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Conceptualizing Case-based Simulation Framework: Evidence from Electrical Technology in TVET Case Study

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This study was conducted to generate the Electrical Case-based Simulation (CBS) framework that contributes to the transformation of TVET learning pedagogical practices. CBS is believed to be able to enhance the ability of TVET students in soft skills required by the industry, such as thinking skills and problem solving skills. This study used case study design through a mixed-method approach. A total of four electrical technology curriculum implementers from a vocational college had participated in this study. Evaluation of the case-based simulations were made by experts using questionnaires whereby the absolute agreement among them was then determined using Intraclass Correlation Coefficient (ICC). A high value of agreement was obtained for both the CBS process and structure categories. The qualitative data was thematically analyzed. Three themes (achieve electrical course learning outcomes, opportunity to learn and related to electrical technology of content) had emerged for the process category and five themes (enhance electrical technology students' thinking skills, workplace situation, students' engagement, enhance electrical students' problem solving skills and trigger learning activities) for the structure category. From the ICC results and the curriculum implementers views, it can be construed the case-based simulations reflected the workplace situations. In conclusion, this study contributes to the creation of electrical CBS framework that can be used as a guide for curriculum implementers and industry to support the transformation of TVET education in Malaysia.

Keywords: TVET, case-based simulation, electrical cases, expert's views, thinking

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INTRODUCTION

The globalization of Technical Vocational Education Training (TVET) gained world attention when the United Nations General Assembly in September 2015 decided to ratify the Sustainable Development Goals (SDGs), in which it also marked the acceptance by world leaders that previous development approaches were unsustainable. It is seen as such because developing countries are less focused on TVET Education, despite the fact that TVET Education is able to improve the economic status of a country (Bhurtel, 2015; Mohammad Shafi et al., 2021; PENJANA, 2019). This is reinforced by the United Nation 2030 agenda which focuses on thinking about prosperity, human beings and the interconnected planet (Berestova, 2020; McGrath, et al., 2020). This agenda is a sign of a high-level commitment to a new way of thinking about the intertwining of economic, environmental and social development through TVET. To boost the field of TVET Education, UNESCO has developed a clear plan to ensure that TVET is part of a transformative approach to the development of a country. Reliable and comprehensive skills system can be built to support individuals, communities and organizations to generate and sustain financial acquisition opportunities through TVET (UNESCO, 2016). The skills required for TVET students as preparation for their workplace (Lauzon, 2018; Ramamuruthy, Alias, & DeWitt, 2021) include communication, problem solving, collaboration, thinking skills, creativity and other soft skills. However, TVET Education in Malaysia has also undergone a change in Education policy as TVET Malaysia focuses on the direction of employment and industry by ensuring that TVET students master practical knowledge and skills in line with industry demands (Adnan et al., 2021; Sulaiman & Mohd Salleh, 2016; Kenayathulla, 2021). The importance of TVET education can be translated with over 60 per cent of jobs having been created in the 11th Malaysia Plan (2016 to 2020). This agenda continues until the 12th Malaysia Plan (2021 to 2025) (PENJANA, 2019). However, there are still complaints from the industry regarding the level of thinking skills among students to enable them to face challenges in the workplace (Azmi & Salleh, 2021; Hadi, Hassan, Razzaq, & Mustafa, 2015; Makhbul et al., 2015).

There is an issue raised by the industry that it is a challenge to place TVET graduates in the world of work. The demand in the workplace is not limited to mastery of knowledge only. Thinking and problem solving skills are also among the important requirements that they need in order to face real situation in the field (Azid et al., 2019; Wannapiroon et al., 2022). Therefore, students need to be educated with such skills starting from the primary school levels. However, learning involving thinking skills implemented in schools is still less effective (Zhaffar et al., 2017) because existing learning practices poorly reflect the processes of thinking skills and problem solving in real workplace situations. In order to strengthen the process of thinking skills, Sternberg (2020) suggested three essential elements of thinking; analytical, creative and practical should be included in the learning process. Analytical thinking refers to solving problems that occur and making decisions. Creative thinking is solving new problems in different ways, whereas practical thinking refers to a person’s ability to adapt to the environment without involving any obstacles or problems that occur (Sternberg, 2020). Herreid

(2013) suggests case-based learning as a learning simulation tool to provide real learning experiences for students as they mimic real workplace situations in learning. Hence, this study incorporated analytical, creative and practical thinking in the development of the TVET workplace cases.

This is in line with Malaysia's target of 20% renewable energy (RE) in its generation mix by 2025 (Abdullah et al., 2019; Harun et al., 2021), which is an opportunity given to young entrepreneurs in the electrical field to develop RE. However, knowledge and skills related to RE among them need to be strengthened to face challenges in RE entrepreneurship. Accordingly, the Malaysian government intends to create young RE entrepreneurs through TVET institutions to produce qualified technical personnel in preparation for the 20% RE generation by 2025. However, graduates from TVET institutions still lack the capabilities to become electrical entrepreneurs due to lack of competence in entrepreneur knowledge, confidence, creativity, innovation, problem solving, and thinking skills to face global challenges (Abdullah et al., 2019; Harun et al., 2021). Therefore, this study was conducted to improve analytical, creative and practical thinking skills among TVET students in Malaysia.

Learning through electrical case-based simulation requires TVET students to learn to interact and manipulate basic knowledge when interacting with situations that resemble the world scenario of employment in the electrical industry. According to (Jhala & Mathur, 2019; Nkhoma et al., 2016), case-based learning allows students to apply their knowledge to a problem. Electrical case-based simulations encourage students to identify problems by focusing on electrical issues, developing and evaluating alternatives and subsequently offering solutions. Case-Based Learning (CBL) approach is a student-centered teaching methodology that exposes students to workplace situations that need to be solved using their content knowledge and thinking skills (Ali et al., 2018; Nunohara et al., 2020). Nkhoma et al., (2016), who examined the value of developing case-based learning activities based on Bloom’s Taxonomy of thinking skills suggested case-based learning to stimulate learning and encourage learning through critical thinking as students apply knowledge when analysing cases (Azid et al., 2020). The process of analysing cases improves the skills of evaluating judgment and subsequently the process of evaluating judgment improves the creative solution. This is in line with the view of Ellet (2007) who stated that case-based learning must involve one of the following four types of situations namely (i) problems, (ii) decisions, (iii) assessments and (iv) rules. Meanwhile, Herreid and Schiller (2013) stated that the characteristics of good case-based learning are; (i) short (one to three pages can work well for most instructors and appropriate to the teaching period, (ii) can create controversy in which issues presented produce a competitive discussion atmosphere, (iii) have dialogue between characters so that it seems more realistic to the reader, (iv) have interesting characters. In this study, the use of electrical case-based learning was able to encourage an active investigation process based on the prepared cases which created prompts for guided discussion based on facts and case content.

RESEARCH QUESTION

1. What are the curriculum implementers' agreement values on the process and structure of electrical CBS?
2. What model is formed resulting from curriculum implementers' views on the process criteria and structure criteria in constructing and designing electrical CBS?
3. What is the emerging framework to develop electrical CBS based on the implementers' views?

METHOD

Research design

Researchers used case-study research design with mixed-method (triangulation design) for this study (Hancock et al., 2021), to collect and analyse quantitative and qualitative data. Both of these data sets were collected at the same time during the case-based simulation evaluation session. After analysing the data sets separately, the researchers tried to combine them by comparing or synthesizing the results and linking the two types of data (Plano-Clark et al., 2008). Triangulation design analysed quantitative and qualitative data simultaneously. The researchers compared and analysed the quantitative and qualitative data and subsequently synthesized the results of the data analysis. Both the quantitative and qualitative results were integrated to produce a conclusion based on the research questions.

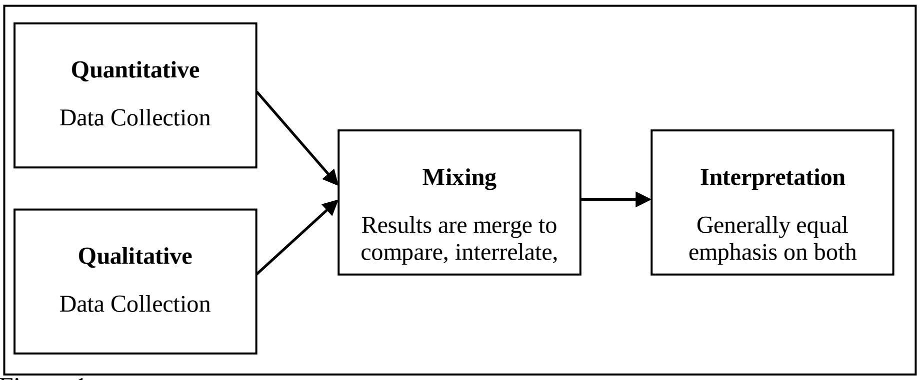

Figure 1
Research design with mixed-method (triangulation design)
Source: Plano-Clark, Huddleston-Casas, Churchill, Green, Garrett (2008).

Sampling & Research procedure

A total of four electrical technology curriculum implementers were involved as study samples. Purposive sampling technique was applied to select the samples based on the set of criteria: 1) all samples should be electrical curriculum implementers who are experienced in teaching electrical technology courses in vocational colleges, 2) Their teaching experience in the field is more than eight years, 3) they have expertise in the field, and 4) all samples are willing to attend our meeting and voluntarily be part of our study.

Detailed explanations about the nature and purpose of the study were presented to them. There were 10 curriculum implementers who attended a briefing session for this study. After having clear objectives, the curriculum implementers were willing and eager to be part of the study as they realized that their involvement would benefit their institutions and students. Those who intended the briefing recommended four (4) of them to represent the curriculum implementers' view. All study samples were formally appointed and the letter of consent certifying that all information provided was for research purposes only were signed.

The evaluation session began and the samples were given time to give their ratings based on the process category and the structure of the case. After all cases were rated, a discussion session through focus group interviews was conducted to get feedback on the electrical case-based simulation built by the researchers. The evaluation process was video-taped with respondents' permission for the purpose of data analysis. The selection of the subjects/respondents based on the agreements given by respondents after detailed explanation about the nature and purpose of the study were presented to them. There were a number of curriculum implementers who attended briefing sessions for this study, after having clear objectives of the study; they were willing and eager to be part of subjects of the study as they realized that their involvement in the study would benefit their institution and their students. Those who intended the briefing recommended 4 of them to represent the implementers' view. As for criterion, all samples should have more than 8 years of teaching experience in the field and that they are willing to attend our meeting and voluntarily be part of our study.

All study samples were formally appointed and invited to attend a case-based simulation evaluation session on a day and date agreed between the researchers and the study samples. All samples signed a letter of consent certifying that all information provided was for research purposes only. The evaluation session began with a briefing on the purpose of the study and the presentation of each conducted electrical case-based simulation. The samples were given time to give their ratings based on the process category and the structure of the case. After all cases were rated, a discussion session through focus group interviews was conducted to get feedback on the electrical case-based simulation built by the researchers. The evaluation process was video-taped with respondents' permission for the purpose of data analysis.

Test analysis

Quantitative data were analysed using intraclass correlation coefficient (ICC) to see agreement among the raters on case-based simulations constructed by researchers (Landers, 2019). This analysis was conducted on two categories, namely the process and structure of case-based simulation. ATLAS.ti 9 software was used to analyse and form the theme of qualitative data (Morse et al., 2017). ATLAS.ti 9 serves to categorize data, form code or themes, and help analyse data in an organized and systematic manner

(Morse et al., 2017). Icons such as add documents, quotations, codes, memos, networks, links, project explorer and A-Docs were used to enter raw data, build code and code the data as well as memos for the purpose of explanation for each element that was coded through conversation transcripts of four curriculum implementers. Based on the theme, a network was formed to explain the relationship of one code to another code (code-code relation). Consequently, the results formed themes related to the research questions.

Instrumentation & Reliability

A set of questionnaires measuring the process category and structure of case-based simulation construction was adapted from Kim et al. (2015); Herreid, (2007) which consisted of a scale of 1 (very weak) to 10 (very excellent). Meanwhile, the interview protocol was developed by the researchers and underwent a face and content validity process by three qualitative research experts at Universiti Utara Malaysia. Expert comments and suggestions were considered when improving the interview protocol. Pilot test was implemented to 55 college vocational teachers in electrical technology programme to measure the reliability of questionnaire. The Cronbach alpha value was .82.

FINDINGS

Quantitative Findings

Based on descriptive analysis, Table 1 shows the profile of four curriculum implementers in the field of electrical technology. Three of the curriculum implementers have more than 10 years of teaching experience while one has five years of teaching experience but with seven years of working experience in the industry. All of them (n=4) have qualifications in the electrical field.

Table 1
Curriculum implementers' profile

Curriculum Implementers (not their real name)	Age	Gender	Qualification	Teaching Experiences	Industry Experiences
Mr. Hanan (R1)	40	Male	Degree in Electrical	12 years	-
Mr. Khairul (R2)	37	Male	Degree in Electrical Engineering	5 years	7 years (electrical engineer)
Mr. Mahfuz (R3)	36	Male	Degree in Technology & Education (Electrical Engineering)	14 years	-
Mrs Ain (R4)	36	Female	Degree in Technology & Education (Electrical Engineering)	14 years	-

The reliability values for all criteria were high for all cases, case one (electrical fraud case), case two (electrical shock case), case three (leaking generator case), case four, (short circuit case), case five (company cash budget case) and case six (organizing internal training/workshop case) as shown in Table 2.

Table 2
Reliability value for each electrical case-based simulation

Cases	Criteria	
	Process items=5	Structure items=6
Case 1: A Case of Electrical Fraud	.972	.960
Case 2: A Case of Electrical Shock	.938	.807
Case 3: A Case of Leaking Generator	.972	.972
Case 4: A Case of Short Circuit	.972	.937
Case 5: A Case of Company Cash Budget	.992	.916
Case 6: A Case of Organizing Internal Training/ Workshop	.938	.980

Table 3 displays the experts' evaluation consensus values of Case 1 which showed that the average intraclass correlation coefficient (ICC) score for process was .972 with confidence interval 95% from .876 to .998 (F (3, 12 = 36.000, p <0.000), and as for electrical case-based simulation structure the average of ICC score was .934 with confidence interval 95% from .761 to .995 (F (3, 27 = 15.251, p <0.000). For Case 2, the result showed that the average ICC score for process was .938 with confidence interval 95% from .588 to .996 (F (3, 6 = 16.000, p <0.000) and as for electrical case-based simulation structure the average of ICC score was .965 with confidence interval 95% from .873 to .998 (F (3, 27 = 28.742, p <0.000).

The experts' evaluation consensus values of Case 3 showed that the average ICC score for process was .972 with confidence interval 95% from .876 to .998 (F (3, 12 = 36.000, p <0.000) and as for electrical case-based simulation structure the average of ICC score was .982 with confidence interval 95% from .934 to .999 (F (3, 27 = 55.286, p <0.000). In Case 4, result showed that the average ICC score for process was .972 with confidence interval 95% from .876 to .998 (F (3, 12 = 36.000, p <0.000) and as for electrical case-based simulation structure the average of ICC score was .956 with confidence interval 95% from .839 to .997 (F (3, 27 = 22.667, p <0.000). Meanwhile, for Case 5, the average ICC score for process was .938 with confidence interval 95% from .720 to .996 (F (3, 12 = 16.000, p <0.000), and as for electrical case-based simulation structure the average of ICC score was .986 with confidence interval 95% from .947 to .999 (F (3, 24 = 70.750, p <0.000). For Case 6, the average ICC score for process was .938 with confidence interval 95% from .588 to .996 (F (3, 6 = 16.000, p <0.000), and as for electrical case-based simulation structure the average of ICC score was .992 with confidence interval 95% from .970 to .999 (F (3, 27 = 121.000, p <0.000). These quantitative findings indicated that all the experts showed high agreement values for the process and structure criteria of all the electrical cases.

Table 3
Intra-class correlation Coefficient (ICC) value based on process criteria

		95% Confidence Interval		F Test with True Value 0			
	Intra-class Correlation b	Lower Bound	Upper Bound	Value	df1	df2	Sig.
Case 1: A case of electrical fraud							
Single Measures	.875	.585	.990	36.000	3	12	.00
Averages Measures	.972	.876	.998	36.000	3	12	.00
Case 2: A case of electrical shock							
Single Measures	.833	.322	.987	16.000	3	6	.00
Averages Measures	.938	.588	.996	16.000	3	6	.00
Case 3: A case of leaking generator							
Single Measures	.875	.585	.990	36.000	3	12	.00
Averages Measures	.972	.876	.998	36.000	3	12	.00
Case 4: A case of short circuit							
Single Measures	.875	.585	.990	36.000	3	12	.00
Averages Measures	.972	.876	.998	36.000	3	12	.00
Case 5: A case of company cash budget							
Single Measures	.750	.340	.979	16.000	3	12	.00
Averages Measures	.938	.720	.996	16.000	3	12	.00
Case 6: A case of organizing internal training/ workshop							
Single Measures	.833	.322	.987	16.000	3	6	.00
Averages Measures	.938	.588	.996	16.000	3	6	.00

Table 4
Intra-class correlation coefficient (ICC) value based on electrical case-based simulation structure criteria

		95% Confidence Interval		F Test with True Value 0			
	Intra-class Correlation b	Lower Bound	Upper Bound	Value	df1	df2	Sig.
Case 1: A case of electrical fraud							
Single Measures	.558	.241	.955	15.251	3	27	.00
Averages Measures	.934	.761	.995	15.251	3	27	.00
Case 2: A case of electrical shock							
Single Measures	.735	.408	.976	28.742	3	27	.00
Averages Measures	.965	.873	.998	28.742	3	27	.00
Case 3: A case of leaking generator							
Single Measures	.844	.586	.987	55.286	3	27	.00
Averages Measures	.982	.934	.999	55.286	3	27	.00
Case 4: A case of short circuit							
Single Measures	.684	.343	.970	22.667	3	27	.00
Averages Measures	.956	.839	.997	22.667	3	27	.00
Case 5: A case of company cash budget							
Single Measures	.886	.667	.991	70.750	3	24	.00
Averages Measures	.986	.947	.999	70.750	3	24	.00
Case 6: A case of organizing internal training/ workshop							
Single Measures	.923	.763	.994	121.000	3	27	.00
Averages Measures	.992	.970	.999	121.000	3	27	.00

Qualitative Findings

Qualitative findings based on interviews of curriculum implementers, which were fully transcribed as verbatim prior analysis (Shaffie, et al., 2018), have contributed to the construction of the process criteria model (Figure 2) and structure criteria model (Figure 3).

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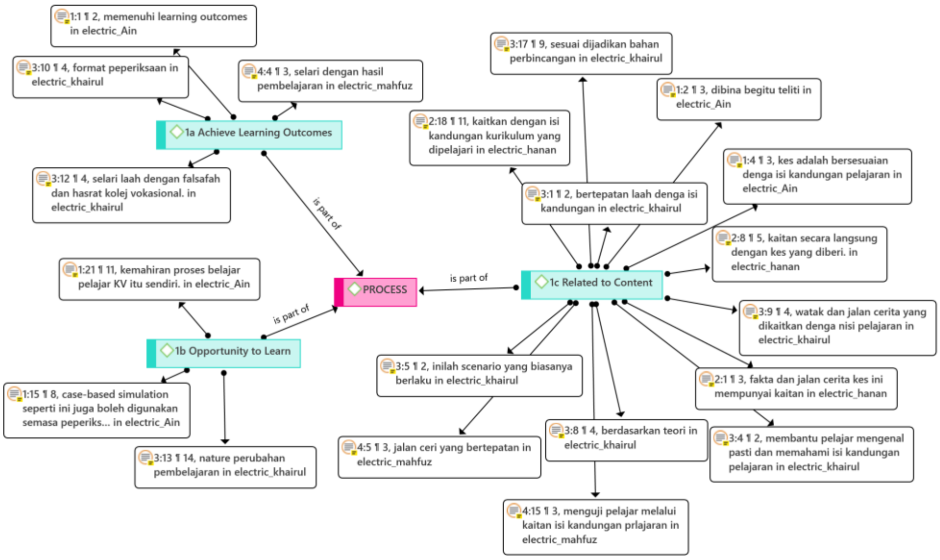

Figure 2
Model of process criteria

Based on the interview session there were three themes that described the process criteria during the development of electrical case-based simulation. The first theme was to achieve learning outcomes. For the first theme which was ‘achieve learning outcomes’, three curriculum implementers stated that CBS electrical meets the learning outcomes of the courses in the electrical technology program in vocational colleges: *“Electrical CBS covers electrical courses learning outcomes”* (R4), *“Electrical CBS aligns with electrical courses learning outcomes”* (R3)*“Electrical CBS aligns with the college vocational examination format”* (R2)*“Electrical CBS aligns with the educational philosophy of college vocational”(R2)*.

The second theme which was ‘the opportunity to learn’, the curriculum implementers commented that CBS electrical provides opportunity to learn to vocational college students through the understanding that CBS provides a new learning environment for vocational college students: *"In my opinion CBS brings a change in the nature of* *learning in vocational colleges because it has not yet been applied in vocational college learning" (R2)*

In vocational colleges, self-learning process skills are highly emphasized. With the availability of CBS, it can be a space and opportunity to nurture self-learning process skills. This was agreed upon by the instructor at the Vocational College. She commented that *"the use of CBS in my opinion can foster the self-learning process skills of vocational college students" (R4)*. Furthermore, it is a meaningful learning material for students to prepare themselves for exams: *"I support CBS because it can be used as a meaningful learning material in preparing vocational college students for exams" (R4).*

Finally, the last theme was 'relates to content'. For this theme, all curriculum implementers stated the same thing that CBS complied and was in line with the content of electrical technology courses in vocational colleges and *"cases in CBS comply with the content of electrical technology courses in vocational colleges" (R3).*

Among them, they agreed that the cases/scenarios created in CBS were related to the scenarios that vocational college students often learn in electrical theory and practice classes: *"CBS is directly related to the electrical content that vocational college students learn" (R1).* The content of CBS developed was in line with the content of electrical lessons and could be used as discussion materials in electrical technology course classes: *"cases built through CBS are suitable for the content of electrical lessons in vocational colleges and can be used as learning materials" (R4)*. In fact, they also stated that the storyline, facts and characters found in CBS fit the electrical technology curriculum learned in class: *"the characters and case stories developed are very much related and relevant to the content of electrical lessons" (R2), "the facts and storyline of the cases have relevance to the learning of electrical technology courses in vocational colleges" (R1)*. R2 stated and agreed with the rest that *"electrical CBS helps students identify and understand the content of electrical technology courses."* In other words, as a whole they agreed that the development of CBS was directly related to the content of electrical technology lessons studied by vocational college students.

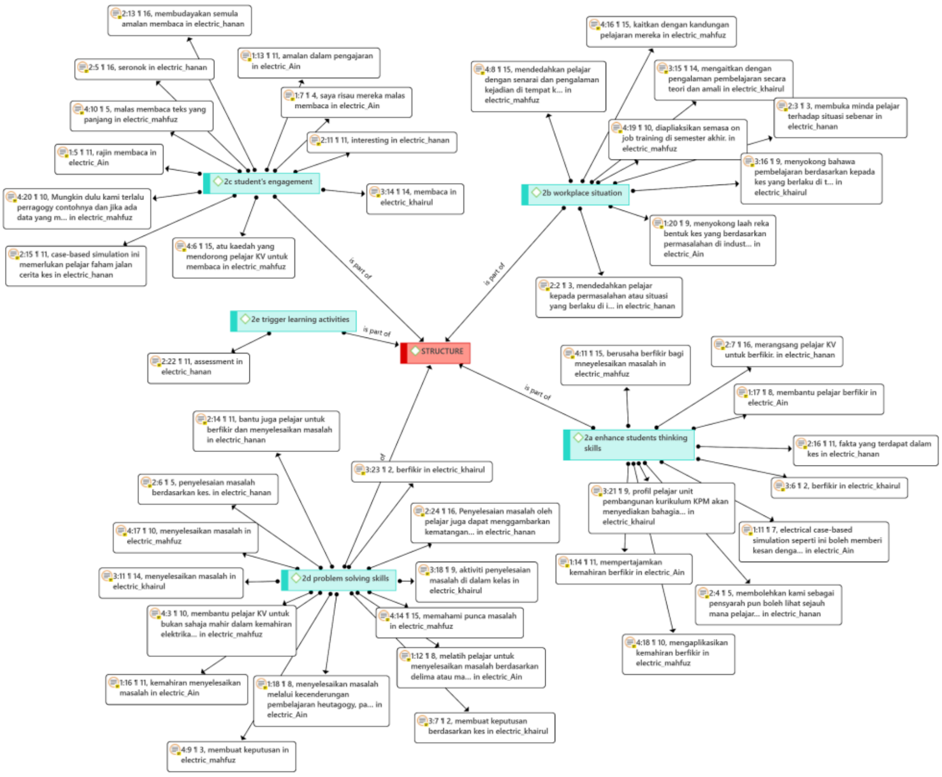

Figure 3
Model of electrical case-based simulation structure

The structure model in Figure 3, formed as a result of interviews with the electrical curriculum implementers, shows five themes that describe the criteria for electrical case-based simulation structure. All curriculum implementers talked about similar things and thus can be concluded through five themes namely (i) student’s engagement, (ii) problem solving skills, (iii) trigger learning activities, (iv) workplace situation, (iv) enhance students' thinking skills. This means that the CBS built has these five themes to represent the structure criteria in designing and developing case-based simulations. Based on the first theme of 'students’ engagement', all curriculum implementers said that electrical CBS brought new changes in the learning process of vocational college students by cultivating reading practices, as stated by (R3) that *"CBS is a method that stimulates vocational college students to read electrical cases”. "CBS is interesting, fun and re-cultivates the practice of reading among vocational college students" (R1). Furthermore, "the use of CBS allows students to be more diligent in reading cases even though they may have been too lazy to read before" (R4).* (R1) and (R4) said that CBS has great potential to encourage students to read to understand the facts of the case and identify the best solution based on the problems in the case: *“CBS needs students to* *understand the storyline of the electrical case" (R4)*. The changing learning climate that focused on case-by-case reading for problem solving was very interesting, fun and re-cultivated the practice of reading among vocational college students. Thus, CBS contributed to a new pedagogical practice towards engaging students to be actively involved in case-based problem solving: *"CBS requires students to read the entire electrical case to understand the facts and storyline" (R2).*

The second theme was 'sharpening college vocational students' problem solving and thinking skills. CBS provided opportunities for students to solve problems based on dilemmas or issues in a case*: "CBS trains college vocational students to solve problems based on dilemmas or problems that exist in the case" (R4).* CBS stimulated students to think about solving electrical problems. CBS could be used as a problem-solving activity in the classroom that urged students to solve problems and make decisions: "*allows students to think to solve problems "(R2), (R1); "Helping college vocational students not only skilled in electrical skills but also able to solve problems based on electrical cases" (R3);* CBS described student maturity in thinking: *"enabling students to understand the root cause of problems on a case-by-case basis" (R3); "Problem solving through CBS reflects students' thinking maturity" (R1).*

Electrical CBS structure triggered learning activities because problems related to electrical technology courses created in the case could be used as formative assessment activities in theory and practical classes of vocational college students: *"CBS can be used as formative assessment material for vocational college students in the classroom" (R1); "CBS is a learning activity that requires students to think to solve problems based on electrical cases" (R3).* Students think while undergoing CBS learning activities: *"CBS learning activities cultivate students' thinking" (R4).*

Based on the interviews, all implementers said that CBS electrical was relevant to workplace situation because it involved real situations in the industry: *"I agree that case-based learning that occurs in the workplace reveals learning experiences in the industry" (R2)*; *"I support that the cases are designed based on problems in the industry to provide experience on job training to students" (R4)*. All curriculum implementers supported that cases were designed based on problems in the industry or workplace situation: *"Electrical CBS can be applied by students while at work later"* (R3). Problems in the case of preparing college vocational students for on job training in the final semester could also be solved through CBS: *"Exposing students to problems or situations that occur in the workplace during on job training" (R1).* Cases related to the content of electrical technology can open students' minds to real situations in the workplace: *"CBS opens minds and exposes students to scenarios and experiences of workplace incidents in the field of electrical technology" (R3), (R1).* CBS was able to relate to practical and theoretical learning experiences: *"CBS has successfully linked theoretical and practical learning experiences among college vocational students" (R2); "CBS associates electrical lesson content with workplace situations" (R3).*

Based on the analysis of the qualitative data above, CBS was significant in two main categories, namely the developing process of the case and the structure element of the case (refer Figure 4). In the developing process of the case, the first category included three themes namely 'achieve electrical course learning outcomes', 'opportunity to learn' and 'relates to electrical technology content'. Meanwhile, for the second category, it included 'enhance electrical technology students' thinking skills, workplace situations, students' engagement, enhance electrical students' problem-solving skills and trigger learning activities. Thus, it can be observed that all eight of these themes were the impact of CBS.

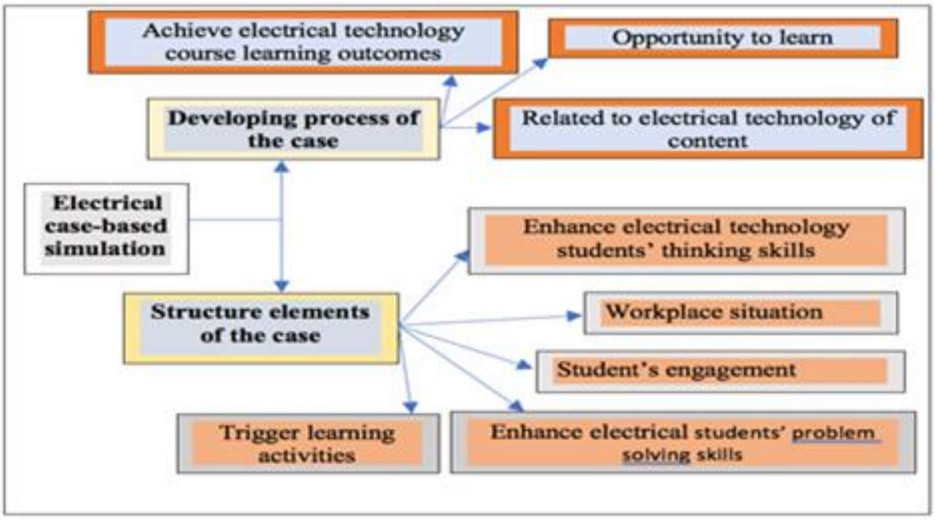

Figure 4
The ATLAS.ti output: Electrical case-based learning simulation development criteria

Collating quantitative and qualitative findings

For concurrent interpretation, quantitative data clearly showed parallelism with qualitative data when all curriculum implementers gave high agreement values to the two categories of CBS, namely process (range: .938-.972) and structure (range: .934-.992). Evidence of this high value of agreement could be translated through the analysis of interview data of all curriculum implementers who agreed that developing process of case-based simulation *"reflected the learning outcomes of the course" (e.g. R1) "provides space for students to learn and in line with the content of electrical technology of vocational students" (e.g. R2)*. While the high value of agreement for structure could be evidenced by the explanation from curriculum implementers that the elements contained in CBS can *"strengthen thinking skills" (e.g. R4), "problem solving skills" (e.g. R3), "produce learning activities" (e.g. R3),* and importantly *"CBS describes scenarios that occur in the workplace that are meaningful for vocational college students as a preparation and simulation of future experiences in the electrical industry" (e.g. R4).*

DISCUSSION

The process implemented to produce electrical case-based simulation was as proposed by (Nkhoma et al., 2016; Herreid et al., 2012) by considering all the elements in case construction as well as the verification process of experts in the field of electrical technology. Expert verification was performed to ensure that the case constructed met the case construction criteria. Among the main criteria given attention was that CBS "meets the learning outcomes and content of electrical technology courses in vocational colleges". This is in line with the statement of Herreid et al. (2012), that the characteristics of good case-based learning apart from being brief, should also be appropriate to the time period with a course that includes course learning outcomes.

CBS develops students' maturity to think because it gives students the opportunity to understand the root cause of problems (Azid et al., 2020). The thinking process occurs when issues and dilemmas are created in a case that puts students in a state of curiosity thus prompting the investigative process to resolve the case. Nkhoma et al. (2016), in his study that developed case-based learning based on Bloom's Taxonomy of thinking skills, stressed that case-based learning is able to stimulate students' critical thinking skills. Feedback from the curriculum implementers was that the case could bring students to reality in the workplace. This can trigger students' thinking in solving the problem described in the constructed case (Arantes do Amral et al., 2021). According to Ali et al. (2018); Herreid and Schiller (2013), Case-Based Learning (CBL) approach provides opportunity for students to be familiar with their workplace situations whereby they need to solve problems using their knowledge and thinking skills.

Electrical case-based simulations provide opportunities for students to learn more meaningfully by encouraging active student involvement through reading, debating, analysing and suggesting solutions. As highlighted by Herreid et al. (2012), good case-based learning features should create meaningful controversy where the issues contained in the case trigger a competitive discussion atmosphere among students. Learning through CBS is able to trigger analytical, creative and practical thinking among TVET students. This is in line with Nkhoma et al. (2016), who stated that case-based learning allows students to apply the content of the lesson when solving problems through cases.

Electrical CBS is an authentic case-based learning activity that leads to students' practical skills. It is also an activity that demonstrates the application of mastery of the electrical technology content. Nkhoma et al. (2016), suggests that case-based learning promotes learning through the application of knowledge when analysing cases. In addition, Ellet (2007), agrees that case-based learning should involve among others, making assessments and decisions on cases. While Herreid et al. (2012), touched on authentic features in the constructed cases for example providing dialogues and characters so that the case looks realistic to the students.

Electrical case-based simulation framework

Figure 5 shows the CBS Electrical construction framework which has two phases, namely process and structure. The first phase of the process was divided into two stages, namely (i) developing process and (ii) expert validating process. Expert validating process involved experts in the field of electrical technology who are also experienced curriculum implementers. This process was to verify that CBS met the content of electrical technology and was able to achieve the learning outcomes of the course. For the second phase, the structure of the case should describe the electrical workplace situation, create empathy, promote students' engagement, promote thinking skills, enhance problem solving, encourage to create solutions and trigger learning activities. This mixed-method study contributes to the production of an ideal CBS framework to meet the needs and requirements of the industry in the field of electrical. This learning material should be able to help test students' ability to apply electrical theory in electrical workplace scenarios.

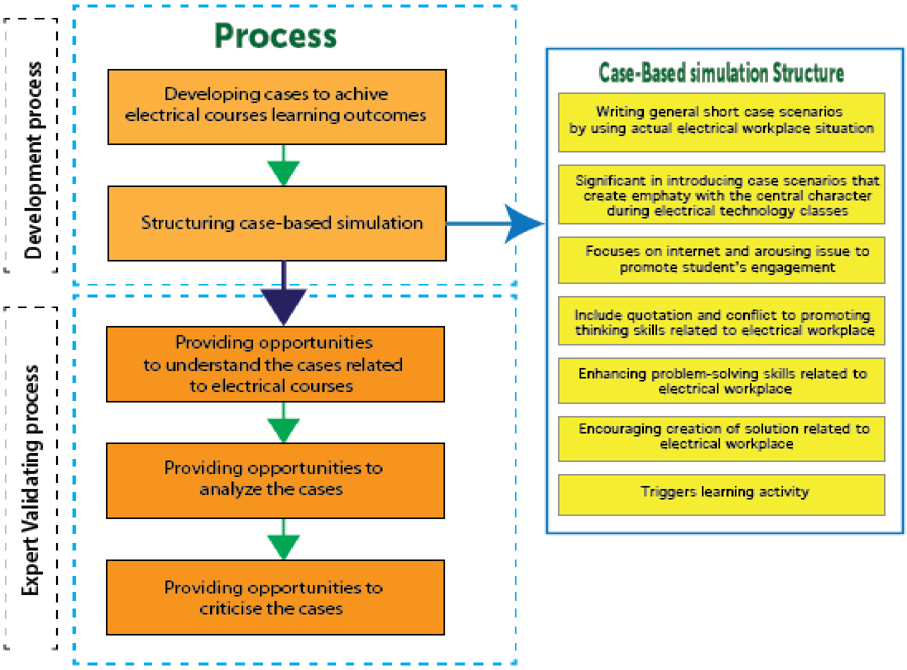

Figure 5
Nurul, Busthami & Ruzlan electrical case-based simulation process framework

The key findings of this study have implications for the need of vocational colleges' educators to start considering the use of alternative teaching and learning approaches that has the potential to enhance problem-solving skills and thinking skills among vocational college students despite the assumption that these students mostly need hands-on learning methods. The use of CBS can potentially help educators to ensure that their students also possess thinking and solving problems skills when they are at their workplaces later. The findings of the study that pertains to the views of curriculum implementers form the basis for the development of the potential CBS framework because these implementers are knowledgeable of both the course content and the sort of knowledge that they impart to their students. Moreover, these educators are also in a more reliable position to evaluate the relevance of the content of the CBS, as to whether or not the developed cases really happen at workplaces where the students will work in the future. Each case should include two main criteria, namely process and structure. Based on Figure 4, the researchers had developed a framework as shown in Figure 6, whereby it indicates the focus for the future development of similar case-based simulations by vocational college curriculum implementers that is the case should 1) be able to achieve electrical course learning outcomes, 2) provide opportunity to learn, 3) relate to electrical technology content, 4) have the potential to enhance electrical technology students' thinking skills, 5) relate to workplace situations, 6) enhance students' engagement, 7) enhance electrical students' problem-solving skills, and 8) trigger learning activities. This framework will also serve as guideline for future researchers who are interested in implementing case-based simulation as alternative learning strategies in their classrooms. This study only involved the views of vocational college curriculum implementers within the electrical technology course in TVET education. Similar further studies involving case-based simulations can be carried out in other courses in TVET education as well as other education fields (Melo, 2018).

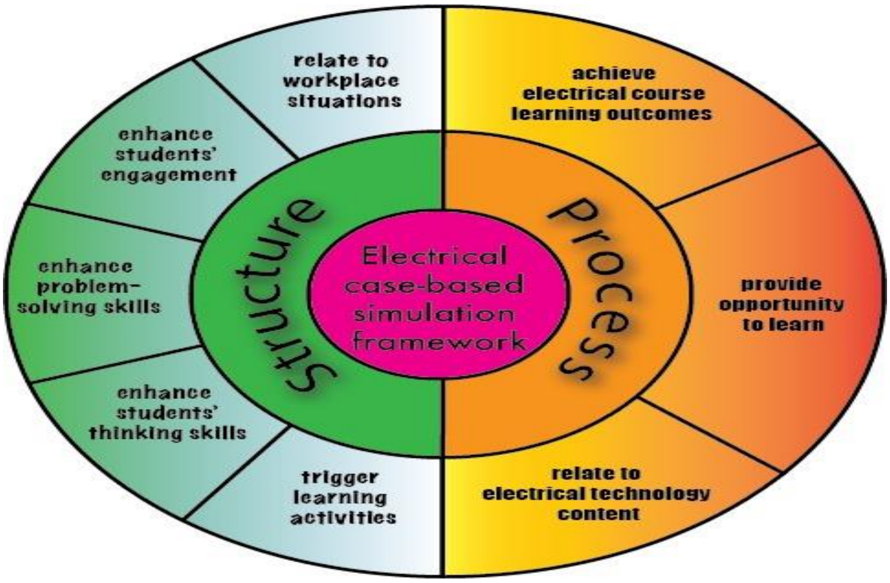

Figure 6
Nurul, Busthami & Ruzlan electrical case-based simulations content framework

CONCLUSION

In conclusion, the analysis of interview data using ATLAS.ti has proved through Figure 4 that there were two important criteria discussed by the electrical curriculum implementers, namely: (i) developing process of the case and (ii) structure elements of the case. For the developing process, the electrical case must achieve course learning outcomes, provide opportunities for students to learn and have a connection with the content of electrical technology, while for the second category, the structure elements of the case involved several important elements such as enhance electrical technology students' thinking skills, enhance electrical technology students' problem solving skills, workplace situation, students' engagement and trigger learning activities.

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