Investigating the Higher Education Students' Perception of an Interactive Virtual Processing Station Application

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ABSTRACT

This study aims to evaluate the Virtual Processing Station as a simulation-based learning medium in the context of engineering education, based on student perceptions. Student perceptions of this medium were evaluated based on four main aspects: relevance, attention, interest, and usefulness. This study involved 30 students from the Department of Electrical Engineering Education at Yogyakarta State University who had used the Virtual Processing Station in laboratory practice sessions. Data were collected through a questionnaire with 17 statements using a Likert scale and supplemented with qualitative feedback from respondents. The results showed that this learning medium was very well received by students, with an average rating of 90.59%. The relevance aspect received the highest score (92.92%), followed by the interest aspect (90.83%) and usefulness (90.56%). Although the attention aspect received a slightly lower score (84.72%), the medium was still considered quite effective in capturing students' attention during the learning process. Positive comments from respondents emphasized the effectiveness of this medium in helping students understand both the practical and theoretical concepts of PLC-based industrial automation systems. The conclusion of this study indicates that the Virtual Processing Station has great potential in supporting more interactive and efficient engineering learning. However, there is still room for improvement in areas such as the user interface and visualization. Future research should focus on assessing the short-term and long-term impacts of this medium, particularly through larger sample sizes and objective assessments of student performance before and after using the Virtual Processing Station. This approach will provide deeper insights into how these medium influences learning outcomes and the development of practical skills in engineering education.

1. Introduction

In recent years, technological developments in the context of the Industrial Revolution 4.0 have brought major changes to industrial automation systems. These systems not only help improve production efficiency but also integrate digital technology with physical processes [1], [2]. Various industrial sectors have utilized this technology to increase productivity, minimize human error, and maximize cost savings. Industrial automation based on this technology allows more accurate control of machines and manufacturing processes through sophisticated devices such as sensors, actuators, and automatic control systems [3].

In the midst of this technological transformation, the Programmable Logic Controller (PLC) plays a very important role as the main control system in many industrial automation applications.

PLCs enable the automatic operation of industrial machines based on predetermined programs, controlling complex processes with high precision [4], [5]. PLCs have become a vital component in various factories and manufacturing industries, enabling real-time, flexible, and customizable process control to meet the needs of increasingly dynamic industries [6], [7]. Although PLC technology offers many advantages, PLC operation and programming require special competencies. A technician or operator must understand the basic logic of programming as well as analytical skills to create programs that suit the needs of the automation system. Mastery of the software used to program the PLC is also an absolute requirement. This ability is one of the challenges in the world of education because not all students or technicians can easily master PLC programming logic without intensive training and adequate tools [8].

One of the major obstacles in education and training related to industrial automation is the high cost of hardware and the size of the space required. Industrial automation system devices, such as PLCs and other supporting machines, require significant investment in terms of cost and physical resources. In addition, these devices also take up quite a lot of space in the laboratory or factory, making access to these tools limited, especially in educational environments with limited budgets [9].

As a solution to the limitations of physical devices in education, virtual machine technology that is able to represent PLC-based automation systems is developing rapidly [10], [11], [12], [13], [14]. This technology allows for digital simulation of industrial processes without having to use actual hardware. In the world of education, virtual machines offer flexibility and ease in simulating various automation processes without space and cost limitations, thus providing wider opportunities for students to learn and practice.

One example of the application of virtual technology in automation systems is the Virtual Processing Station, which allows for simulation of PLC-based industrial process control. This technology allows students or industry practitioners to design, test, and validate PLC programs virtually without having to use real hardware. Virtual processing stations are one of the important tools in industrial automation education because they allow the learning and evaluation process to be carried out at a lower cost and with a high level of flexibility. In the context of learning, virtual processing stations are often used to validate programs created by students. After compiling a PLC program, students can test it in a simulation environment to ensure that the program functions properly according to the desired purpose. This validation process is important for identifying errors in the program and making adjustments without the need for real hardware, so that training time and costs can be significantly reduced.

The main advantage of a virtual processing station is its ability to operate entirely within a computer system without the need for additional hardware. All components that are usually found in industrial automation systems are replicated virtually, providing realistic and interactive simulations. This technology allows students to learn and practice anywhere and anytime, without limited access to physical laboratories. This opens up greater opportunities for educational institutions to improve the quality of learning. This study aims to examine students' perceptions regarding the use of virtual processing stations as a tool to validate PLC programs. The main focus of this study is to understand how students respond to the experience of using this technology, both in terms of ease of use, effectiveness in learning, and their overall feelings. By understanding students' perceptions, it is hoped that this study can provide recommendations for technology developers.

2. Virtual Processing Station Application

A virtual processing station is a digital replication of a processing station machine commonly used in manufacturing processes to process workpieces from raw materials to finished products. This system allows virtual simulation of production steps using Programmable Logic Controller (PLC)-based control. Several virtual laboratory applications for electrical machines have been created by various researchers. For example, virtual laboratory workpiece transfer station [15], virtual reality-based automation factory [11], simulation of conveyor system with workpiece transfer arm [12], workpiece storage system simulator [9], all of which virtualization models of these studies can be used to validate PLC programs.

In this study, the main components of the virtual processing station include a rotary table, inspection solenoid, up-and-down spindle, drilling machine, clamping, and ejector. The rotary table moves the workpiece from one stage to the next, starting with the solenoid inspecting the workpiece surface. After inspection, the spindle automatically lowers the drill to perform drilling. The clamping maintains the stability of the workpiece during drilling, and the ejector pushes the workpiece to the next station after the process is complete. A control panel consisting of start, stop, emergency, and indicator light buttons is used to control the process, all of which are regulated by the PLC.

The process begins when the start button is pressed, which triggers the movement of the rotary table to the inspection stage. Once completed, the table rotates to the drilling station, where the workpiece is clamped, and the drill spindle operates automatically. After drilling, the table moves to the ejector to move the workpiece to the next station. The entire process is controlled by a PLC with the help of sensors and actuators to ensure smooth operation. The type of PLC used is a Siemens PLC, with programming done using Step-7 and the Ladder Diagram (LD) programming language. The program created in Step-7 is then uploaded to PLCSim (PLC Simulator), allowing process simulation without the need for physical hardware. The inputs and outputs of the Virtual Processing Station are directly connected to the terminals in PLCSim, so that when a button is activated, the signal is forwarded to PLCSim. The Ladder program detects active inputs, processes them, and activates the appropriate outputs on the Virtual Processing Station. As depicted in Figure 1, a snapshot of the user interface of this virtual processing station application is presented offering a visual representation of the tool being inspected.

The interaction between the Virtual Processing Station and PLCSim takes place in real-time, creating a realistic simulation environment to validate PLC programs. Students can test and verify programs without the need for physical hardware. The Virtual Processing Station system architecture consists of several simulation components that work together to replicate PLC-based control processes. Simatic Manager Step-7 is used to create and manage PLC programs. Once the program is created, it is tested through S7-PLCSim, which simulates PLC functions virtually. S7-ProSim connects the PLC simulation to the virtual model, reading output from the PLC and sending signals to the virtual model, and sending input from the virtual model back to the PLC.

Fig. 1. The user interface of the virtual processing station application

3. Research Design and Procedure

This study uses a quantitative approach with a survey method to measure students' perceptions of the use of Virtual Processing Station as a learning medium. The questionnaire used in this study consisted of 17 statements, with each statement having 4 answer options. Each statement is designed to evaluate perceptions based on four main aspects: relevance, attention, interest, and usefulness [16], [17], [18], [19], [20]. The relevance aspect includes 4 statements that focus on the extent to which the learning medium is appropriate to the material and needs of students. The attention aspect

consists of 4 statements that measure the media's ability to stimulate learning interest and increase students' focus during the learning process. The interest aspect, with six statements, evaluates the media's appearance and performance, including how the media attracts users' attention visually and functionally. Finally, the usefulness aspect includes 3 statements that assess the flexibility of the media, and the benefits felt by users in supporting the learning process. Table 1 shows an outline of the questionnaire used in this study to assess students' perceptions.

Table 1. The outline of the questionnaire

Aspect	Indicator	Item number
Relevance	Relevance of media to the material	1, 2,
	Relevance of media to the needs of the learners	3, 4,
Attention	Media stimulates students to learn	5, 6,
	Media enhances focus and concentration	7, 8,
Attraction	Media appearance	9, 10, 11,
	Performance	12, 13, 14,
Usefulness	Flexibility	15, 16,
	The benefit of providing assistance	17.

This research was conducted at the Control System Laboratory in the Department of Electrical Engineering Education, Universitas Negeri Yogyakarta. A total of 30 respondents, consisting of students in the department, participated in this study. Before filling out the questionnaire, students first used the Virtual Processing Station in a practical session that took place in the laboratory. They were given the opportunity to explore the features of the system, then filled out the questionnaire provided to assess their experience.

In the initial session, students were given a briefing on the purpose of the study, an introduction to the Virtual Processing Station features, and operational instructions. Next, a simple demonstration was given to clarify the concept and was followed by a question-and-answer session. After the briefing, students were asked to use the virtual processing station according to the worksheet provided. During the practical session, students were free to explore the features provided and could ask the instructor for help if they had difficulty. At the end of the session, students were asked to fill out a paper-based questionnaire with clear filling instructions.

In addition, this study also collected qualitative data through open comments and suggestions from participants. They were asked to share their experiences while using the Virtual Processing Station, providing their views and feelings about the application. These comments provide deeper insights into user experiences, contributing to a more comprehensive understanding of the effectiveness and usability of a virtual processing station in an educational context. This study also adhered to ethical standards, including obtaining informed consent from participants, maintaining the confidentiality and anonymity of data received, and adhering to the principles of academic integrity [21], [22], [23], [24], [25]. Data obtained from the questionnaire were analyzed to understand students' perceptions of the effectiveness, ease of use, and potential sustainability of the Virtual Processing Station as a simulation-based learning tool in higher education settings. This analysis is expected to provide further insight into the strengths and weaknesses of this learning medium and provide recommendations for its future development.

4. Research Results

This section discusses the results of the study on students' perceptions of the use of Virtual Processing Station as a simulation-based learning medium. The assessment was conducted based on a questionnaire filled out by respondents after they used the application in a laboratory practice session. The data collected included respondents' responses to four main aspects: relevance, attention, interest, and usefulness. In addition to quantitative analysis, this study also examined qualitative data from open comments provided by participants. The results of this analysis provide a clearer picture of the effectiveness and involvement of this learning medium in supporting the educational process in the college environment.

4.1. The Quantitative Data Collection

Quantitative data in this study were collected through a Likert-based questionnaire with a four-point scale, covering four main aspects: relevance, attention, interest, and usefulness, which are presented in Table 2. Each aspect was assessed by 30 respondents, who were first-time users of the Virtual Processing Station during laboratory practice sessions. The total score of each aspect was calculated and averaged to provide an overview of students' perceptions of the effectiveness of this learning medium. For example, the relevance aspect showed a relatively high average score, reflecting the suitability of the learning medium to the material being taught.

Table 2. The quantitative data collected from respondent's

Aspect	Relevance	Attention	Attraction	Usefulness
Minimum score	4	4	6	3
Maximum score	16	16	24	12
Average score	14,87	14,07	21,8	10,87
Percentage (%)	92,92	87,92	90,83	90,56

4.2. Data Categorization

In this study, data categorization is an important step to organize and group the quantitative information collected. Data from each respondent was grouped based on the total score on the Likert scale, then classified into several categories, ranging from "very feasible" to "very poor." This grouping was done to gain a more comprehensive understanding of the participants' overall evaluation of the virtual processing station. For example, the majority of respondents placed this medium in the "very feasible" category, indicating a positive acceptance of its use as a simulation-based learning aid. As seen in Table 3, the feedback given by the respondents was categorized into four different levels, ranging from "very poor/very inadequate" to "very good/very adequate." This classification allows for a more comprehensive understanding of the participants' responses and their overall evaluation.

Table 3. Classification of respondent's response

Score Interval	Category
(Mn + 1.5 SBn) – (Mn + 3.0 SBn)	Very Good/Very Feasible
(Mn) – (Mn + 1.5 SBn)	Good/ Feasible
(Mn – 1.5 SBn) – (Mn)	Poor/Unfeasible
(Mn – 3.0 SBn) – (Mn – 1.5 SBn)	Very Poor/Very Unfeasible

Mn: nominal mean value [1/2*(highest ideal score + lowest ideal score)]
SBn: nominal standard deviation [1/6*(highest ideal score – lowest ideal score)]

4.3. Data Analysis

The collected data were analyzed quantitatively using a descriptive statistical approach. Each aspect of learning was analyzed to determine the distribution of scores among respondents. The scores obtained in Table 2 were analyzed quantitatively and categorized based on Table 3. Based on the assessment of the media relevance aspect, the average score of 30 respondents was 14.87. The score obtained was then compared with the eligibility criteria in Table 3, placing the media relevance aspect in the "Very Feasible" category. The same method was used to determine the eligibility criteria for other aspects. In the attention aspect, the average score from respondents was 14.07, with the eligibility criteria in the "Very Feasible" category based on Table 3. The interest aspect got an average score of 21.8, and the usefulness aspect got an average score of 10.87. Based on the eligibility category in Table 3, both aspects, interest and usefulness, were categorized as "Very Feasible".

In this study, the analysis focused on four key aspects: relevance, attention, interest, and usefulness. These aspects were selected based on their immediate impact on student engagement and the effectiveness of learning media, as supported by prior research. However, broader dimensions such as long-term knowledge retention and the impact on practical skills should be considered in future evaluations, as these elements contribute significantly to assessing the overall effectiveness of learning tools in applied education contexts. For example, as in [10] [11] [12] [13] highlight that while engagement and relevance play a critical role in short-term learning outcomes, factors such as

long-term knowledge retention and the development of practical skills are equally important for sustained learning efficacy.

The chosen aspects in this study were intended to provide immediate feedback on students' perceptions of the media's effectiveness in enhancing their learning experience. However, future research should incorporate a more comprehensive evaluation framework, exploring how Virtual Processing Station influences not only short-term engagement but also long-term learning retention and practical skill acquisition. This will provide a more holistic understanding of the media's overall impact on student learning outcomes and its potential to foster skill development in the context of technical education.

Discussion

Based on the calculation results of the values obtained from user responses, they will then be converted into percentages. In the media relevance aspect, the value is 92.92% with the category "Very Feasible," in the attention aspect, the value is 87.92% with the category "Very Feasible," in the interest aspect, the value is 90.83% with the category "Very Feasible," and in the usefulness aspect, the value is 90.56% with the category "Very Feasible." Based on the overall percentage of eligibility in each aspect, a percentage value of 90.59% is obtained and is included in the category "Very Feasible." The conversion of Likert scores into percentages is carried out to provide an interpretation that is easier to understand. The percentage distribution of answers for each option is calculated, and this provides further insight into the level of acceptance or agreement of respondents to the various aspects assessed. For example, the results of the relevance aspect show that 94% of respondents consider this medium to be very relevant to their learning needs. In addition, the usefulness aspect also shows a high percentage, indicating that the majority of students feel that the virtual processing station provides significant benefits in supporting their learning process.

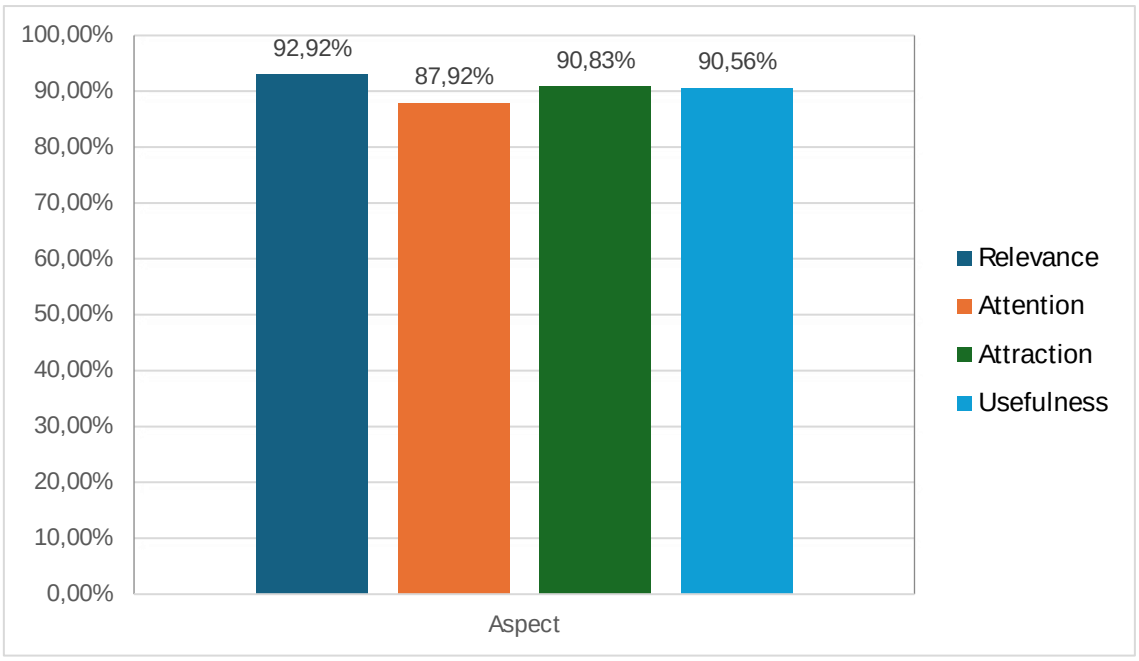

Fig. 2. Column diagram of all aspects of evaluation

The results of this study indicate that the use of Virtual Processing Station as a simulation-based learning medium received a very positive response from students. Based on quantitative data analysis, most of the aspects measured, such as relevance, interest, and usefulness, received very high scores. This is in line with the findings of previous studies, which emphasized that simulation-based learning media can increase student involvement and understanding of the material being taught. Positive feedback from respondents confirms the effectiveness of this medium. Here are some comments given by respondents regarding their experiences using Virtual Processing Station:

- "From the modules and lab sheets that I have read, the processing station simulator media can really help students to better understand the form and workings of the original processing station."
- "The media developed is very interesting."
- "The tool is good and easy to use."
- "It is very good and interactive for learning on a personal computer."
- "Very helpful in the learning process."
- "Learning media that is easy to understand for students who are still new to it."
- "The product developed is good; special training is needed for educators so that its use is maximized in the classroom."
- "Very helpful in learning."
- "A good tool to use as a learning medium."
- "Good in helping the learning process."
- "This learning medium will certainly be very helpful in learning, especially when learning outside the laboratory or workshop."
- "The product developed is good; special training is needed for educators so that its use is maximized in the classroom."
- "The buttons used should be labeled, for example, START button, STOP button, and exetra. "
- "The input and output addresses should be listed in a separate menu to identify the addresses of the buttons, sensors, actuators, and lights. "
- "If there is an error in the PLC program configuration, the table may spin continuously, and the spindle may perform drilling. When this happens, it appears as if physical contact occurs between mechanical components, even though it's only in the visualization. There should be space between the mechanical components to prevent this. "

These comments highlight various positive aspects of the learning media, such as ease of use, flexibility, and interactivity that support the learning process, both in and outside the laboratory. However, although the results obtained showed a high level of acceptance, several aspects require further attention. Several students suggested that the interface interaction and visual experience could be enhanced, particularly with the addition of clear labels on the buttons, such as START and STOP, to improve usability. Figure 3 shows the user interface before and after the revision of the buttons section. They also recommended providing a separate menu that lists the input and output addresses to help identify the connections for buttons, sensors, actuators, and lights. Figure 4 shows the list of input output addresses according to the respondent comment.

(a) (b)

Fig. 3. Improved user interface with added labels on buttons and lights, (a) before revision, (b) after revision

(a) (b)

Fig. 4. Added input output address menu (a) List of menu, (b) List of input output address

Furthermore, some students noted a potential issue with the simulation when an error in the PLC program configuration occurs. In such cases, the table may spin continuously, and the spindle may start drilling indefinitely, which creates the appearance of physical contact between mechanical components in the virtual environment. However, since the system operates virtually, this is not a safety concern. The virtual environment allows for mechanical components to intersect visually without any real physical risk. This is actually one of the strengths of a virtual system, as it minimizes unsafe conditions that could occur when using real equipment. The ability to visualize component movement and potential errors safely is a valuable feature that enhances the learning experience without endangering users.

Overall, the results of this study provide a clear picture that the Virtual Processing Station has great potential in supporting simulation-based learning in higher education, particularly in teaching industrial automation systems. In the short term, the use of VPS can enhance student engagement, increase interest, and improve understanding of complex concepts in a safe and flexible environment. In the long term, VPS has the potential to contribute to sustained knowledge retention and the development of practical skills necessary for industrial automation.

Further improvements should focus on expanding the sample size in future studies to ensure more comprehensive data. Additionally, objective assessments of student performance both before and after using the VPS will be crucial for measuring the real impact of this tool on learning outcomes. By incorporating these broader evaluations, it will be possible to assess both the immediate and long-term effects of VPS on students' learning experiences and skill development.

5. Conclusion

This study aims to evaluate the Virtual Processing Station as a simulation-based learning medium, focusing on students' perceptions as the primary users. The results show that the medium has been very well received, with high scores for relevance, interest, and usefulness, averaging 90.59% overall. The relevance aspect scored the highest at 92.92%, indicating that the medium aligns well with students' needs in understanding Programmable Logic Controller (PLC)-based automatic control concepts. The aspects of interest and usefulness also scored highly, at 90.83% and 90.56%, respectively, demonstrating that the design is engaging and effective in helping students understand the material interactively. The attention aspect, while slightly lower at 84.72%, is still in the good category, indicating its effectiveness in maintaining student focus during learning. Positive feedback from students further supports these findings, as they reported that the Virtual Processing Station greatly helped them understand the form and function of a real processing station. Moving forward, further improvements should address both the short-term and long-term impacts of this medium. In the short term, the tool effectively increases student engagement and understanding, while for the long term, future research should focus on larger sample sizes and employ objective assessments of students' knowledge and skills both before and after using the medium. This approach will provide a deeper understanding of the sustained learning outcomes and practical skills development facilitated by this simulation-based learning tool.

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