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An Inquiry-based Learning Approach in Engineering Education regarding Simulation Practice on Automation Control.

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Abstract: Automatic control is currently used widely, so it is in engineer curriculum of every major of institutions, which is instructed in most major curriculums. Each curriculum focuses on application of mathematics in high theory in order to describe the system behavior, which makes learners in automatic control subject. The learners face with the understanding of occurring after the input stimulation, which results the learner's lack of practice skills on instrument and control. Therefore, to promote learners to understand the system behavior, and gain practice skills, this research presents the instructional model focused on learner's vision on the system behavior by using computer program in order to simulate the abstract work on computer screen, and connect to concrete work from op-amp electrical circuit on PCB, and measure the system behavior from inquiry -based learning. Teachers are facilitators to monitor learners to connect the simulation with the testing of op-amp instrument. It is operated effectively by learners who are able to see the overall results from the experimental presentation through websites, which learners present through google sites. The researcher will take the instructional model to use with third-year learners.

Keywords: Inquiry-based Learning, Simulation, Operational Amplifier

1. Introduction

The control system engineering (or automatic control) is an important work in the production process in order to produce work following the design effectively. It is an autonomous driving, which is driven with robot. Therefore, an engineering education needs to provide control system engineering in every major that learners have to learn about engineering. Learning in the past, teachers taught theory using equation in applied mathematics for describing phenomenon and behavior of (Pena et al., 2022) linking theory to practice. At present the computer program is used to reduce the gap between theory that learners need to have prior knowledge about mathematics before, it leads to real practice. Teachers have to use various active learning instructions in order to help learners who have poor basic mathematics to understand the system behavior. (Al-khazraji & Ismaeel, 2020) The software program sometimes used MATLAB as a device for learning. It helps learners to have more vision on system behavior, that learners are able to adapt parameter value in the same time as system response on computer screen. (Marin et al., 2020) When learners are able to connect theory to software computer, the connection to practice, it is developed for model in industrial work, (Hernandez et al., 2020; Kaluz, Klauco, & Cirka, 2019; Arrieta, Duque & Villa, 2019) which helps learners understand and connect theory to practice completely, in the same time the work of the model development of the system has the limitation that the learners need to have prior knowledge on electronic sensor, and electronic measurement, or microcontroller, which makes learners successfully-experimented. (Rojas-Moreno, 2019) According to the mention in this paper to present instructional model by using the computer program together with the

electronics simulation in order to practice with theory in automatic control subject for third-year bachelor's degree student on the topic of transfer function of 1st order, and 2nd order system, and controller design using SISO function of MATLAB program in order to test with the system developed.

2. Related Works

2.1 Automatic Control Software Simulation

Taking software package to help in the simulation with the engineering education that it helps learners to connect theory of the complexed equation in applied mathematics with the computer program, which stimulates physical condition related to theory easily. (Kumar & Milanovic, 2022) Learners are able to see the phenomenon after the mathematics value adaptation on the computer screen immediately, and it also helps learners to understand in depth very well. (Herrmann et al., 2022) As the simulation related with the control system engineering views on the behavior in the form of time response graph by comparing between electrical signal and electrics, which stimulate the system called input with the response system in the form of the electrical signal. If the systems are mechanical system, chemical system, or others that are converted to electrical system by sensor. Therefore, learners want to experiment on the behavior system, the learners have to learn about the sensor equipment, and electrical measurement device before. It is the difficulty of learners' learning who do not study in the electrical major before. So, taking the computer program to use in the simulation for experiment on the physics phenomenon for theory concepts to help to reduce the difficulty of learners' learning very well. (Fennell et al., 2019) The proper computer programs are various which are able to stimulate the work in the form of virtual laboratory in order to design the controller of the work system. Learners are able to view the response in the form of graph, and the illustrated photos perfectly, they can see the results each of point on the graph very perfectly in the form of real time, and it reduces the complexity, the danger which will occur with learners, and it also reduces the time length for developing the stimulation model. (Dosoftei & Cojocaru, 2020; Fan et al., 2020; Huilcapi et al., 2023; Vermunt, 2023) Therefore, the simulation is a proper option for learners who practice, and prepare the readiness before the experimentation with the real stimulation model. (Andreenkov & Shunaev, 2022)

2.2 Automatic Control Hardware Simulation

Taking the active device, especially the operational amplifier : Op-amp to develop circuits and take the software program to use in the work simulation. Besides, it helps learners to understand the phenomenon of work, and helps learners to create ideas of Circuits design. Learners are able to compute by using the formula, and measure the parameter value from the electric signal device, which shown in the program immediately to promote learners to have more confidence in the application of the parameter estimation in the Circuits. (Tsvetkova & Borodzhieva, 2021) Moreover, using the Op-amp instead of the second order system, which used in the control system engineering. It is the analog Circuits, leaners are able to connect the Circuits by themselves by using the Op-amp device. The advantages of this device are cheap, can be bought easily, and can be connected through protoboard Circuits. Besides, the Op-amp is able to developed to analog controller easily, and be satisfyingly stable. (Li et al., 2022) Using the Op-amp for the stimulation by developing the printed circuit board : PCB in order to reduce the mistake of connecting the Circuits, and the signal shape which has more noise than the stimulation from real system. (Lara et al., 2018)The experimentation of the measurement, and the parameter value testing from the signal shape easily, and relates to the theory. The learners are able to view the phenomenon, which occurs after controlling, which relates to theory and practice very perfectly. (Beloiu, 2015; Subtirelu, 2015)

2.3 Inquiry-based Learning

Inquiry-based learning is learning management, which focuses on child-center. It emphasizes learners who can search knowledge by themselves by using scientific method. Teachers change their roles to be facilitators and support resources for learning, which can be applied for learning management in engineering education concerning with engineering practice found that it can promote learners have positive attitude towards engineering learning, which uses mathematics equation and understanding in content. After that the design is taken to verify and observe behavior, then report the conclusion occurred from the design, which uses theory knowledge. Learners work in groups, brainstorm, and cooperate to find the answers from the designing step, which assigned by the teachers to try-out and test from these make cooperating skills to find the answers (Gero, Catz & Sabag, 2018), while they help learners have competency on cooperation work including report writing, and the interpreting scientific articles (Jarvisalo et. Al., 2020). Taking the inquiry-based learning to use for this learning, it is the talented issue for teachers in practicing subject (Brookes, 2018). Teachers help learners while problem occurring by learners classify problems and used for problem solving to prevent learners loose the concepts and feel discouraged.

3. Learning approach for automatic control :

3.1 Learning Approach

Learning approach in this research presents the model of the instruction by using the inquiry-based learning together with the active device in the type of op-amp, which stimulated to be 1st order, and 2nd order system including the design of controlling Circuits with the op-amp device. The advantages of the learning of the inquiry-based learning. It helps learners to have good attitude towards learning. (Mueni et al., 2023) It is suitable for the instruction based on both theory and practice, which helps learners understand the science concept to promote the collaboration working, and team of learners. (Dobber et al., 2017) The steps are as follows: step 1 the teacher random the learner's group by each of group has not more than 3 members. Each week teacher defines the learning in each week. Besides, step 2 learners in each group operates the simulation with MATLAB Simscape program using the op-amp circuits, it is the main design by learners have to use the computing formula of the resistor, and the capacitor from theory which is suitable for the questions that the teacher defined in each group in order to connect to 1st order, and 2nd order system. Then measurement of the time constant value from the computer program is done. When the topic of the controlling design uses the order of SISO in the design of controller instead. When the learners understand the Circuits, they connect PCB Circuits by themselves, step 3 the learners measure the time constant from the PCB compared with the theory, it is the step 4 learners check the accuracy, and indicate the mistake in practice, and represent the computing formula, and the last step is learners present work, which is done in each week through webpage with google site program. The step shown in the figure 1. Beginning form step 1: the teacher defines the learning objectives, informs learning principles that learners must learn from the theory to practice, then use questions to encourage learners to find the answers, which are not covered the learners' knowledges, step 2: learners are divided into 3-5 people, after that the teacher presents theory principles, and have learners brainstorm by learners' prior knowledges to find the answers together with the teacher, step 3: expanding the theory concepts to simulate from MATLAB to practice with op-amp on PCB, this step helps the teacher to guide new principles for occurred-problem solving. If the results of testing from the simulation, op-amp, and on PCB are not relevant to the theory, and step 4: learners must conclude the knowledge from the simulation, and practice with electronics gadgets, which how it is related to the theory. If problems are occurred during work, how to solve the problems, and the last step: the teacher must evaluate learner's knowledge, and skills. From the observation, how learners take concepts, and new skills to apply, including skills and team-work process. The role of learners for learning on inquiry-based learning, learners must pay attention to build concepts by themselves by before entering class, they should review the background knowledge to be ready for new lesson or prepare questions for asking in the classroom.

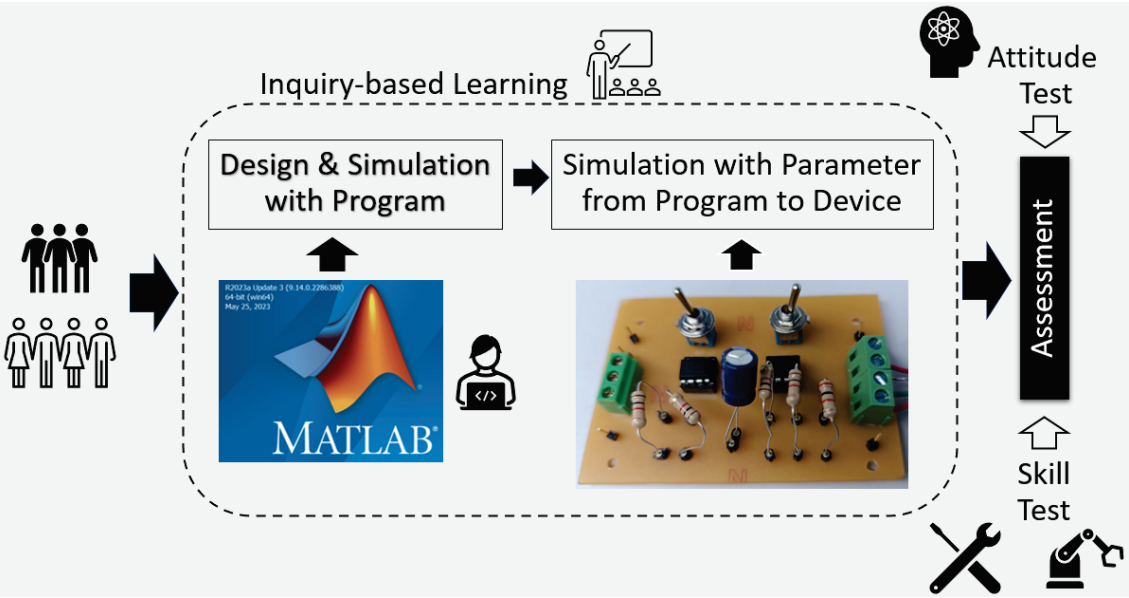

Figure1. Learning Approach

3.2 Simulation Step

The MATLAB program in this research comprised 2 parts as follows:

3.2.1 Simscape

Simscape is the program by using drag and drop device, and draw to connect together. The learners are able to use the electrical measurement device as the authentic device, which shown in figure 2. Learners use simscape to stimulate the work of op-amp Circuits before connecting the Circuits on the PCB sheet.

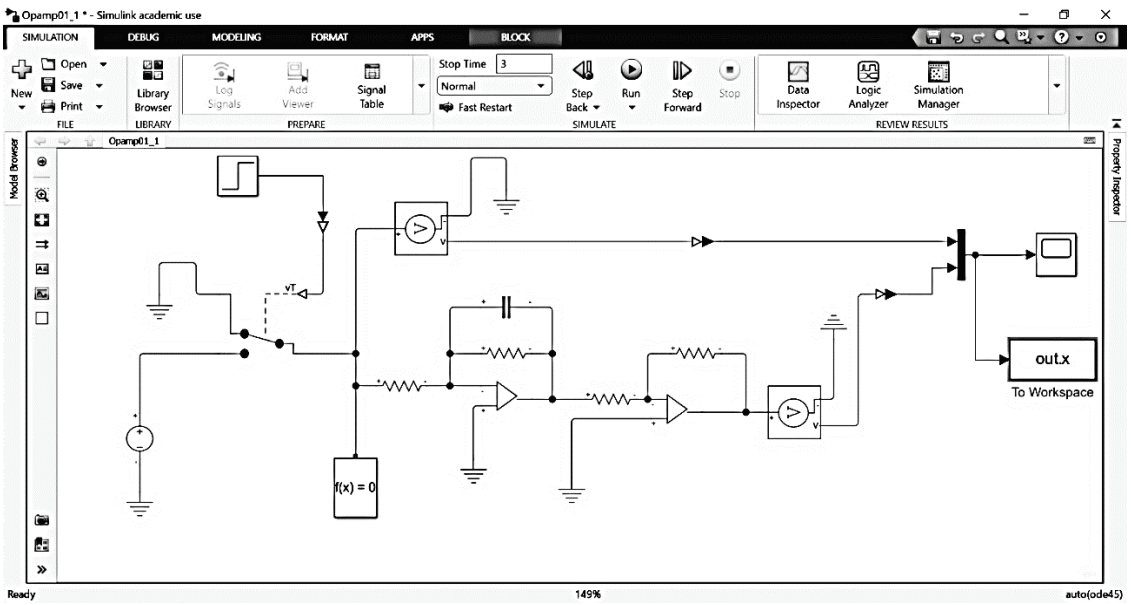

Figure 2. Simscape on MATLAB Program

3.2.2 SISOTOOL command

SISOTOOL command is the command in the text mode of the MATLAB program, which shown in figure 3. It is the type of graphic user interface : GUI, which users are able to fill the transfer function of the parameter value form the op-amp Circuits on simscape in order to design the

controller of parameter value of controller, which shown on computer screen. The users are able to take parameter value to design analog controlling Circuits by using the op-amp immediately.

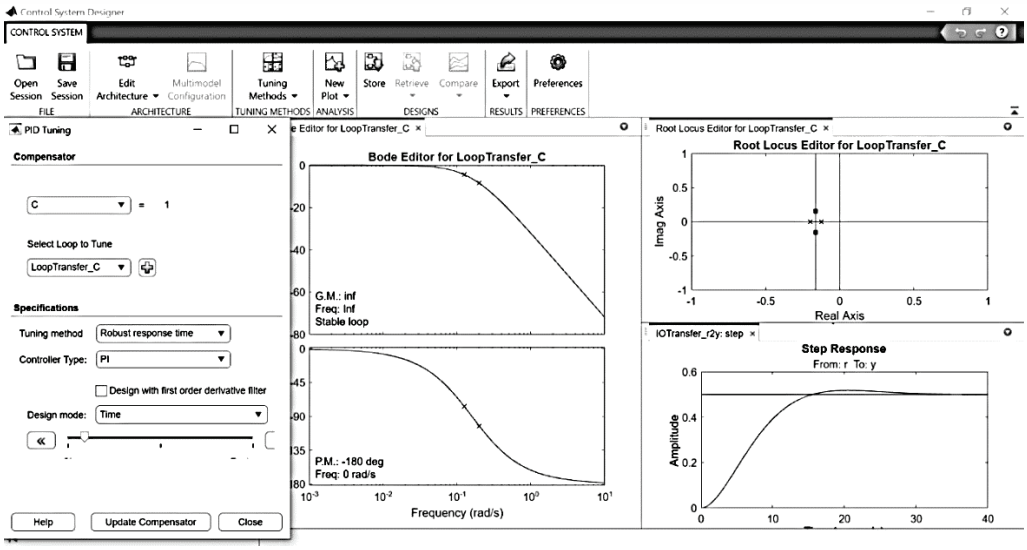

Figure 3. GUI SISOTOOL on MATLAB Program

3.2.3 The op-amp Circuits is a Circuits of 1st order, and 2nd order system, which contained on PCB sheet, it has the point for line connecting, and the connecting point for measure electrical signal between input compared with output, which shown in figure 4. Moreover, it is able to take op-amp Circuits to develop to analog controller Circuits in order to be close loop control as well.

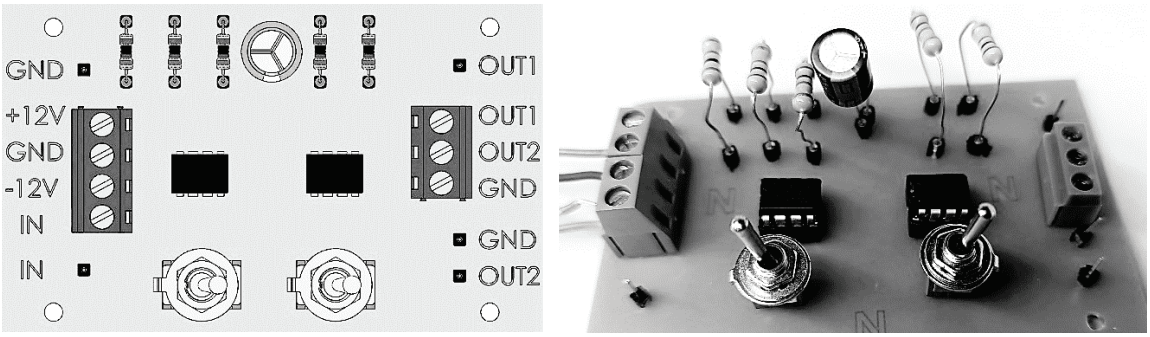

Figure 4. Op-amp Circuits on PCB

3.4 Assessment and Evaluation Step

The evaluation form comprises 2 parts as follows: skill evaluation form, which used for evaluating each learner's skills by this skill evaluation form will do after finishing the learning unit by using the rubrics score. Which is the criterion for the evaluation. After finishing of the skill evaluation, the learners' attitudes towards learning will be done using the criterion of Likert 5-level.

4. Conclusion & future work :

This research presents the model of instruction by using the inquiry-based learning model in an automatic control subject by group of learners help to find the information including with practice by using the MATLAB computer program in the simulation, and the controller together with practice the connecting on the PCB sheet. Learners measure the electrical signal on input

compared with output in order to view the response of the system in the form of graph. Moreover, learners present the work via websites. After completing all topics, Learners do the skill test, and attitude evaluation towards learning. When the information is from the evaluation. The research is presented by using percentage, and standard deviation for further research. In the future these principles will be used in other related subjects with Automatic Control, which are more complexed by comparing with other models such as, project-based learning or flipped classroom.

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