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Contributing factors in learning programmable logic controller using path analysis

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ABSTRACT

Learning Programmable Logic Controller (PLC) programming is influenced by several factors, that is: lecturer competence in PLC programming, adequacy of information technology infrastructure in learning, availability of learning media, vocational guidance procedures, and learning motivation. The purpose of this study: (a) to describe the factors that contribute to PLC programming learning, (b) to formulate a PLC programming competency model, and (c) to examine the determinants of PLC programming learning. Model was tested using Path Analysis method. The results of this analysis are expected to be able to describe the relational patterns between variables in learning PLC programming, as well as the direct and indirect impacts on the mastery of PLC programming competencies.

Keywords: PLC programming competency, path analysis, vocational education.

Article history

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INTRODUCTION

The use of control system technology has grown rapidly along with the development of embedded systems. This is in line with developments in hardware programmable devices, software programmable devices, and PLCs (Suharti et al., 2021). PLC is one of the processing units in the control system. Various industries engaged in manufacturing rely on PLCs as processing machines in the production process (Feng & Wang, 2022; Hendra et al., 2021).

PLC programming competency for vocational education students is a curriculum requirement. This is in line with the learning achievements of PLC programming. Aspects of PLC programming competence comprehensively related to: combinational logic with multivariable input, sequential logic, PLC architecture, PLC programming procedures, ladder diagrams, algorithms, coding, and PLC applications in control systems (*OMRON PROGRAMMING MANUAL*, n.d.). However, the fact is that students have not comprehensively understood the substance of learning PLC programming.

Ladder diagram is the most widely used PLC programming language in the IEC61131-3 standard. The use of ladder diagrams can clearly reveal the relationship between various components, the conversion process is fast, and accurate (Zhao et al., 2012). The transformation algorithm from a ladder diagram into a structured text language using the IEC 61131-3 standard has been tested in application to control systems (Burns et al., 2018a). PLC can be used as a processor that can drive xylophone beaters or traditional musical instruments in Indonesia using LabView software (Syafaat et al., 2017).

The availability of information and communication technology infrastructure that supports learning has a significant effect on increasing the competence of teachers and education staff (Aoki et al., 2013). Students' perceptions in the learning process can be influenced by the teacher, individual experience, and self-confidence, this can be modeled in a structured modeling equation in which there are aspects of direct and indirect impacts of each relationship between variables, this relationship can be implicated in learning in future (Alt, 2015).

Factors that contribute to the achievement of PLC programming competence include: lecturer competence in the learning process, adequacy of information technology supporting infrastructure, availability of learning media, facilitation of vocational guidance for students to optimize competency achievement, and achievement motivation (Burns et al., 2018b; Song & Choi, 2017). The elements that contribute to PLC programming competence are shown in Figure 1.

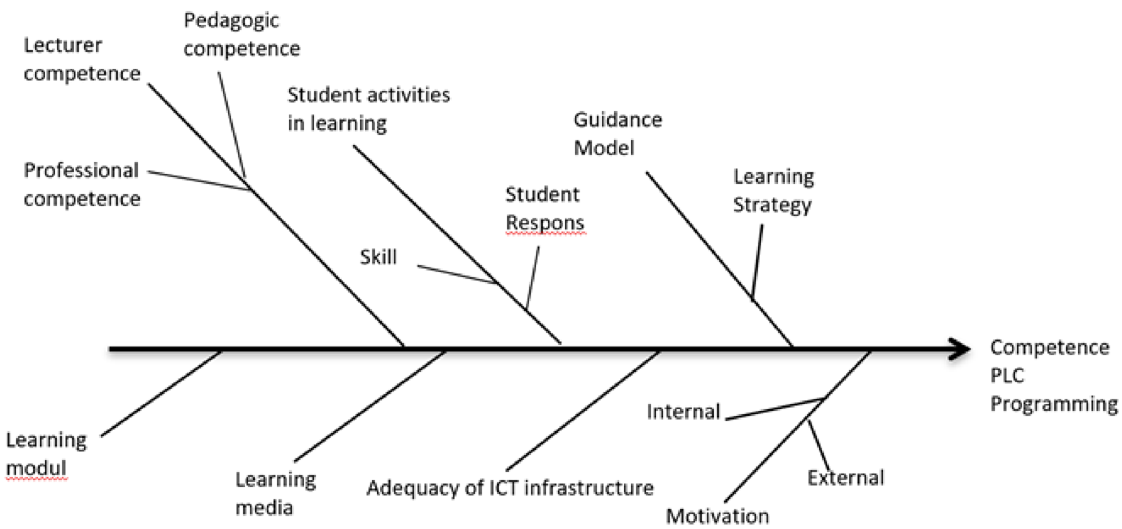

Figure 1. Fishbone diagram in PLC programming competency

METHOD

Models of hypothetical factors that contribute to the achievement of PLC programming are categorized into 6 variables. that is: (a) the competence of lecturers in implementing PLC programming learning is labeled A, (b) the adequacy of information technology infrastructure in the learning process is labeled B, (c) the availability of adequate learning media in the learning process is labeled C, (d) the facilitation of vocational guidance by lecturers to optimization of

PLC programming competency achievement for students is labeled D, (e) achievement motivation is labeled E, and (f) PLC programming competency achievement for vocational students is labeled F. The six variables are analyzed using path analysis (Baby & Kannammal, 2020; Pedhazur, 1997). Hypothetical modeling aims to predict the relational relationships of supporting factors in learning PLC programming. Data analysis in this study uses path analysis. This analysis aims to determine the degree of relationship between variables by looking at the direct and indirect impact on each variable. The relational pattern of the six variables is proposed in Figure 2.

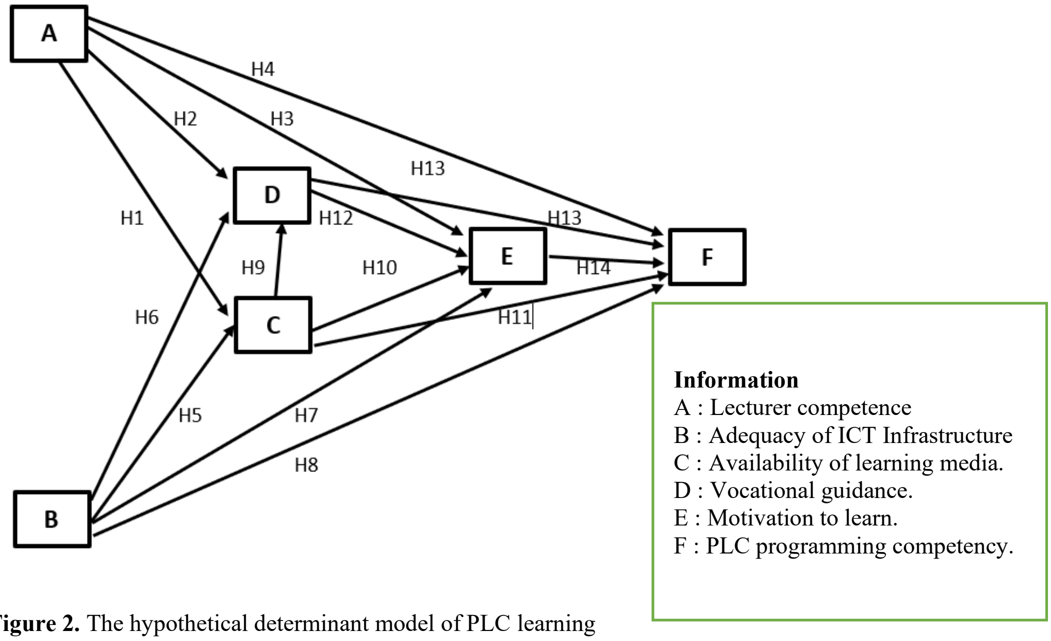

Figure 2. The hypothetical determinant model of PLC learning

The hypothesis in this study: (H1) lecturer competence will have a direct impact on students' ability to program PLCs; (H2) lecturer competence will have a direct impact on the availability of PLC programming learning media; (H3) lecturer competence will have a direct impact on vocational guidance to students; (H4) lecturer competence will have a direct impact on achievement motivation for students; (H5) information technology infrastructure in learning will have a direct impact on students' ability to program PLCs; (H6) Information technology infrastructure in learning will have a direct impact on the availability of PLC programming learning media; (H7) Information technology infrastructure in learning will have a direct impact on vocational guidance for students; (H8) information technology infrastructure in learning will have a direct impact on achievement motivation for students; (H9) the availability of learning media has an indirect impact on vocational guidance; (H10) the availability of instructional media has an indirect impact on achievement motivation for students; (H11) the availability of instructional media has an indirect impact on students' abilities in PLC programming; (H12) vocational guidance has an indirect impact on achievement motivation for students; (H13) vocational guidance has an indirect impact on students' ability to program PLCs; (H14) achievement motivation for students will have an indirect impact on students' abilities in PLC programming.

The population in this study were all students of the Department of Electronics and Informatics Engineering, Faculty of Engineering, Universitas Negeri Yogyakarta who had taken PLC programming courses.. The sample data collection uses the snowball technique (Parker et al., 2020). Several aspects in the preparation of research instruments, among others: (a) population and sample used as a reference for data collection, (b) variables and indicators compiled to find out the relationship between variables, (c) statistical tests needed in connection with data analysis and the goals to be achieved (Siniscalco et al., 2005).

RESULTS AND DISCUSSION

Variable descriptions

Variable descriptions related to variable names, indicators, number of items, and item labels are shown in table 1.

Table1. Variable description

No.	Variable Name	Indicator	Number of Items	Item Labels
1	Lecturer competence	- Ability to master PLC architecture, ladder diagrams, and statement lists. - Ability to design and analyze learning problems	29	A, consist of: a1, a2, …, a29
2	Adequacy of ICT Infrastructure.	- ICT infrastructure in supporting practical learning	3	B, consist of: b1, b2, b3
3	Availability of learning media.	-Hardware, software, and learning media.	4	C, consist of c1, c2, c3, c4
4	Vocational guidance.	-Guidance of knowledge, skills, and attitudes	3	D, consist of: d1, d2, d3,
5	Motivation to learn.	-Internal and external learning motivation.	3	E, consist of: e1, e2, e3, e4
6	PLC programming competency.	-Text based PLC programming. - PLC programming based on ladder diagrams.	4	F, consist of: f1, f2, f3, f4

Validity test

The validity of the instrument uses product moment correlation analysis. Questions/statements are declared valid whenever: (1) r-count > r-criteria, (2) compare the significance (2-tailed) with probability 0.05, if significance (2-tailed) < 0.05 and *Pearson correlation* has a positive value, so the question/statement is declared valid (Quirk, 2016). Validity test results obtained F = 2489.955 significance 0.00, so that all items are declared valid.

Reliability test

Instrument reliability is used to determine the level of consistency of the instruments used in data collection. Reliability test using Cronbach Alpha assisted by SPSS software. Instrument reliability criteria, if the combined item coefficient (alpha reliability) is 0.70 or more then the instrument is declared reliable. The results of the Cronbach's Alpha reliability test obtained 0.975 with a total of 46 questions/statements. Based on the analysis of the data obtained, all items are declared reliable.

Analysis of relations between variables

Based on the hypothetical model shown in Figure 2, the relationships between variables visualized in H1 to H14, the formulations are shown in Table 2.

Table 2. The impact relationship between variables

Hypo thesis	Variable	Impact			Information
		Direct	Indirect	Total	
H1	A → C	ρAC	-	ρAC	-
H2	A → D	ρAD	-	ρAD	-
H3	A → E	ρAE	-	ρAE	-
H4	A → F	ρAF	-	ρAF	-
H5	B → C	ρBC	-	ρBC	-
H6	B → D	ρBD	-	ρBD	-
H7	B → E	ρBE	-	ρBE	-
H8	B → F	ρBF	-	ρBF	-
H9	C → D	ρCD	ρAC	ρAB*ρCD	Impact from A
			ρBC	ρBC*ρCD	Impact from B
H10	C → E	ρCE	ρAB	ρAB* ρCE	Impact from A
			ρBC	ρBC* ρCE	Impact from B
H11	C → F	ρCF	ρAC	ρAC* ρCF	Impact from A
			ρBC	ρBC* ρCF	Impact from B
H12	D → E	ρDE	ρAD	ρAD*ρDE	Impact from A
			ρAD*ρCD	ρAD*ρCD*ρDE	Impact from A
			ρBD	ρBD*ρDE	Impact from B
			ρBC*ρCD	ρBC*ρCD*ρDE	Impact from B, C
H13	D → F	ρDF	ρAD	ρAD*ρDF	Impact from A
			ρAD*ρCD	ρAD*ρCD*ρDF	Impact from A
			ρBD	ρBD*ρDF	Impact from B
			ρBC*ρCD	ρBC*ρCD*ρDF	Impact from B,C
H14	E → F	ρEF	ρAE	ρAE *ρEF	Impact from A
			ρAD*ρDE	ρAD*ρDE*ρEF	Impact from A,D
			ρAC*ρCE	ρAC*ρCE*ρEF	Impact from A,C
			ρAC*ρCD*ρDE	ρAC*ρCD*ρDE*ρEF	Impact from A,C,D
			ρBE	ρBE*ρEF	Impact from B
			ρBD*ρCE	ρBD*ρCE*ρEF	Impact from B,C
			ρBD*ρDE	ρBD*ρDE*ρEF	Impact from B,D
			ρBC*ρCD*ρDE	ρBC*ρCD*ρDE* ρEF	Impact from B,C,D

The results of the first stage path analysis

The description of the data in table 1 is a representation of variables that can be identified by direct and indirect impacts. The data was tested based on the proposed model in Figure 2. The application software used to analyze the data in this study used Lisrell 8.8 pro. The results of the correlation between variables are shown in Table 3. Meanwhile, the results of the first stage path analysis are shown in Figure 3.

Table 3. Correlation between variables

Variabel	A	B	C	D	E	F
A	1	0.704	0.761	0.751	0.433	0.793
B	0.704	1	0.688	0.635	0.444	0.578
C	0.761	0.688	1	0.663	0.239	0.729
D	0.751	0.635	0.663	1	0.490	0.736
E	0.433	0.444	0.239	0.490	1	0.417
F	0.793	0.578	0.729	0.736	0.417	1

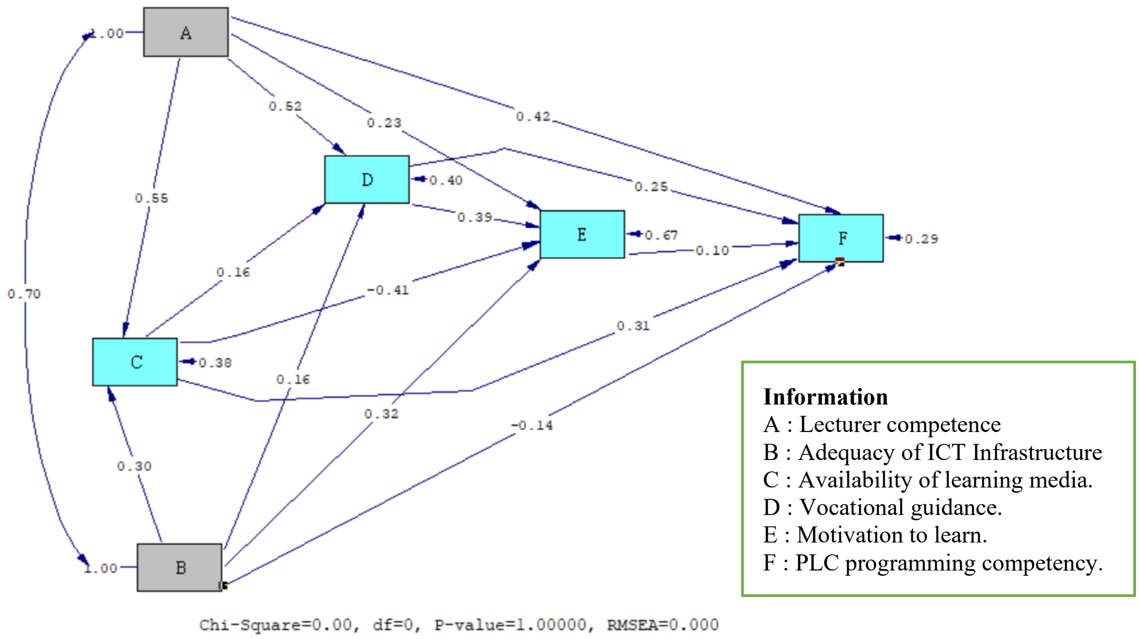

Figure 3. The results of the first stage path analysis (*standardized solution*)

The results of the path analysis in Figure 3 show two relationships with negative values, namely the relationship from variable B to variable F (ρBF) and the relationship from variable C to variable E (ρCE). This means that the two relations do not affect the overall path proposed in the proposed model. Therefore, these two variables were not included in the second stage of the path analysis.

Second stage path analysis

Path analysis without the relationship from variable B to variable F (ρBF) and the relationship from variable C to variable E (ρCE) shows the relationship in Figure 4

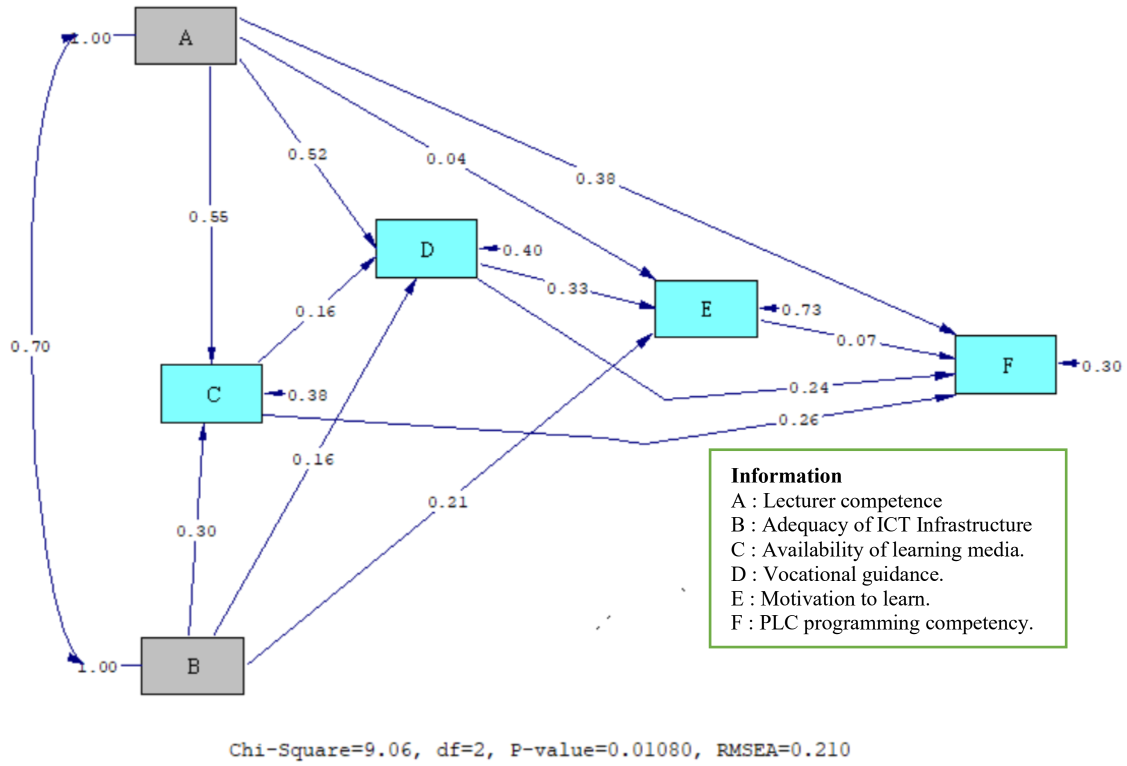

Figure 4. The results of the second stage of path analysis (*standardized solution*)

Figure 4 shows that the direct impact and indirect impact of the relationship between variables is calculated quantitatively, the results are shown in table 4.

Table 4. Quantitative summary of direct and indirect impacts.

Hypo thesis	Variable	Correla tion coefficie nt	Impacts			Information
			Direct	Indirect	Total	
1	A → C	0.761	0.55	-	0.55	-
2	A → D	0.751	0,52	-	0.52	-
3	A → E	0.433	0.04	-	0.04	-
4	A → F	0,793	0.38	-	0.38	-
5	B → C	0.688	0.30	-	0.30	-
6	B → D	0.635	0.16	-	0.16	-
7	B → E	0.444	0.31	-	0.31	-
9	C → D	0.663	0.16	0.55	0.55*0.16 = 0.088	Impact from A
				0.30	0.30*0.16 = 0.048	Impact from B
11	C → F	0.729	0.26	0.56	0.56*0.26 = 0.1456	Impact from A
				0.30	0.30*0.26 = 0.078	Impact from B
12	D → E	0.490	0.33	0.52	0.52*0.33 = 0.1716	Impact from A
				0.52*0.16 = 0.0832	0.52*0.16*0.33 = 0.0275	Impact from A
				0.16	0.16*0.33 = 0.0528	Impact from B
				0.30*0.16 = 0.048	0.30*0.16*0.33 = 0.1584	Impact from B, C
13	D → F	0.736	0.24	0.52	0.52*0.24 = 0.1248	Impact from A
				0.52*0.16 = 0.0832	0.52*0,16*0.24 = 0.02	Impact from A
				0.52	0.52*0.24 = 0.1248	Impact from B
				0.56*0.16 = 0.0896	0.56*0.16*0.24 = 0.0215	Impact from B, C

14	E → F	0.417	0.07	0.04	0.04*0.07 = 0.0028	Impact from A
				0.52*0.33 = 0.1716	0.52*0.33*0.07 = 0.012	Impact from A,D
				0.55*0.16*0.33 = 0.029	0.55*0.16*0,33*0,07 = 0.002	Impact from A,C,D
				0.21	0.21*0.07 =0.0147	Impact from B
				0.16*0.33 = 0.058	0.16*0.33*0.07= 0.0037	Impact from B,D
				0.30*0.16*0.33 = 0.0158	0.30*0.16*0.3* 0.07 = 0.001	Impact from B,C,D

Significance (T-Values)

The significance of each correlation between variables can be known by estimating the T-Value. The T-Value value is obtained from the t-table with N=83 k=6 and degrees of freedom df (n-k-1) = df(76) and a significance level of 0.05, so that a t-table value of 2.665 is obtained. The representation of the T-Value is shown in Figure 5. There are T-values below 2.665, this indicates that the relationship between these variables is not significant.

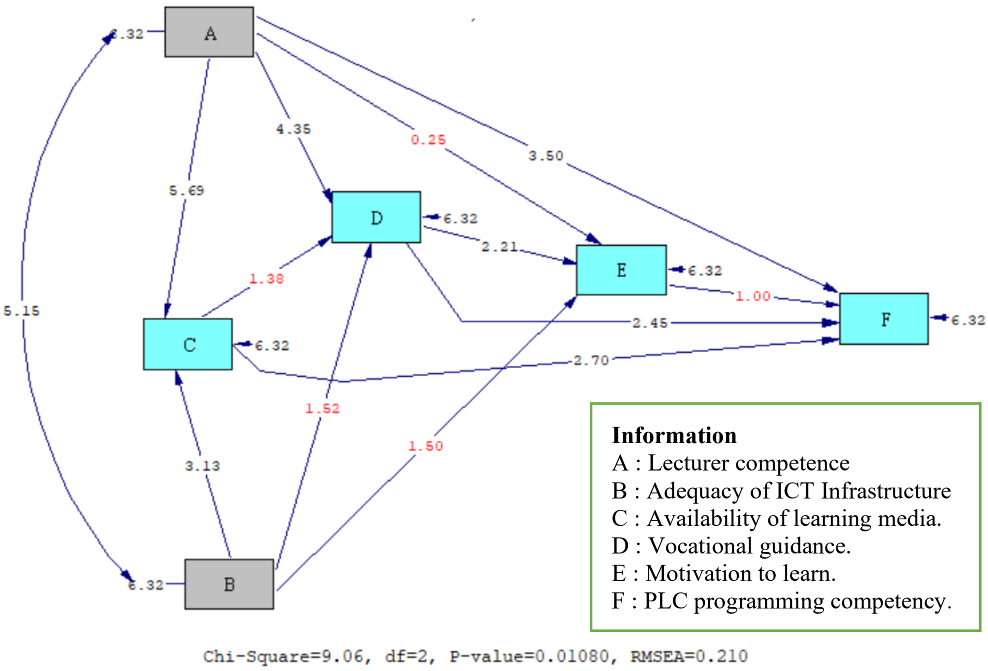

Figure 5. The value of T-Values in the significance of the correlation between variables

Quantitatively, the T-values in Figure 5 can be tabulated in Table 5.

Table 5

Hypothesis	Variable	T-Values	
		Significance	No Significance
1	A → C	5.69	-
2	A → D	4.35	-
3	A → E	-	0.25
4	A → F	4.91	-
5	B → C	3.13	-
6	B → D	-	1.52
7	B → E	-	1.50
9	C → D	-	1.38
11	C → F	3.31	-

12	D → E	2.21	-
13	D → F	2.45	-
14	E → F	-	1.00

Decision modeling on hypothesis testing

Based on the analysis and discussion, a decision can be made to test the hypothesis modeling, the results are shown in table 6.

Tabel 6. Hypothesis test decision

	Hypithesis	Impact	Significance	No Significance
H1	Lecturer competence has a direct impact on students' ability to program PLCs	positive	√	-
H2	Lecturer competence has a direct impact on the availability of PLC programming learning media.	positive	√	-
H3	Lecturer competence has a direct impact on vocational guidance to students.	positive	-	√
H4	Lecturer competence has a direct impact on achievement motivation for students.	positive	√	-
H5	ICT infrastructure in learning will have a direct impact on students' ability to program PLCs	positive	√	-
H6	ICT infrastructure in learning will have a direct impact on the availability of PLC programming learning media.	positive	-	√
H7	ICT infrastructure in learning will have a direct impact on vocational guidance for students.	positive	-	√
H8	ICT infrastructure in learning has a direct impact on achievement motivation for students.	negative	√	-
H9	The availability of learning media has an indirect impact on vocational guidance.	positive	-	√
H10	The availability of learning media has an indirect impact on achievement motivation for students.	negative	√	-
H11	The availability of instructional media has an indirect impact on students' abilities in PLC programming.	positive	√	-
H12	Vocational guidance has an indirect impact on achievement motivation for students.	positive	√	-
H13	Vocational guidance has an indirect impact on students' ability to program PLCs.	positive	√	-
H14	Achievement motivation for students has an indirect impact on students' abilities in PLC programming.	positive	-	√

CONCLUSION

The conclusions obtained are: (1) lecturer competence has a direct and significant positive impact on students' ability to program PLCs. (2) lecturer competence has a direct and significant positive impact on the availability of PLC programming learning media. (3) lecturer competence has a direct and insignificant positive impact on vocational guidance to students. (4) lecturer competence has a direct and significant positive impact on achievement motivation for students. (5) ICT infrastructure in learning will have a direct and significant positive impact on students' ability to program PLCs. (6) ICT infrastructure in learning will have a direct and insignificant positive impact on the availability of PLC programming learning media. (7) ICT infrastructure in learning will have a positive and direct and insignificant impact on vocational guidance to students. (8) ICT infrastructure in learning has a negative and significant impact and has a direct impact on achievement motivation for students. (9) the availability of learning media has a positive and insignificant impact and has an indirect impact on vocational guidance. (10) the availability of learning media has a negative and significant indirect impact on achievement motivation for students. (11) the availability of instructional media has an indirect and positive and significant impact on students' abilities in PLC programming. (12) vocational guidance has an indirect and positive and significant impact on achievement motivation for students. (13) vocational guidance has an indirect and positive and significant impact on students' ability to program PLCs. (14) achievement motivation for students has an indirect and positive and insignificant impact on students' abilities in PLC programming.

REFERENCES

Alt, D. (2015). Using structural equation modeling and multidimensional scaling to assess students' perceptions of the learning environment and justice experiences. *International Journal of Educational Research*, *69*, 38–49. https://doi.org/10.1016/j.ijer.2014.10.001

Aoki, H., Kim, J., & Lee, W. (2013). Propagation & level: Factors influencing in the ICT composite index at the school level. *Computers and Education*, *60*(1), 310–324. https://doi.org/10.1016/j.compedu.2012.07.013

Baby, A., & Kannammal, A. (2020). Network Path Analysis for developing an enhanced TAM model: A user-centric e-learning perspective. *Computers in Human Behavior*, *107*. https://doi.org/10.1016/j.chb.2019.07.024

Burns, M. K., Naughton, M. R., Preast, J. L., Wang, Z., Gordon, R. L., Robb, V., & Smith, M. L. (2018a). Factors of Professional Learning Community Implementation and Effect on Student Achievement. *Journal of Educational and Psychological Consultation*, *28*(4), 394–412. https://doi.org/10.1080/10474412.2017.1385396

Burns, M. K., Naughton, M. R., Preast, J. L., Wang, Z., Gordon, R. L., Robb, V., & Smith, M. L. (2018b). Factors of Professional Learning Community Implementation and Effect on Student Achievement. *Journal of Educational and Psychological Consultation*, *28*(4), 394–412. https://doi.org/10.1080/10474412.2017.1385396

Feng, J., & Wang, X. (2022). Research on electrical automatic control system based on PLC. *Journal of Physics: Conference Series*, *2258*(1). https://doi.org/10.1088/1742-6596/2258/1/012079

Hendra, H., S, P., Hernadewita, H., Hermiyetti, H., & Yoserizal, Y. (2021). Applying Programmable Logic Control (PLC) for Control Motors, Blower and Heater in the Rubber Drying Processing. *Jurnal Ilmiah Teknik Elektro Komputer Dan Informatika*, *7*(1), 131. https://doi.org/10.26555/jiteki.v7i1.20514

OMRON PROGRAMMING MANUAL. (n.d.).

Parker, C., Scott, S., & Geddes, A. (2020). *Snowball Sampling*. https://doi.org/10.4135/URL

Pedhazur, E. J. (1997). *Multiple regression in behavioral research : explanation and prediction*. Harcourt Brace College Publishers.

Quirk, T. (2016). *Excel for Statistics Excel 2016 for Educational and Psychological Statistics A Guide to Solving Practical Problems*. http://www.springer.com/series/13491

Siniscalco, M. T., Auriat, N., & Ross, K. N. (2005). *Questionnaire design Quantitative research methods in educational planning*. http://www.sacmeq.org

Song, K. O., & Choi, J. (2017). Structural analysis of factors that influence professional learning communities in Korean elementary schools. *International Electronic Journal of Elementary Education*, *10*(1), 1–9. https://doi.org/10.26822/iejee.2017131882

Suharti, P. H., Kristiana, H. M., & Amalia, R. N. (2021). Design of flow control system based on PLC armfield pressure control module in chemical engineering laboratory. *IOP Conference Series: Materials Science and Engineering*, *1073*(1), 012053. https://doi.org/10.1088/1757-899x/1073/1/012053

Syafaat, I., Shofwan, I., Sulistijono, I. A., & Ningrum, E. S. (2017). *Timing Manipulation on Ladder Diagram To Adjust the Flexibility and Speed of the Beat On the Robot Gambang*.

Zhao, X., Pei, Z., Wang, L., & Su, Z. S. (2012). Research of conversion algorithm of programmable logic controller ladder diagram to assembly language. *Proceedings - 5th International Conference on Intelligent Networks and Intelligent Systems, ICINIS 2012*, 162–165. https://doi.org/10.1109/ICINIS.2012.29