competencies that are required to work. The learning process as explained by [16] “*emphasizes authentic-learning and assessment that promote higher-order thinking skills: creative, innovative, and problem-solving in real life*”, to support the competencies of graduates who are ready to work in the construction industry. A nation can develop the development of a new world, it is necessary to prepare quality HR, which have multiple and broad skills, as well as multilingual literacy to be able to develop sustainably [17]. The second factor is the graduate competency standards that are applied in the learning process. There are some competencies that are not applied due to time constraints in the implementation of the learning process. Research [18] states that the lack of equipment in vocational high schools and there is no large area for laboratories, the teaching strategy to improve students' preparation to work in the construction industry, competent and not qualified workers run with maximum. In addition, the low interest of students in entrepreneurship [19].

So, it is important to conduct research to determine the framework of VE competencies in developing techniques in accordance with industrial competencies. This is done to obtain ideal standard work competency information that must be mastered by vocational students so that they become competent workers in the field of construction services and whether the competencies provided in vocational schools are in accordance with the competencies needed by the construction service industry. The research results obtained can be used to development, planning of VE curricula that can increase the competence of graduates in building engineering with industry needs and the changes of technology.

1. **Materials and methods**

This research is based on a descriptive survey study, drawing conclusions from testing hypotheses to get answers to the problems studied [20, 21].The design method used is a cross-sectional survey, with the intention of analyzing survey data with quantitative data in describing the attitudes, opinions, behavior, and characteristics of the population [22]. The study was conducted in 8 Vocational Schools consisting of SMKN 2 Klaten, SMKN 1 Purworejo, SMKN 1 Magelang, SMKN 2 Wonosari, SMKN 2 Yogyakarta, SMKN 3 Yogyakarta, SMKN 2 Depok, SMKN 1 Seyegan. Determination of the number of respondents of VE vocational students in building engineering graduates using cluster random sampling techniques obtained by 103 students consisting of architecture engineering students.

* 1. *Measures and covariates*

The questionnaire was prepared based on Permendikbud No. 34 years old. 2018, graduate competency standards and content standards, curriculum documents for the construction and property engineering expertise program 2018, SKKNI No. 374, SKKNI No. 85 of 2015, SKKNI No. 205 of 2015, and SKKNI No. 340 of 2013. The questionnaire consisted of 10 aspects of competence, each aspect of competence consisted of 5 competency indicators. Instrument of Competency of Students in the Department of Construction and Property Engineering is shown in Table 1.

**Table 1.** The instrument for measuring the achievement of vocational student competencies

|  |  |  |
| --- | --- | --- |
| No | Competency Aspects | Item |
| 1 | General competence | A 1-5 |
| 2 | Technical drawing competencies | B 1-5 |
| 3 | Statically structures competence | C 1-5 |
| 4 | Basic building construction competencies | D 1-5 |
| 5 | Land measurement engineering competencies | E 1-5 |
| 6 | Software application and building interior design competencies | F 1-5 |
| 7 | Road and bridge construction competencies | G 1-5 |
| 8 | Estimated construction costs competencies | H 1-5 |
| 9 | Building construction and utility competencies | I 1-5 |
| 10 | Creative and entrepreneurship product competencies | J 1-5 |
| Number of item | 50 |

* 1. *Data analysis*

Statistical descriptive analysis, multicollinearity, normality, and data reduction before being applied in further factor analysis, using SPSS 25.0 software. Univariate normality analysis results from the construct of the measurement model for latent variables, according to the value of skewness and kurtosis with a range of values from -1.96 to +1.96 at a significance level of 0.05 for each question item [22, 23, 24].Multicollinearity analysis can conclude the inter-change matrix with a value of ≤0.90 [23]. After that, all items are included in the criteria for factor analysis test, the data are analyzed on two shelves. Exploratory Factor Analysis (EFA) was carried out to determine the factors of the instrument measuring the achievement of student competencies. Confirmatory Factor Analysis (CFA) is carried out to ensure and clarify whether the specified model and factor loading patterns are appropriate in Indonesia [25].

EFA data analysis is performed using SPSS to reveal how many factors can be formed so that it can find out the correlating factors and the contribution value of each variable to measure the factors [26, 27].The results of the analysis are based on Kaiser-Meyer-Olkin (KMO) values, Bartlett test values, Measure of Sampling Adequacy (MSA), communality values, total variance values described related to eigenvalues, factor loading, plot scree. Furthermore, CFA is performed on a model that is based on hypothetical factors using AMOS 22. For the assessment of the hypothesized construct position, construct validity is carried out using convergent and discriminant validity.

1. **Results and discussion**

The first result conducted in this study is a preliminary analysis intended to find out the data that has been obtained from the survey results. Data obtained from 103 vocational education students majoring in architecture engineering in Indonesia. All 50 questions are called competency items. Because items A3, A4, B1, B2, C1, C3, D3, D4, E1, E3, F1, F4, G1, G5, H2, H4, I2, I3, J3, J5, obtain skew and kurtosis values outside the range of numbers -1.96 to +1.96 and the level of significance with values ≤0.05 [24] then the 20 items were declared not normally distributed and excluded and not included in further factor analysis. After the item is released, the data that still survive or have normal distribution is 30 items and descriptive statistics are analyzed again as in Table 2. The acquisition of 30 items reached normality with skew values ranging from -1,723 to -0,056, with kurtosis values ranging from -1,938 to +1,938.

**Table 2.** Results of statistical descriptive analysis and data normality

| No | Variable | Mean | Std. Deviation | Skew | Kurtosis | Analysis N |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | A1 | 3,776 | 0,447 | -1,723 | 1,938 | 103 |
| 2 | A2 | 3,659 | 0,477 | -0,67 | -1,551 | 103 |
| 3 | A5 | 3,753 | 0,460 | -1,535 | 1,231 | 103 |
| 4 | B3 | 3,647 | 0,505 | -0,893 | -0,564 | 103 |
| 5 | B4 | 3,624 | 0,511 | -0,777 | -0,783 | 103 |
| 6 | B5 | 3,694 | 0,464 | -0,843 | -1,29 | 103 |
| 7 | C2 | 3,906 | 0,718 | -0,056 | -0,589 | 103 |
| 8 | C4 | 3,576 | 0,543 | -0,755 | -0,568 | 103 |
| 9 | C5 | 3,682 | 0,539 | -1,451 | 1,162 | 103 |
| 10 | D1 | 3,694 | 0,464 | -0,843 | -1,29 | 103 |
| 11 | D2 | 3,624 | 0,487 | -0,51 | -1,74 | 103 |
| 12 | D5 | 3,624 | 0,487 | -0,51 | -1,74 | 103 |
| 13 | E2 | 3,765 | 0,454 | -1,626 | 1,563 | 103 |
| 14 | E4 | 3,635 | 0,508 | -0,834 | -0,68 | 103 |
| 15 | E5 | 3,682 | 0,493 | -1,08 | -0,141 | 103 |
| 16 | F2 | 3,624 | 0,534 | -0,976 | -0,151 | 103 |
| 17 | F3 | 3,576 | 0,520 | -0,563 | -1,105 | 103 |
| 18 | F5 | 3,741 | 0,467 | -1,449 | 0,935 | 103 |
| 19 | G2 | 3,600 | 0,493 | -0,408 | -1,833 | 103 |
| 20 | G3 | 3,635 | 0,484 | -0,562 | -1,684 | 103 |
| 21 | G4 | 3,694 | 0,464 | -0,843 | -1,29 | 103 |
| 22 | H1 | 3,671 | 0,473 | -0,726 | -1,473 | 103 |
| 23 | H3 | 3,600 | 0,493 | -0,408 | -1,833 | 103 |
| 24 | H5 | 3,694 | 0,464 | -0,843 | -1,29 | 103 |
| 25 | I1 | 3,706 | 0,484 | -0,615 | -1,621 | 103 |
| 26 | I4 | 3,682 | 0,539 | -0,783 | -1,386 | 103 |
| 27 | I5 | 3,647 | 0,481 | -0,953 | -0,437 | 103 |
| 28 | J1 | 3,682 | 0,468 | -1,294 | 0,655 | 103 |
| 29 | J2 | 3,659 | 0,501 | -1,451 | 1,162 | 103 |
| 30 | J4 | 3,682 | 0,517 | -1,218 | 0,223 | 103 |

The case of multicollinearity, the inter-correlation among ten (10) items of competency analyzed in construction values ranged from 0.248 to 0.737. These results indicate that the discriminant validity of the competency variable is achieved because of the matrix value between correlations ≤0.90 [23, 25].

* 1. *Reliability of instrument*

Reliability is the stability and suitability of each score found [22].It is said to be reliable if the question items get the same and identical scores when the instrument is tested several clans and in different times and places. The reliability value of an item is based on the Cronbach Alpha (CA) value [21].According to [28], if the CA value ranges from 0,91>x≤1,0 then the item is categorized very high, 0,71>x≤0,90 is categorized high, 0,31>x≤0,70 is categorized as moderate, and 0,00≥x≤0,30are categorized as low. The results of the instrument's reliability are shown in Table 3.

**Table 3.** Reliability analysis of competency items

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | Competency Aspects | Item | CA | Overall CA |
| 1 | General competence | 3 | 0,761 | 0,956 |
| 2 | Technical drawing competencies | 3 | 0,698 |
| 3 | Statically structures competence | 3 | 0,769 |
| 4 | Basic building construction competencies | 3 | 0,915 |
| 5 | Land measurement engineering competencies | 3 | 0,865 |
| 6 | Software application and building interior design competencies | 3 | 0,797 |
| 7 | Road and bridge construction competencies | 3 | 0,909 |
| 8 | Estimated construction costs competencies | 3 | 0,899 |
| 9 | Building construction and utility competencies | 3 | 0,869 |
| 10 | Creative and entrepreneurship product competencies | 3 | 0,684 |

* 1. *Exploratory Factor Analysis (EFA)*

In this EFA test, the study considers testing items that have passed the multicollinearity and normality and reliability tests for each item. All 30 items that passed were included in 10 aspects of competency. EFA test criteria are based on KMO Index values, Bartlett's Test, Measure of Sampling Adequacy (MSA), communalities, factor loading, eigenvalues, and plot scree. The results of the KMO Measure of Sampling Adequacy obtained a value of 0.886 more than 0.70, then the coverage of each factor is satisfactory. Bartlett's Test of Sphericity Approx. Chi-Square obtained a value of 1932,501; df = 35; Sig. = 0,000. Scree plot pattern to reduce variance to several factors. The point at which the slope of the line begins to change, that is where the limit of the number of factors that can take. This point is called the inflection point. In Figure 1, after the 10th point, the line begins to change in tilt and the variations explained are less and less. Thus it can reduce 30 items to 10 factors.



**Figure 1.** Scree plot of achieving student competency framework

The next step identifying the extraction of community values, eigenvalues, percentage variants, and loading factors is shown in Table 4. The value of communalities indicates the value of the variable under study whether it is able to explain the magnitude of the effective contribution (%) of each variant to the factor formed for each item. The communality value of each variant must be,50.50, if the communalities value is lacking, then the factors are not included in the CFA analysis [24, 25, 22]. The results of the communalities in this instrument range from 0.751 to 0.909 (≥0.50) can be categorized as adequate variants in the instrument. MSA values range from 0.709 to 0.961 (≥0.70). The rotated component matrix shows the loading factor on each factor. The results of data analysis, it is recommended for all items (30 items) to measure the level of competency achievement. This value is obtained from high loading factors ranging from 0.461 to 0.899 (>0.40).

**Table 4.** MSA, communalities, factor loading

| Var. | Item | MSA | Comm. | Factor Loading |
| --- | --- | --- | --- | --- |
| Components |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| A | A1 | ,741a | 0,751 |  |  |  |  | 0,828 |  |  |  |  |  |
| A2 | ,709a | 0,770 |  |  |  |  | 0,760 |  |  |  |  |  |
| A5 | ,795a | 0,717 |  |  |  |  | 0,772 |  |  |  |  |  |
| B | B3 | ,821a | 0,888 |  |  |  |  |  |  | 0,899 |  |  |  |
| B4 | ,861a | 0,820 |  |  |  |  |  |  | 0,739 |  |  |  |
| B5 | ,813a | 0,870 |  |  |  |  |  |  | 0,837 |  |  |  |
| C | C2 | ,882a | 0,784 |  |  |  |  |  |  |  |  | 0,501 |  |
| C4 | ,926a | 0,782 |  |  |  |  |  |  |  |  | 0,558 |  |
| D | D1 | ,939a | 0,767 | 0,705 |  |  |  |  |  |  |  |  |  |
| D2 | ,878a | 0,909 | 0,794 |  |  |  |  |  |  |  |  |  |
| D5 | ,873a | 0,880 | 0,850 |  |  |  |  |  |  |  |  |  |

**Table 4.** MSA, communalities, factor loading - continue

| Var. | Item | MSA | Comm. | Factor Loading |
| --- | --- | --- | --- | --- |
| Components |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| E | E2 | ,887a | 0,719 |  |  | 0,717 |  |  |  |  |  |  |  |
| E4 | ,846a | 0,794 |  |  | 0,710 |  |  |  |  |  |  |  |
| E5 | ,872a | 0,873 |  |  | 0,677 |  |  |  |  |  |  |  |
| F | F2 | ,931a | 0,764 |  |  |  |  |  |  |  | 0,503 |  |  |
| F3 | ,930a | 0,779 |  |  |  |  |  |  |  | 0,461 |  |  |
| F5 | ,889a | 0,762 |  |  |  |  |  |  |  | 0,600 |  |  |
| G | G2 | ,925a | 0,879 |  |  |  |  |  | 0,760 |  |  |  |  |
| G3 | ,865a | 0,884 |  |  |  |  |  | 0,718 |  |  |  |  |
| G4 | ,865a | 0,861 |  |  |  |  |  | 0,709 |  |  |  |  |
| H | H1 | ,870a | 0,829 |  |  |  | 0,590 |  |  |  |  |  |  |
| H3 | ,912a | 0,864 |  |  |  | 0,649 |  |  |  |  |  |  |
| H5 | ,927a | 0,803 |  |  |  | 0,711 |  |  |  |  |  |  |
| I | I1 | ,961a | 0,809 |  | 0,706 |  |  |  |  |  |  |  |  |
| I4 | ,948a | 0,797 |  | 0,658 |  |  |  |  |  |  |  |  |
| I5 | ,883a | 0,797 |  | 0,761 |  |  |  |  |  |  |  |  |
| J | J1 | ,861a | 0,885 |  |  |  |  |  |  |  |  |  | 0,785 |
| J2 | ,894a | 0,804 |  |  |  |  |  |  |  |  |  | 0,667 |
| J4 | ,854a | 0,816 |  |  |  |  |  |  |  |  |  | 0,775 |

Table 5 shows the summary results of the Exploratory Factor Analysis (EFA) value for competency framework research to determine the achievement of architectural engineering student competencies in Indonesia. Classification details that have passed the EFA test are based on KMO index values, Bartlett's Test, MSA, factor loading, and eigenvalues which have all passed the recommended values.

**Table 5.** Exploratory factor analysis measurement indicator

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | Value Results | Recommendation | Category | Source |
| Indeks KMO | 0,886 | 0,50 ≥ x ≤ 0,8 | suitable | [22, 24, 25] |
| 0,80 ≥ x ≤ 1,0 | suitable |
| Bartlett's Test | p <0,000 | p <0,05 | suitable | [24, 29] |
| MSA | 0,709 – 0,961 |  < 0,07 | dropout |
| Factor Loading | 0,461 - 0,899 | 0,4 - 0,9 | suitable | [22, 24, 25] |
| Nilai eigen | >2,228 | ≤ 1,0 | dropout |

* 1. *Confirmatory Factor Analysis (CFA)*

Based on the EFA results, this study consisted of 20 competency variables to measure the level of achievement of vocational education students. CFA analysis is intended to prove and confirm the validation of the data for each factor of the instrument measuring the level of achievement of vocational student competencies. CFA can prove the suitability of the suggested model with the factor structure analyzed through EFA [22]. Model fit assessments are based on chi-square (χ2) and include an absolute mismatch index and a relative compatibility index. The absolute mismatch index includes the root mean of estimated error (RMSEA) [25] and the relative-goodness index follows the values set in CFI, TLI, IFI [24]. It is assumed that CMIN/df values range from 1 to 5 which can be interpreted as acceptable models and data, Comparative Fit Index (CFI) index value ≥0.90, Tucker Lewis Index (TLI) value ≥0.90, IFI value ≥0,90, and RMSEA index ≤0.08 with a meaningful and acceptable error rate. Figure 2 visualizes the measurement model for mastery of VS competencies.



**Figure 2.** Measurement model for the achievement of vocational student competencie

Ten competencies along with 30 sub indications of competency analyzed were hypothesized very well. The results of χ2 = 487,695, Degrees of freedom = 359, Prob. Lev. = 0,00. In the fit model, the index dof, χ2/df = 1.358, CFI = 0.928, TLI = 0.913, IFI = 0.931, and RMSEA = 0.065, show that the data from the sample matches the mastery competency model of vocational education students architectural engineering in Table 6.

 **Table 6.** A measurement model for the achievement of vocational student competencies

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Value | Recommendation | Source |
| (χ2/df) or CMIN/df | 1,358 | ≤5.00 |  [29, 22, 24, 25] |
| Prob. level | 0,000 | ≤0,05 |
| RMSEA | 0,065 | ≤0,08 |
| IFI | 0,931 | ≥0,90 |
| TLI | 0,913 | ≥0,90 |
| CFI | 0,928 | ≥0,90 |

In this instrument (Table 7), construct reliability (CR) and Average Variance Extracted (AVE) are analyzed. Analysis of the choice of construction values ≥0.50 is rated from the loading factor value, then the AVE from 0.518 to 0.796. If the AVE is ≤0.9, the validity of the discriminant is has been satisfying [24]. The results of the analysis of all components of the model fulfillment instrument for measuring students' achievements of competence and compatibility with the provisions of [22, 25].

**Table 7.** CFA result, construct validity evaluation

|  |  |  |
| --- | --- | --- |
| Construct | CR | AVE |
| General competence | 0,928 | 0,518 |
| Technical drawing competencies | 0,914 | 0,504 |
| Statically structures competence | 0,955 | 0,630 |
| Basic building construction competencies | 0,964 | 0,796 |
| Land measurement engineering competencies | 0,929 | 0,711 |
| Software application and building interior design competencies | 0,948 | 0,569 |
| Road and bridge construction competencies | 0,974 | 0,769 |
| Estimated construction costs competencies | 0,971 | 0,748 |
| Building construction and utility competencies | 0,958 | 0,541 |
| Creative and entrepreneurship product competencies | 0,879 | 0,586 |

This structure is in accordance with the original fact structure, although 20 items of competency items have fallen out of 20 items because the data do not meet the descriptive statistical requirements and data normality so there are still 30 items of competency items. The findings of this study are consistent with previous studies [22, 25]. The CFA approach also verifies and proves the suitability of variants on instruments to measure the level of mastery of student competencies. The reliability value can reach the target for the Indonesian sample in the feasible category. The hypothesis of the instrument for measuring competency mastery has been valid and reliable to be implemented in vocational education students in Indonesia.

1. **Conclusion**

This study confirms the validity and reliability of measurement instruments for achieving the competency level of architectural engineering vocational students in Indonesia. It is expected that this research as information material for vocational teachers in adding insight and compilation of competencies needed by the construction service industry in the learning process so as to improve the competency of postgraduate students, so that schools can be used as information, recommendations, implementing and monitoring school programs, especially in the implementation of school curriculum programs, in the teaching and learning process so as to improve the mastery of student competencies in accordance with the needs of the world of construction service sector work.

This research can be as a recommendation for vocational schools in adding insight in the compilation of competencies needed by the construction industry in the learning process so as to improve the competency of architecture engineering students in Indonesia, as input and curriculum development in vocational engineering architectural techniques, and can be used as information and input in preparing graduates to be ready to work in the construction industry in order to become competent graduates in accordance with the needs and development of technology. For the construction industry it can be used as information, advice, and input in making and planning policies in planning, and overseeing programs in improving and developing the competence of construction workers and other policies related to employment in Indonesia and building cooperation with the construction industry so that graduates will be competent in accordance with their fields and in line with expectations.

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