The development of intelligent control media for problem-based learning with power-of-two approach

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Abstract. The present study aims to (1) develop intelligent control (IC) media (hardware, software, and manual instruction) for Planning of Industrial Automation System (PIAS) course, (2) describe the results of the implementation (validation and verification) of the developed IC media, and (3) improve the quality of learning and student learning outcomes (LOs). This is research and development (R & D) carried out through two stages. (1) First, the development of IC media and operational function programs, (2) Second, the product implementation was carried out by involving students. The data were collected by observation, documentation, and questionnaire, and were analyzed by descriptive quantitative and evaluative techniques. The results obtained are as follows. 1) The developed learning resources, are perceived as Good (76%) by students, 2) The learning process using IC instructional media seems “Good” (71%), 3) Based on the predetermined targets, the researcher found that students make a very significant improvement in terms of the mastery of the PIAS course materials, specifically in IC System. As recorded in three assessment stages, students obtaining grade A and B are 20%, 60%, and 80% consecutively. The results show that in the third assessment, 80% of students have exceeded than the predetermined target of 75%.

1. Introduction

The revolution of telecommunication and information technology in learning have probably crated problems on lectures, namely efforts to develop the abilities and capacities of students as optimal, creative, and adaptable individuals. This makes the lecturer-centered learning (TCL) model less appropriate to apply, and lecturers need to strive for the student-centered learning (SCL) [1]. SCL learning supports students to be able to do customization or construction of knowledge delivered by lecturers. In that case, learning requires each individual to have a thoughtful, complex, and creative personality who possesses intellectual, social, and personal skills. This, unfortunately, does not happen in the Planning of Industrial Automation System (PIAS) learning process.

PIAS reveals theories mostly dealing with considerably complex mathematics, mechanics and dynamics, programming, and control system in which the instructional media becomes inevitable to activate students' intellectual, social, and personal skills [2]. As researched, the use of IC media in learning is believed to be able to foster a variety of student competencies and nurture their inspiration, creativity, moral, intuition (emotion), and spirituality.

PIAS learning requires a practical approach to develop the full potential of students [3]. IC media equipped with a student book or worksheet and manual instruction seems appropriate to PAIKEM [4], [5]. Supported by power-of-two approach through problem-based learning (PBL), the instructional media should be developed in such a manner that SCL whose foundation refers to constructivism can optimally improve student LO [6]. Based on the description above, the research problems can be identified as follows. (a) The development of communication and information technology is thought to have a significant influence on the needs to change the learning strategy from TCL to SCL. (b)
Learning with TCL approach carried out in PIAS has not been able to develop student competencies. (c) Learning with TCL approach conducted in PIAS also has not been able to optimize student LO. (d) Learning of PIAS is theoretically assumed to be unable to foster student inspiration, creativity, moral, intuition (emotion), and spirituality. (e) Development of IC media for PIAS learning is allegedly capable of supporting PAIKEM [7], [8].

The focus of the present research is the development of IC media for PIAS. Based on the identification of the above problems, this study is limited to the followings. (a) PIAS learning with the SCL approach is carried out to develop students' intellectual, social, and personal competencies and skills. (b) The implementation of SCL in PIAS is intended to foster student competencies in constructing knowledge embedded in the LO. (c) PIAS learning should be carried out with the assistance of IC media through PAIKEM with a problem-based approach and power-of-two model. Therefore, the objectives of this study are (a) to produce IC media (the hardware, software, worksheet and manual instruction) for PIAS that are appropriate for developing student competencies, (b) describe the results of the implementation (validation and verification) of the developed media in PIAS course through PAIKEM with a problem-based and power-of-two approach.

2. Research Method
The present study employs a Research and Development approach. In its implementation, two stages were carried out, namely: the stage of developing the product, intelligent control (IC) model, and the product implementation or trial in the teaching and learning process. In the product development stage, the process sought to develop a model of the IC simulation hardware with various supporting components and software for various IC operations.

The steps of product development carried out include (1) a selection and analysis of system requirements (intelligent control hardware and software models), (2) making prototypes, (3) designing the hardware model and algorithms, (4) translating the algorithm into program codes for operations, (5) hardware/software testing, and (6) program revision and improvement.

In the product implementation phase, the previously developed hardware/software were used in the real situation. This follows the ten steps proposed by Borg & Gall, namely research and information collecting – reviewing literature, observing classes that will be used for implementation, and preparing for implementation, and planning – defining the observed skills, determining the order of goals to be achieved, and testing the ease of implementation. Later, developing the preliminary form of the product, the third step, was carried out by preparing instructional materials (choosing, organizing, and packing the materials), preparing the manual used for learning, and preparing evaluation instruments to assess to what extent the objectives have been achieved.

The fourth step would be the preliminary field-testing or the use the product in the actual situation in the class. Products were used in class involving 20 to 35 students. In this process, interviews about the use of the product, observation of the results and impacts of using the product, collecting data using various instruments, and analyzing data and observations were carried out. In this step, product testing was on the user's side, namely by the end-users through beta testing. The test carried out was in the form of product verification and validation. On the fifth step was the main product revision, a process of revising or repairing the product. Later, the main field-testing, which was the use of improved products in classroom learning. Products were utilized in a class involving 30 to 40 students. In this case, interviews, observations, data collection, and analysis were carried out. Operational product revision as the next step resembled the re-processing the product repair and refinement by referring to the input suggested by the data. Step 8, the operational field-testing, took the form of reusing the improved products in a class comprising 40 to 50 students. To see the results and impacts of the products, data collection (observation and interviews) and data analysis were conducted.

Step 9, the final product revision, was the last product improvement with the intention that the greatly improved products have been obtained. Lastly, in step ten the dissemination and implementation were carried out. These included efforts to report the latest products that have been perfected and tested through several stages and the results of research into various research journals regarding the findings that were obtained and ready to be implemented on a wider scale of use.
In its implementation, the product development was carried out in the Computer Laboratory and Electrical Engineering Education Laboratory of Faculty of Engineering, Yogyakarta State University, while the product implementation was conducted in the Department of Electrical Engineering Education, YSU Yogyakarta. Both stages were carried out from February to May 2019. The respondents of the study include lecturers and students of the Department of Electrical Engineering for the validation and verification.

As mentioned, the current study includes two phases, namely: (1) product development in the form of intelligent control model with the software and manual, and (2) implementation of the products results in real situations in the classroom-learning context. The data were collected by the following:

2.1. Product development phase

2.1.1. Observation, regarding the needed intelligent control model and their supporting items, as well as (1) accuracy of instructions (syntax error), (2) accuracy of the process (run time error), (3) accuracy of results (logic error), and (4) verification and validation of the products (white/black-box testing).

2.1.2. Questionnaires and interviews, regarding the completeness and accuracy of the hardware and software functions.

2.1.3. Documentation, concerning the material, form, and model of the robot and the program used.

2.2. Product implementation phase

2.2.1. Observation, on the precision, accuracy, functionality, and capability of the hardware/software produced.

2.2.2. Documentation, the students' data, scores, and learning outcomes.

The data collected are the description of students’ ability, the scores of test results, and problems of the IC programs produced. The documentation includes students’ data, scores, and pre-, whilst-, and post-program achievement.

The tools and materials used in this study include (1) one unit of personal computer (a minimum of Pentium IV 1.2 GHz 512Mb HD 60Gb RAM) for the product development and implementation, (2) a scanner for retrieving image data, (3) a digital camera/camcorder for taking live images, (4) a printer for printing work results, (5) C-program software, code vision for code programming, and (6) supporting hardware (flash disk and CD ROM). Data were analyzed by means of quantitative and evaluative descriptive analysis techniques. These techniques were used because this study does not test hypotheses. In addition, the feasibility, capability, and effectiveness of the products were analyzed to see how they work in its function to measure the students’ competency.

3. Results

3.1. The Model of the IC Media

Learning resources needed are in the form of the learning media of the IC System, based on observation data in the learning process, which serve to motivate students. IC material by students is considered a difficult material because the IC System course contains numbers and symbols which in the presentation need to be displayed more interestingly. This study focuses on the materials in the IC System as a part of JST Supervised Learning, which is one of the intelligent system materials that have a high level of abstraction. Based on data from the research results, instructional media can help students to better understand the course materials.

The model preferred is in the form of instructional media that can motivate students to learn with more concentration, and it must be carefully designed. Elements of clarity and computing are the main driving forces that need much more attention. Computational elements that explain the JST learning process are pretty necessary for an effort to bring the students’ mind to better understand IC abstraction. Supported by texts in the form of written information and formula of numbers, its presentation becomes more interesting, so that the learning resource has a fairly great strength to aid students in better material understanding. More importantly, the IC model must be made with clarity
and size of the image and the size of the text to suit the needs of the subject matter. For this reason, validation by the experts must be done. Based on student assessment data on the produced model in the form of IC media, the mean scores are 74% (Good) for competencies, 77% (Very Good) for images, and 75% (Good) for texts. This means that the model in the form of IC instructional media used is Good. It also means that the model of IC instructional media in the form of an intelligent control system is Good to be used for learning of IC System.

3.2. Learning by Using the IC Media

As found in the research results on learning, the use of instructional media should follow the sequences below.

3.2.1. Pre-teaching

At this stage, the lecturer plans the materials to be presented. The materials are arranged in a sequence from simple to complex ones. The materials are arranged in the form of pointers with brief explanations of the theories and examples of applications. Based on the materials, visualizations should be made to facilitate students' reasoning ability. Visualizations can be charts and multimedia forms. Besides, there should be something ready to be presented, also something made to be duplicated and shared with students. This makes possible the students to have a copy of the materials when the lecturer explains them in front of the class.

3.2.2. Whilst-teaching

The materials that are ready to be presented (of course have been validated) by the lecturer are used in the learning process. In this case, the lecturer must be able to regulate the use of the prepared materials. The model of IC media in this study includes the followings. 1) The lecturer sets the student condition to be ready to learn. 2) The lecturer presents the materials by IC System instructional media. 3) The lecturer prepares students for discussion. 4) The lecturer provides the material for the discussion. 5) The lecturer divides students into groups for discussion by the power-of-two model, and then guide and monitor the discussion. 6) The lecturer prepares students and provides some questions for practice. 7) The lecturer guides students while working on the questions. 8) The lecturer gives questions for individual practice without giving guidance at a certain time.

3.2.3. Post-teaching

The procedures done by the lecturer before ending the class include three points. 1) The lecturer corrects the answers and reflects on what has been learned. 2) The lecturer comments on the results of the student's work. In this case, the lecturer by word of mouth convey motivational messages if there are students who have not been able to master the intended materials, 3) The lecturer delivers the materials that need to be learned for the next meeting. 4) Lastly, the lecturer closes the lesson.

Based on student assessment, the learning model used obtains a mean score of 71% with a Good category. This means that the learning model used is Good or appropriate. It also implies that learning by using IC media in the form of computer-assisted media is Good for use in PIAS learning, specifically for the topic of IC System.

3.3. Student Achievement

Based on the analysis results, the data obtained concerning the scores of students, it can be clearly seen that in the first assessment, 20% get grade A and B, in the second assessment 65% obtain grade A and B, and in the third assessment 80% achieve grade A and B. These results provide the fact that learning by using IC media and appropriate learning methods can improve the student achievement. Students' abilities are measured through tests of memorization, understanding, application, analysis, evaluation, and creativity. The acquisition of high LO means that a high level of mastery is achieved. Conversely, low LO will illustrate a low mastery level. Based on the assumptions that have been made, the students’ mastery of knowledge is the basis for achieving student competency. Thus, it
suggests that students who have higher scores on learning outcomes mean that they have greater ability, which also means higher competency. This also applies to the reversed conditions.

The target set out in this study regarding the ability of students has been exceeded. The highest target set is that 75% of students achieve grade A and B. Based on the analysis results, it is apparent that there is a significant increase in the achievement of mean scores of the three assessment stages.

Such an achievement has the contribution of IC media in the learning process. Actually, most lecturers hardly take the efforts done in the current study in teaching the same course. They usually use the handbook solely, explain, give examples of questions, and then work on the questions. This would be unfortunate for students who have the low ability. Therefore, such methods seem to always produce unsatisfying learning. The results of this study, conversely, indicate that the learning process using IC media and appropriate learning methods can overcome the problems faced in the Intelligent Control System course, specifically and other subjects in general.

In the first assessment, the achievement of reasoning abilities is still far from what is expected, because there is only 20% of students who can reach the Good category of mastery. While a large percentage is in the Fair and Bad categories. Based on the results of this first assessment, further efforts were made to improve the way of learning and presentation of examples of problems. Supporting efforts were done by delivering lecture materials systematically with pointers and examples of practical problems, followed by practice assignments.

In the second assessment, the percentage of student achievement somewhat increases as the achievement of students in the Good category has reached 65%, meaning that it has exceeded 50% compared to the first assessment which only reaches 20%. The increase of about three times is very significant. However, based on the research target, this has not yet reached the desired target, namely 75. The achievement of 65% is still below that target, or there is still 35% with Fair or Bad category. To improve the learning outcome, various efforts were carried out. These efforts include the development of problems (problem-based) by using a more interactive learning model, namely discussion. The aim was to motivate students to be more interested and proactive in learning. Previous efforts that are already meet the student needs were carried out continuously so that the actions in learning were perfected and added with other media.

In the third assessment, the achievement achieves 80% or a 15% increase from the second assessment result. This achievement has exceeded the desired target of 75% having Good category. Through efforts to improve the learning, the enhanced actions were found to be able to increase the ability quite significantly. The remaining 20% rests in the Bad category. This of course still needs continuous improvement in the learning process so that the most optimal learning outcomes can be achieved.

Based on the list of the obtained scores above, it is apparent that the achievement of the final scores of the students and the mean score of 65.35 can be calculated. According to the conversion table, the score is in category C (Fair). After repairs to learning, the mean score of 69.45 or category B (Good) has been achieved. Thus there is a significant increase in learning outcomes after using the right learning model with the support of the developed IC media.

4. Conclusion
Based on data analysis results and the discussion, three conclusions are formulated as follows.

- Learning resources in the form of intelligent control (IC) learning media can be very well used to support the learning process of the IC System with a subject matter of intelligent control. The scores regarding media, according to students, are 74% for competence, 77% for images, and 75% for text.
- The way the learning process using the IC media acquires a Good result if it is used to support the learning process of the IC System. The mean score as given by the users is 71%, or in a Good category.
- The student's mastery of the lecture materials in Planning of Industrial Automation System (PIAS) course, specifically in the subject matter of intelligent control is indicated by the achievement of learning outcomes by learning using the IC media model. Based on the
predetermined target, it turns out to experience a very significant increase. Achievement of the
target in the first assessment is only 20%, in the second assessment is 60%, and in the third
assessment becomes 80%. The results obtained suggest that the third assessment can reach 80%,
meaning that it has exceeded the target of 75%.

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