An Automotive Vocational Instructional Model: *Supporting the 21st Century Competencies and Industrial Revolution 4.0*

Nirmala Adhi Yoga Pambayun*, Kir Haryana

Universitas Negeri Yogyakarta, Indonesia
**Corresponding author. Email: nirmalaadhi_yp@uny.ac.id, nirmalaadhi.2021@student.uny.ac.id*

ABSTRACT
This study aims to determine the instructional model in automotive vocational in higher education that is suitable to support the development of the 21st century competencies and the Industrial Revolution 4.0. This study is quantitative research with the survey method. The research respondents are alumni of the Automotive Engineering Education Study Program of Universitas Negeri Yogyakarta who have worked in the linear job in the automotive field, both in the field of education and the automotive industry, with a total 100 people. The data were collected using a questionnaire equipped with an explanation of instructional models, which had previously been determined through a literature review by researchers suitable for the automotive field. The data were analysed by using the descriptive analysis technique. The results show that the most suitable instructional models for theoretical learning is cooperative learning and project-based learning models for practical learning. The determination of the instructional model needs to be adjusted to the conditions of the learning input and the learning objectives to be achieved.

Keywords: *automotive vocational, Industrial Revolution 4.0, instructional model, the 21st century competencies*

1. INTRODUCTION

Teaching-learning process in university must match the profile of the graduates to be formed. Vocational education in higher education is very closely related to the world of work, and graduates from vocational study programs are expected to be ready to work, to become entrepreneurs, or to continue to higher education levels. In the current era of disruption, the type of work in certain fields has changed due to technological development and community [1]. We know that today there are many jobs changing and even disappearing due to technological advances [2]. Automotive Engineering Education Study Program, as a producer for vocational school teachers and trainers in the automotive industry, must be able to adjust the learning process in order to produce graduates that are competent and in accordance with the needs of the world of work.

The 21st century competencies are important points to be integrated into learning so graduates can compete and exist in the world of work. There are four main skills students need to master in the 21st century: creativity, critical thinking, communication, and collaboration [3]. Binkley et al. divide the skills that need to be mastered by students in the 21st century into four: 1) ways of thinking: creativity, critical thinking, problem solving, decision making, learning and innovation; 2) ways of working: communication and collaboration; 3) tools for working: information and communication technology (ICT) and information literacy; 4) living in the world: citizenship, life and career, and personal and social responsibility. These abilities have implications on high adaptability with teams, technological changes, work culture, and ability to solve problems and innovate [4]. This competency cannot be used as a separate course; it can be integrated into appropriate courses since the formation of this competency requires a relatively long process and time.

Determining the instructional model needs to pay attention to many aspects so learning can achieve the expected goals. The automotive engineering education department requires input from the world of work and

industry to be able to adapt the learning process on campus to the characteristics of graduates needed in the world of work. There are several things to consider in choosing a learning model: 1) learning problems that occur; 2) the learning objectives to be achieved; 3) characteristics of students; 4) characteristics of learning materials; 5) when and where learning is carried out [5]. These aspects must be identified in advance by educators to be able to determine the appropriate instructional model. Each instructional model has its own characteristics and will be effective if the characteristics of the instructional model are in accordance with the conditions and characteristics of the learning input. The challenge that will be faced in the selection of learning models is the supporting facilities, where until now the infrastructure in vocational education has difficulty keeping up with the conditions of technological developments in the world of work [8].

Learning models that are oriented towards the formation of the 21st century competencies and the Industrial Revolution 4.0 and that are in accordance with the characteristics and learning objectives in the automotive engineering study program include inquiry/ discovery learning models, problem-based learning models, project-based learning models, and cooperative learning models. Each instructional model has its own character and stages. The explanation regarding these learning models is as follows:

1.1. Inquiry/Discovery Learning Model

The inquiry/discovery learning model aims: 1) to help students think analytically and 2) to encourage students to be more daring and creative in imagining [9]. Furthermore, the advantages of the inquiry/ discovery learning model are: 1) real life skills: students learn about important things but are easy to do, and they are encouraged to be active and not passive; 2) open-ended topic: the themes studied are not limited, and they can be sourced from anywhere; 3) intuitive, imaginative, innovative: students learn by mobilizing all their potential, from creativity to imagination, and they will become active learners, out of the box; 4) opportunities to make discoveries: with various observations and experiments, students have the opportunity to make discoveries [9]. The stages of the inquiry/discovery learning model are as follows, 1) formulating questions; 2) planning; 3) collecting and analysing data; 4) drawing conclusions; 5) applying and following up.

1.2. Problem-based Learning Model

Problem-based learning is a progressive and learner-centred active learning approach where problems are used as starting points and anchors for the learning process [10]. In problem-based learning, students' motivation to identify and study concepts and principles in solving problems is stimulated by real problems that they will be faced in the world of work. Small groups are created as places where students learn to develop the ability collectively in acquiring, communicating, and integrating information [11].

Problem based-learning has the appropriate characteristics to meet the learning needs of the 21st century. A strong reason for implementing problem based learning is the characteristics of an emphasis on real-world competencies, such as self-learning skills, collaborative learning, problem solving, and decision-making [12]. Through this learning model, it is expected that competencies that can support success in the world of work can be supplied to students so that the world's need for a competent workforce can be met.

The problem-based learning stages are: 1) students are given problems; 2) during the discussion, students ask questions that describe the aspects of the problem; 3) students are rankings, and decide which questions the entire group will follow up on and which issues can be given to individuals, who then teach the rest of the group. Students and teachers discuss what resources are needed to research the problem and how they can find the answer; 4) when students regroup, they explore the problem, integrating new knowledge gained into the context of the problem. Students are encouraged to summarize their knowledge and connect it to newly acquired concepts. Students then define a new problem through this process students will see that learning is an ongoing process and there will always be issues to be explored [11].

Almost similar to the stages above, Tan, O. S states that the problem based-learning stage consists of several steps: 1) presentation of the problem; 2) problems are used to trigger questions; 3) problem based-learning stages (Initial analysis, Generating learning issues, Iteration of problem solving independently and collaboratively); 4) Integration of new knowledge; 5) Presentation and evaluation of solutions [12].

1.3. Project-based Learning Model

Project-based learning uses projects as a medium to achieve learning goals that include attitudes, knowledge, and skills [13]. Through the implementation of project-based learning, students will practice planning, carrying out activities according to the plan, and displaying or reporting the results of activities.

Projects are classified into several types. There are types of projects based on the nature and order of their activities: 1) structured projects, which are determined by the teacher including topics, materials, methodology, and presentation techniques; 2) unstructured projects,

which are determined by students; 3) semi-structured projects, which are projects that are determined and managed jointly by teachers and students [13].

Tippelt divides the steps in project-based learning into six stages, namely 1) informing, planning, deciding, implementing, controlling, and evaluating [13]. Based on the description of the stages of the learning model, project-based learning was adapted to conditions in higher education. The stages of the project-based learning model are as follows: 1) project determination, 2) design of project completion steps, 3) preparation of the project implementation schedule, 4) completion of the project with supervision and facilitation from the teacher, 5) the preparation of reports and presentation / publication of project results, and 6) evaluation of the process and the final results of the project.

1.4. Cooperative Learning Model

The cooperative learning model is an instructional model in which students learn in small groups (generally consisting of 4-5 students) with heterogeneous membership, such as different levels of ability, gender, and ethnicity/race [14]. There are five kinds of variations of cooperative learning models, namely, 1) Student Teams Achievement Divisions (STAD), 2) Jigsaw, 3) Group Investigation, 4) Think Pair Share, 5) Numbered Heads Together [14].

Cooperative learning excels in helping students understand difficult concepts [15]. Cooperative skills contained in cooperative learning (social skills) have an important function to train students in smooth working relationships and tasks. Where the role of working relationships can be built by developing communication between group members. While the role of the task is done by dividing the tasks between group members during the activity. As a learning skill, the cooperative skill apparently has levels, namely the initial level, intermediate level, and advanced level [16].

Cooperative learning has many benefits, including: 1) improving effective learning time; 2) improving self-confidence; 3) improving students' attitudes toward subjects, teachers, and schools; 4) increasing students' focus on the learning process; 5) increasing tolerance; 6) reducing conflict between students in learning process; 7) reducing student apathy; 8) deepening understanding of learning materials; 9) increasing student learning motivation; and 10) improving student learning outcomes [18]. On the other hand, cooperative learning can improve the ability to see the world from other viewpoints, improve harmonious relationships between ethnicities in school or in the classroom, increase students' confidence, and appreciate the shortcomings and abilities of others. There is a better interaction between students thus making the learning process more interesting [19]. This exciting learning can improve the learning achievement of students.

2. METHOD

This research is descriptive research with quantitative data type with the survey method. The subjects of this research are alumni of the Automotive Engineering Education Study Program, Faculty of Engineering, Yogyakarta State University who have worked in a linear world of work in the automotive sector, both in the field of education and the automotive industry with a total of 100 people. The data were collected through by using a questionnaire equipped with an explanation of learning models, which had previously been determined through a literature review by researchers suitable for the automotive field. The respondents can choose more than one type of learning model for one subject area. The data were analysed using descriptive analysis techniques to facilitate the presentation and interpretation of the research data.

3. RESULT AND DISCUSSION

3.1. Theory Courses Instructional Model

This research instrument presents the stages of four learning models considered in accordance with the demands of learning in higher education today: the inquiry/discovery learning model, problem-based learning model, project-based learning model, and cooperative learning model. The respondents could choose more than one learning model deemed appropriate to the characteristics of the course, the formation of the 21st century competencies and the demands of work in the Industrial Revolution 4.0. In addition, respondents could also propose other learning models. The courses in the automotive engineering education study program were grouped according to their clumps so 10 subject clusters were obtained. The courses used were competency courses in automotive field. Pedagogic courses and general courses were not included in this study. Through this research, it was expected that alumni who had worked and had work experience in the world of education and the automotive industry could provide an overview of learning models that were in accordance with the demands of the current world of work, especially those that could provide students with the 21st century competencies and the demands of the current Industrial Revolution 4.0.

Based on the results of the research, the most suitable instructional model for theoretical subjects in the Automotive Engineering Education Study Program is the cooperative learning model. The cooperative learning model focuses on students being able to work and study in groups, and with this learning model it is

expected that peer teaching will occur so that between students can exchange information, discuss, and be able to answer questions/tasks/problems that arise and are given by the lecturer. In this case, the lecturer plays a role in guiding the group to work and study, providing an evaluation of what students get in studying and working in groups and giving awards to groups that get good learning achievements. The ability to work together and collaborate is one of the important competencies that graduates must possess in the 21st century. When viewed jobs in the world of work, all are interrelated systems and must support each other to achieve the desired goals.

Table 1. Instructional Models for Theory Courses

No	Field of theory courses	Instructional models			
		Cooperative	Project-based	Problem-based	Inquiry/discovery
1	Automotive basic	42*	23	38	30
2	Engine	40*	33	30	21
3	Chasis	40*	27	37	31
4	Electrical	40*	31	32	25
5	Vehicle body	27	54*	24	20
6	Design	29	61*	18	11
7	Motorcycle	37	46*	27	17
8	Heavy equipment	36*	33	31	23
9	Vehicle diagnosis	27	32	42*	34
10	Regulation and management	38*	21	30	33
Average		36	36	31	24

*: highest score

The experimental results showed that students had consistent learning effectiveness in the two heterogeneous groups, the results that were significantly different between the two experimental groups were in terms of interaction between students. The results of this study indicate that the results achieved in learning are not significantly different but from the interaction side there are significant differences. This is where the advantages of cooperative-based learning. The soft skills of students related to cooperation, communication, empathy, and others can be trained [20].

Buchs et al. found that teachers consider cooperative learning as a model that is not easy to implement, more than 40% of teachers use the model only occasionally and only 33% use it in learning regularly. Teachers report they have difficulty including cooperative learning in the curriculum since it takes longer time to achieve learning goals and evaluate students [21]. The results of this study illustrate that the implementation of cooperative learning must be done with careful planning so that learning time is not wasted and can be used effectively. In addition, this can be overcome by optimizing learning with flip or blended learning so that when in class students already have a basic knowledge base.

After cooperative-based learning, there is project-based learning, which is the most preferred choice for subjects in the field of body, design, and motorcycles. Project-based learning is learning that uses projects as a medium in the learning process to achieve attitude, knowledge, and skill competencies [17]. These three courses are very suitable for the implementation of project-based learning because these courses have the potential to produce products and the students will be more honed in their abilities when given a project directly. Another reason why this model is suitable for motorcycle courses is that almost all students have motorbikes so it will be very interesting if learning is combined with projects. Students can directly explore more deeply related to the vehicles they have.

Chiang & Lee, based on their research results, show that project-based learning can increase the learning motivation of vocational school students and facilitate student to increase their problem solving abilities, giving projects indirectly encourages students to solve problems that arise to complete the project. Students' motivation to master the material will be higher because to complete the project, students must master the material [18]. The problem based-learning model is considered the most suitable for vehicle diagnosis courses. Vehicle diagnosis courses include engine, electricity, chassis, and motorcycle diagnosis. This model is very suitable to improve and develop students' analytical skills in diagnosis, since from the learning stages in this model, students are trained to solve problems presented by the lecturer. Dolmans et al. state that problem-based learning is widely used in learning in higher education. The results of his research prove that students feel very satisfied with problem-based learning. However, in the learning process, there are still problems often encountered, such as too directive tutors, too structured problems, and the learning process in students groups that do not work [19].

Based on this research, the respondents' choices of the learning models, the difference between one model and another is not very significant. Therefore, it does not mean that only the most suitable model can be used. However, other learning models can also be used by considering the conditions of the learning input [5].

3.2. Practical Courses Instructional Model

Practical courses have a different character from theoretical courses, where in practical courses, students are directly exposed to training object in laboratories or workshops. Practical courses incline more to forming the psychomotor abilities of students. Respondents can choose more than one learning model that is deemed appropriate to the characteristics of the course, the formation of the 21st century competencies and also the demands of the world of work in the Industrial Revolution 4.0.

The higher number in the table indicates that the greater the percentage of the number of respondents who choose the model. It means that the most suitable learning model is the project-based learning model. Fields of practical courses in accordance with the learning model include basic automotive, engine, chassis, electricity, body, design, motorcycle, and heavy equipment.

According to Lasauskiene and Rauduvaite, based on the results of their research in implementing project-based learning, positive feelings and attitudes are needed from lecturers such as developing student competencies, collaboration between lecturers and students, and their professional development to get maximum results. The strength of the project-based learning model is the type of project provided by the lecturer and their ability to guide students to complete projects with specified quality and according to the targeted time. The right project and mentoring from the lecturer will provide an in-depth learning experience and can be a valuable provision for students when they enter the world of work [20].

Mills & Treagust found that conventional learning models will not be able to meet the accreditation needs and demands of the world of work. There needs to be a breakthrough in the learning model, one of which is by combining learning with projects. In its implementation, it is necessary to increase the complexity of the given project. This can increase the satisfaction of graduate or industrial users. In addition, the engineering profession and academia are more familiar with the concept of projects in their professional practice, compared to the concept of problem-based learning. Thus, project-based learning will be more easily adopted and adapted by engineering study programs at universities than problem-based learning [21].

The problem-based learning model is considered suitable for vehicle diagnosis courses. In this course, students are required to solve problems that will later be encountered in the world of work in carrying out vehicle maintenance and repairs. Problem-based learning in technical and vocational education and training (TVET) can reduce the gap between theory and practice, because problem-based learning model provides an interesting and challenging learning experience with flexible learning spaces and activities [22].

Sada et al. based on the results of their research concluded that the use of the problem-based learning approach in the teaching and learning process at TVET will 1) accelerate students' high-level skills; 2) assist students in solving problems effectively, collecting and evaluating information related to problems, and developing solutions; 3) be adaptable; 4) improve technical competence; and also 5) be able to work with others, especially in a team setting [23].

Table 2. Instructional Models for Practical Courses

No	Field of practical courses	Instructional models (%)			
		Cooperative	Project-based	Problem-based	Inquiry/discovery
1	Automotive basic	25	56*	26	19
2	Engine	34	49*	29	16
3	Chasis	31	47*	42	13
4	Electrical	28	49*	33	20
5	Vehicle body	20	76*	20	13
6	Design	23	71*	20	11
7	Motorcycle	29	53*	25	17
8	Heavy equipment	31	44*	33	20
9	Vehicle diagnosis	25	44	46*	22
Average		27	54	30	17

*: highest score

4. CONCLUSION

This study provides an overview of instructional models in automotive vocational higher education that can support the 21st century competencies and the Industrial Revolution 4.0. Based on the learning models, the most suitable for automotive vocational theory course is cooperative-based learning, and for practical learning is project-based learning. This research provides an overview of which instructional models can be chosen in certain subject areas. The choices can be adjusted to the conditions of learning input and learning objectives, since this study is not an absolute choice, considering that the choice of the respondents in each learning model are not significantly different.

REFERENCES

[1] World Economis Forum, The future of jobs: employment, skills and workforce strategy for the fourth industrial revolution. Switzerland: World Economic Forum, 2016.

[2] I. U. The Economist, Driving the skills agenda: Preparing students for the future. London: The Economist Report, 2015.

[3] J. Bialik, M., Fadel, C., Trilling, B., Nilsson, P., Groff, Skills for the 21st century: What should students learn. Boston: Centre for Curriculum Redesign., 2015.

[4] M. Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., Rumble, Assessment and teaching of 21st century skills. Dordrecht: Springer, 2012.

[5] T. Van den Akker, J., Branch, R. M., Gustafson, K., Nieveen, N., Plomp, Design approaches and tools in education and training. London: Springer Science & Business Media, 2012.

[6] J. U. Okorie, Fundamental of teaching practice. Enugu: Fourth Dimension Publishers Co. Ltd, 1979.

[7] N. M. Baba, Basic Principles and methods of teaching. Kaduna: Joyce Publishers, 2007.

[8] N. A. Y. Pambayun, H. Sofyan, K. Haryana, Vocational high school infrastructure conditions and the challenges in facing the era of literation and industrial revolution 4.0, J. Phys. Conf. Ser., vol. 1700, no. 1, pp. 0–8, 2020, doi: 10.1088/1742-6596/1700/1/012068.

[9] K. Anam, Pembelajaran berbasis inkuiri. Yogyakarta: Pustaka Pelajar, 2015.

[10] E. Baldwin, MS; Beltran, RO & Chernobilsky, Enhancing thinking through problembased learning approaches: International perspectives. Thomson Learning Asia, 2004.

[11] D. E. Duch, B. J., Groh, S. E., Allen, The power of problem-based learning: A practical" how to" for teaching undergraduate courses in any discipline. Stylus Publishing, LLC, 2001.

[12] O.-S. Tan, Enhancing thinking through problem-based learning approach: International perspective. 2004.

[13] R. Tippelt, The project method in vocational training. Munich: InWEnt, 2003.

[14] R. . Arends, Learning to teach. New York: McGraw-Hill, 2012.

[15] R. E. Slavin, Educational psychology: Theory and practice. Boston: Allyn and Bacon Publishers, 2009.

[16] L. Lundgren, Cooperative learning in the science classroom. New York: McGraw-Hill, 1994.

[17] F. Stoller, Establishing a theoretical foundation for project-based learning in second and foreign language contexts, Proj. Second Foreign Lang. Educ. Past, Present. Futur., pp. 19–40, 2006.

[18] H. Chiang, C. L., Lee, The effect of project-based learning on learning motivation and problem-solving ability of vocational high school students, Int. J. Inf. Educ. Technol., vol. 6, no. 9, pp. 709–712, 2016.

[19] C. P. Dolmans, D. H., De Grave, W., Wolfhagen, I. H., Van Der Vleuten, Problem-based learning: Future challenges for educational practice and research, Med. Educ., vol. 39, no. 7, pp. 732–741, 2005.

[20] A. Lasauskiene, J., Rauduvaite, Project-based learning at university: Teaching experiences of lecturers, Procedia-Social Behav. Sci., vol. 197, pp. 788–792, 2015.

[21] D. F. Mills, J. E., Treagust, Engineering education—Is problem-based or project-based learning the answer, Australas. J. Eng. Educ., vol. 3, no. 2, pp. 2–16, 2003.

[22] T. S. Ahlfeldt, S., S. Mehta, Measurement and analysis of student engagement in university classes where varying levels of PBL methods of instruction are in use, High. Educ. Res. Dev., vol. 24, no. 1, pp. 5–20, 2005.

[23] R. Sada, A. M., Mohd, Z. A., Adnan, A., Audu, Effects of problem-based learning in teaching and learning of technical and vocational education and training, Int. J. Sci. Res. Publ., vol. 5, no. 5, pp. 1–3, 2015.