

Development Module for Electronic Design in the Design and Technology (D&T) Subject: A Needs Analysis Approach

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To Link this Article: <http://dx.doi.org/10.6007/IJARPED/v12-i2/17337>

DOI:10.6007/IJARPED/v12-i2/17337

Published Online: 16 June 2023

Abstract

This qualitative study aims to identify the crucial elements for developing effective electronic design learning materials for Design and Technology (D&T) education. Five D&T secondary school teachers with expertise in electronic design were selected through purposive sampling and interviewed using a semi-structured format. Atlas.ti 9 software was used for transcribing and thematically analyzing the data, resulting in two themes. The first theme highlights the primary factors affecting teaching aids in the Electronic Design Topic. In contrast, the second theme identifies important elements required for Module Development for Electronic Design Topic in D&T education. The essential elements include module characteristics, learning kits, and simulation software. This study provides insights into creating more efficient and effective learning experiences for students in electronic design by utilizing a needs analysis.

Keywords: Electronic Design, Development, Validity and Reliability, Technology Design

Introduction

Design and Technology (D&T) education is an important field that focuses on developing students' creativity, problem-solving skills, and practical knowledge related to designing and producing products. In Malaysia, the D&T curriculum adheres to guidelines provided by the Ministry of Education through the *Dokumen Standard Kurikulum dan Pentaksiran* (DSKP). In secondary school, the Design and Technology (D&T) subject is mandatory for students from Form 1 to Form 3, with topics divided into two categories: theory and practical categories (Sahaat et al., 2020). One of the topics that combine both theory and practical aspects is electronic design. Electronic Design entails designing and building electronic circuits, devices, and systems. As technology continues to advance, the importance of Electronic Design in the field of D&T education has become more significant. The D&T subject, which includes electronic design under the technology application theme, requires students to meet specific learning standards outlined in DSKP. Therefore, incorporating technology into the curriculum is crucial to meet these standards (Yusriza et al., 2021).

However, designing effective learning materials for Electronic Design requires a thorough understanding of the learners' needs and preferences. A needs analysis is a

systematic process that can help identify the learners' needs, preferences, and challenges related to a specific topic or subject. Needs analysis is a process that involves gathering information or data on the specific needs of a group of individuals or stakeholders in a particular domain, such as education or social services (Hamid et al., 2020). Conducting a needs analysis is essential in developing learning modules as it provides valuable insights into the learners' learning styles, preferences, and challenges. This information can then be used to create effective and engaging learning materials. In the context of Electronic Design in D&T education, conducting a needs analysis is crucial to ensure that the learning materials are engaging, effective, and aligned with the learners' needs and preferences, ultimately leading to developing a high-quality electronic design module. A needs analysis was conducted as the initial stage of the module design (Abdelmohsen, 2020). Before designing the module, the specifications of the module requirements identified in the analysis phase must be checked again (Hamid et al., 2021).

Research on needs analysis in the context of D&T subjects is rare, particularly in electronic design. Most needs analysis in D&T subjects aims to develop modules or teaching aids. According to the previous study, Ahmad et al (2019) need an analysis study to develop a sketch module for secondary Design and Technology (D&T) students. The study found that teachers face difficulties in implementing D&T teaching schools, and students struggle with mastering topics such as sketching. Teachers require a detailed and structured sketching module to develop the difficult-to-master skills of sketching in students, as indicated by interviews with several teachers.

Kiong et al (2022) study the need for an inventive problem-solving module integrated with project-based learning while also identifying the challenges Design and Technology teachers face in implementing project-based learning. The research found the implementation of project-based learning in Design and Technology faces several challenges, including difficulty in mastering inventive problem-solving phases and low student performance. Developing quality modules that integrate inventive problem-solving and project-based learning can facilitate teachers in guiding students effectively and producing high-quality products.

Padzil et al (2022) explore the need to apply design thinking in Design and Technology subjects from teachers' perspectives. The study results showed a need to apply design thinking among D&T subjects, and teachers acknowledge that implementing design thinking in education can enhance student development, including improving 21st-century skills and understanding, creating a fun learning environment, and applying elements across the curriculum.

This study aims to perform a needs analysis to identify essential elements required for developing effective and engaging learning materials catering to learners' needs and preferences for the topic of Electronic Design in D&T education. The study will focus on identifying the learners' prior knowledge, learning styles, and preferences related to Electronic Design. The findings of this study are expected to contribute to improving the teaching and learning process in D&T education, specifically in the area of Electronic Design, by providing insights into the learners' needs and preferences that can guide the development of effective learning materials. In developing electronic design learning modules, it is crucial to ensure that the modules are designed to meet the needs and requirements of the students. A module aims to identify clearer objectives of the teachings and arrange activities more systematically (Russell, 1974; Sidek & Jamaludin, 2005). The modules must be designed to facilitate the acquisition of knowledge and skills required to understand electronic design

principles. This is where the need analysis process comes in, which involves understanding the learners' characteristics, learning styles, and educational background to create a suitable learning environment that fosters learning. Module requirement analysis identified the module's objectives, target users, content of the module, learning theories and pedagogy involved in the delivery of content in the module (Hamid et al., 2021). Needs analysis is a powerful tool that helps clarify and validate true needs (Akyel & Ozek, 2010).

Methodology

Research Method

This study utilized qualitative research methods to obtain data and explore research questions regarding the perspectives of Design and Technology (D&T) to identify the important elements needed to develop effective and engaging learning materials that meet the needs and preferences of the learners. Using interview techniques, the researcher commonly aims to obtain the interviewee's perspective by interpreting the meaning of the described phenomena (Kvale, 1996). According to Merriam (2002), qualitative data provides a comprehensive understanding of the phenomena under investigation. This data type enables researchers to explore complex and subjective experiences in-depth, which may not be possible using quantitative methods. The researchers used a semi-structured interview format to ensure that the data collected from the participants was relevant and informative. The method used in this study involved a flexible interview protocol and open-ended questions supplemented by probes and comments to explore participants' thoughts, feelings, and beliefs about a particular topic. This flexible technique allows the interviewer and interviewee to elaborate on the topic to pursue an idea or response in greater detail (Alamri, 2019). This allowed the researcher to collect in-depth and sometimes sensitive data, making it an effective approach for gathering rich qualitative information (DeJonckheere & Vaughn 2019). This approach enabled the researchers to gather rich and detailed data about the participants' experiences, opinions, and suggestions regarding electronic design in D&T education.

Participants

The present study utilized purposive sampling techniques to gather information and gain insight into the current phenomena at the study site, in line with the established research methodology (Creswell, 2013; & Silverman, 2002). Purposive sampling involves selecting participants based on specific characteristics or traits relevant to the research question (Bhardwaj, 2019). After obtaining ethical approval and consent from the Education Planning and Research Division (EPRD) and the participating schools, a purposive sampling technique was utilized to select five secondary school D&T teachers who were recognized experts in electronic design as participants for the study. The inclusion criteria for selecting teachers as study participants were at least four years of teaching experience in D&T subjects and expertise in electronic design and microcontroller programming. This study followed Merriam & Tisdell's (2016) recommendation of selecting the most knowledgeable individuals to understand the phenomenon at the research site comprehensively. The study ensured that the selected participants could provide in-depth and comprehensive information on the topic under investigation by implementing a rigorous selection process.

Instrument

The study used a semi-structured interview protocol to investigate the importance of incorporating design thinking into the teaching of Design and Technology (D&T), specifically emphasising the Electronic Design topic. A semi-structured interview is a flexible approach to data collection that allows the interviewer to converse with the interviewee while using a pre-determined set of questions to guide the discussion. This approach enables the researchers to gather in-depth information about the perspectives and experiences of the interviewees, in this case, educators and experts in D&T, about the importance of design thinking in electronic design. The selection of semi-structured interviews as the data collection method was based on their suitability for exploring complex and sensitive issues and enabling detailed investigation, as well as the diverse backgrounds of the sample group that precluded using a standardized interview schedule (Louise & Alison, 1994). The interview protocol was developed based on a review of relevant literature and previous research, and the questions aimed to identify the key components required to implement this topic in D&T education effectively. According to Merriam (1998, 2002, 2009), semi-structured interviews are a commonly used and suitable method for gathering precise data on specific topics of interest. The semi-structured interview method is also effective in gaining insights into the participants' behaviours, feelings, and perceptions regarding the studied issues.

Thematic Analysis

Thematic analysis is a qualitative research method that researchers use to organise and analyse complex data sets systematically. It is a search for themes that can capture the narratives available in the account of data sets (Dawadi, 2020). Thematic analysis is a widely used method for analyzing qualitative data that allows researchers to identify, analyze, and report patterns or themes within the data. The process involves multiple steps, including conducting interview sessions, transcribing the interviews, and analysis. It also involves identifying themes through careful reading and re-reading of the transcribed data (King, 2004; Rice & Ezzy, 1999).

The data obtained from the interviews were transcribed and analyzed using Atlas.ti 9 software. Transcribing interview recordings into text format requires meticulous attention to detail and accuracy to accurately represent the participants' spoken words. Transcription methods may vary depending on personal preferences and the researcher's capacity to produce an easily analyzable document in their desired format (McMullin, 2023). This process demands patience, thoroughness, and repetition to ensure the correct interpretation of every word spoken. Through the coding process, the researchers identified several key themes, which were then analyzed in detail, using relevant literature to support the findings. During thematic analysis, researchers may merge some categories into the same category while others may form multiple themes in response to the research questions (Creswell, 2013).

The thematic analysis process proved valuable for gaining a deeper understanding of the participants' perceptions and opinions regarding developing effective learning materials for the Electronic Design topic. This approach enabled the researchers to identify important themes within the data and provide a comprehensive analysis. Overall, the thematic analysis process is a reliable and systematic method for analyzing qualitative data, which could be useful for other researchers seeking to analyze similar data.

Results and Discussions

This study's primary objective was to collect data through semi-structured interviews with five teachers from secondary schools. The interviews were focused on identifying the critical components necessary for developing effective and engaging learning materials for the Electronic Design topic in the D&T subject. Thematic analysis was then conducted to examine the transcripts, leading to the identification of three distinct themes, specifically:

Theme 1: Main factors teaching aids needed in the Electronic Design Topic on the Electronic Design Topic in Design and Technology Subjects

This section presents the key themes identified through thematic analysis, which helped to identify the main factors necessary for effective teaching aids in the Electronic Design Topic in Design and Technology Subjects. The experts who participated in the study identified three main factors that need to be addressed, which are (1) the background of the teacher in the field, (2) lack of student interest, and (3) difficulties with the electronic design topic. These factors were found to be significant barriers to effective teaching and learning of the Electronic Design Topic, and thus, require attention in developing teaching aids for this topic. Figure 1 displays the main factor of teaching aid needed for electronic in Design and Technology (D&T) subject, as identified through thematic analysis using Atlas.ti 9 software.

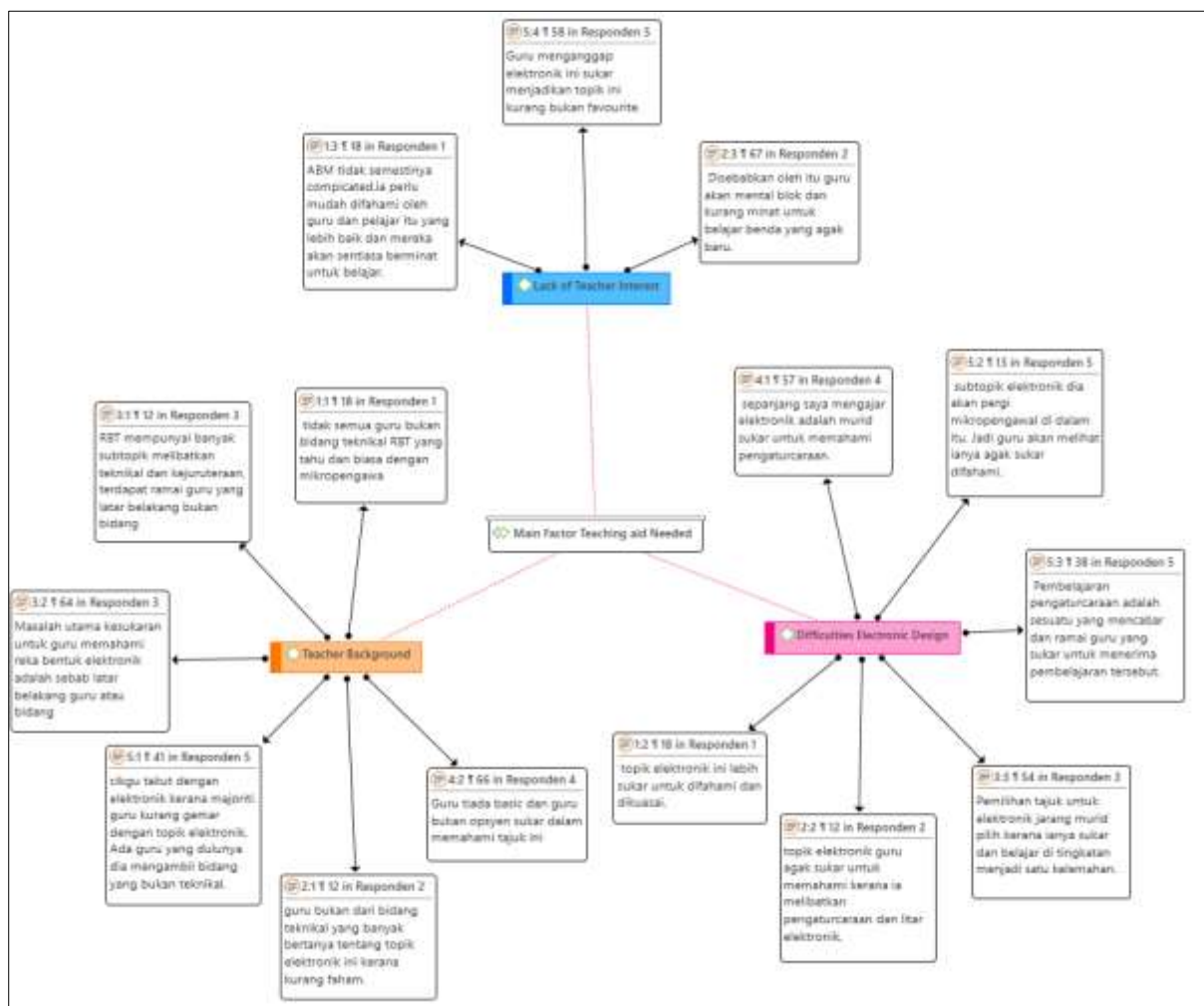


Figure 1: Main Factor Teaching Aid Needed for Electronic In D&T Subject

(1) The background of the teacher in the field

This study's sub-theme (1) emphasizes the impact of a teacher's background on the effectiveness of teaching and learning in Design and Technology (D&T), specifically in electronic design. As evidenced by their comments, the participants agreed that teachers with a technical background needed a thorough understanding of the subject's content. The following statement demonstrates this.

"We really need teaching aids for the RBT subject, especially in the Electronics sub-topic; it is very necessary. This is because not all non-technical field RBT teachers are familiar with microcontrollers and the like." (GR1)

"The electronic topic is quite challenging for teachers to understand as it involves programming and electronic circuits. Non-technical teachers usually ask many questions about this electronic topic because they have a limited understanding." (GR2)

"The teachers without basic knowledge and those who are non-option find it difficult to understand this topic. However, with the help of good teaching aids and modules that provide clear guidance, this issue can be resolved." (GR3)

The teacher's background can significantly impact the effectiveness of teaching and learning in Design and Technology (D&T), particularly in the area of electronic design. If the teacher has a technical background, teaching the technical aspects of electronic design effectively can be easier. The teacher may need help explaining complex concepts and theories to the students, leading to confusion and poor learning outcomes. In a study conducted by Masingan & Sharif (2019), it was found that teachers who were not from a technical background lacked a comprehensive understanding of the objectives, goals, and focus of the D&T subject, which led to difficulties in mastering its content, especially in the field of electronic design.

The integration of technology by non-technical teachers in the RBT subject in secondary schools is still low, limited only to the enhancement level (Masingan & Sharif, 2021). In D&T, electronic design plays a crucial role, requiring specialized knowledge and skills, especially in microcontroller programming. If the teacher is not proficient in this area, they may struggle to facilitate learning and provide the necessary guidance and support. As a result, students may not develop the knowledge, skills, and confidence required to excel in this area, limiting their future opportunities and career prospects.

(2) lack of teacher interest

Sub-theme (2) of the study highlights the lack of student interest in Electronic Design in Design and Technology (D&T) education. The study participants reported that teachers often found this topic uninteresting, negatively impacting their engagement and motivation to learn and teach. It is evident in the following statement.

"The teacher considers electronics as difficult, which makes this topic less favorable." (GR5)

"Teachers and students may experience mental blocks and lack of interest in learning new things." (GR2)

A lack of interest in a subject can significantly impact a student's learning success and result in lower exam scores (Halik et al., 2020). This is particularly true for topics like Electronic Design in D&T education, where students may need help grasping technical and complex concepts. If students do not find the subject interesting, they may have difficulty engaging with the material and may not make the necessary effort to succeed. As a result, they may struggle to perform well on exams and assignments.

(3) difficulties with the electronic design topic

Sub-theme (2) emphasizes the challenges associated with the topic of Electronic Design in Design and Technology (D&T) education. It is evident in the following statement:

"Students rarely choose the topic selection for electronics because it is difficult and learning in secondary school is one weakness. When entering Form Three, it causes students to forget to apply.." (GR3)

"The most prominent weakness I have observed while teaching electronics is that students find it difficult to understand programming.." (GR4)

"The most significant weakness that I have encountered while teaching electronics is that students find it difficult to understand programming.." (GR5)

Sub-theme (3) highlights teachers' and students' difficulties with the electronic design topic in Design and Technology (D&T) education. This topic can involve complex programming difficulties and electronic circuits, which can be challenging to understand and apply. The difficulty in describing the flow of program code execution is one of the main factors in understanding programming concepts because students do not have no experience (Istiyowati et al., 2021).

Theme 2: The important elements needed on Module Development for Electronic Design Topic in Design and Technology Subjects.

Through thematic analysis, this research identified the key elements important for module development on Electronic Design Topic in Design and Technology (D&T) subjects. The participants, who were experts in the field, identified three main elements that should be considered: (1) module characteristics, (2) learning kits, and (3) simulation software.

(1) Module Characteristics

Developing a comprehensive module for the Electronic Design Topic in Design and Technology subjects ensures students have the necessary skills and knowledge to apply in real-life situations. The first essential characteristic of such a module is its alignment with the Dokumen Standard Kurikulum dan Pentaksiran (DSKP). By adhering to the DSKP, the module is designed to cover all the necessary topics required in the curriculum, providing students with a solid foundation of knowledge. The Malaysian Curriculum Development Division (BPK) under the Ministry of Education Malaysia has developed the DSKP as the primary guide for teachers at the school level (Sahaat & Nasri, 2020).

The second critical characteristic of a module is the practical steps it provides. The module should include clear pictures, programming explanations, and a systematic approach to teaching the topic. With these elements, students can easily follow the instructions and

better understand the topic. This is especially important for Electronic Design Topic, which can be difficult to grasp.

The third essential characteristic is the inclusion of real-life applications. The module should incorporate application learning to encourage students to apply their knowledge in practical scenarios. Students learning should incorporate academic rigor to expand and renew strategic capabilities, real-life connections and competencies that are transferable to their future professions and work (Down & Golam, 2021). This helps students develop problem-solving skills and critical thinking, essential skills for success in the field of Design and Technology. The real-life applications also enable students to see how their learning topic can be applied in the real world.

The fourth characteristic is self-learning. Self-learning modules are designed to cater to the independent learning needs of students and offer features such as flexibility, accessibility, transferability, ease of use, learner accountability, motivation, cost-effectiveness, safety, and time-saving, making them an effective tool for learning (Tohidi et al., 2019). The module should be designed to allow students to learn at their own pace by including self-study materials such as books, learning kits, and videos. This approach is crucial, especially for students needing more time to understand the material. The module should also provide feedback mechanisms to help students gauge their progress and identify areas where they need improvement.

The final characteristic of a module for the Electronic Design Topic in Design and Technology subjects is the incorporation of video demonstrations. Video demonstrations provide a time-efficient and information-rich alternative to physical demonstrations, particularly when a teacher or coach is unavailable or unable to perform a specific task (Ivan & Andrea, 2017). Visual demonstrations of the concepts discussed in the module can enhance students' understanding of the topic. Students can reinforce their learning by seeing how the concepts are applied in practice. In conclusion, these five essential characteristics are crucial for developing a comprehensive module for the Electronic Design Topic in Design and Technology subjects. The research results are presented in Figure 2, which outlines the necessary characteristics for developing Electronic Design modules in Design and Technology subjects. The analysis was conducted using the Atlas.ti 9 software. The study findings on the required characteristics of the electronic module for Design and Technology (D&T) education were analyzed using Atlas.ti 9 software and presented in Figure 2.

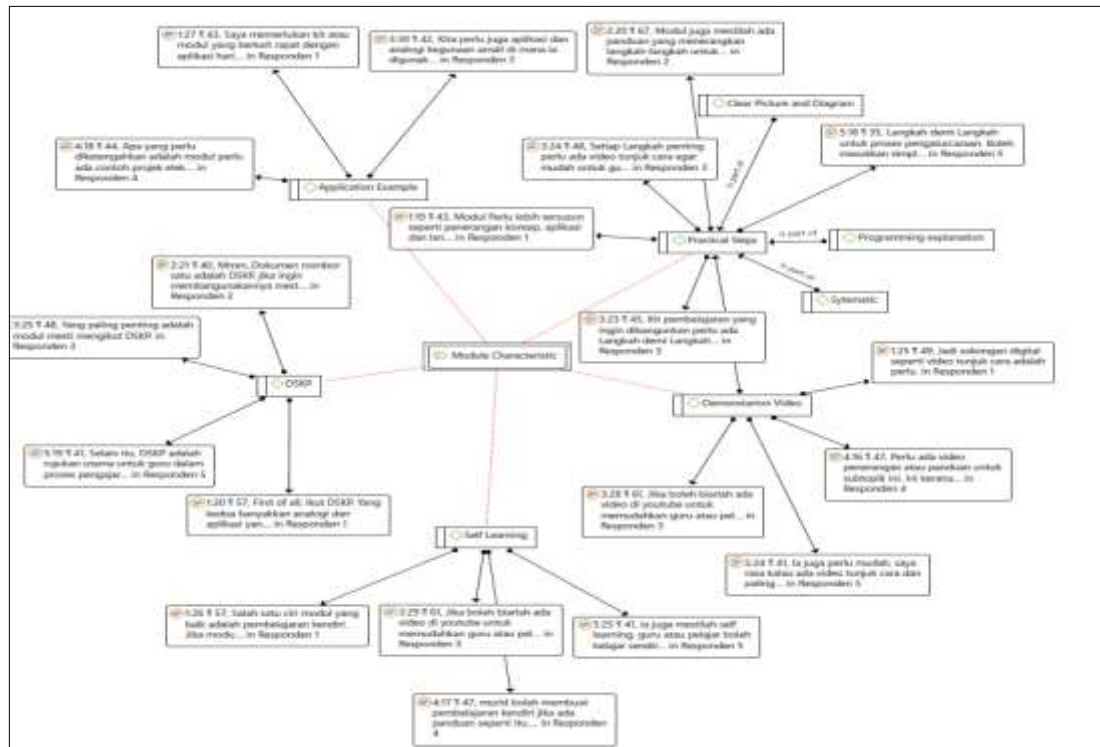


Figure 2: Characteristic Module Needed for Electronic In D&T Subject

Sub-theme (1) emphasizes the characteristic module needed topic of Electronic Design in Design and Technology (D&T) education. Below are some of the related evidence:

"The most important thing is that the module must follow the DSKP. It sets out the learning outcomes, content standards, and performance standards that students are expected to achieve at different levels of education.." (GR3)

"The module must have clear guidelines or step-by-step instructions, clear pictures for conducting experiments, hardware installation, and a systematic approach to programming.." (GR5)

"What needs to be emphasized is that the module should have examples of electronic projects and their applications." (GR4)

"One of the characteristics of a good module is self-learning. If the module or kit requires the full assistance of a teacher or textbook, it is not a good module or kit." (GR1)

"If possible, it would be beneficial to have instructional videos on platforms like YouTube to facilitate easy access for teachers and students. This way, students can have a self-directed learning experience without relying solely on textbooks." (GR3)

(2) Learning Kits

Learning kits are crucial for the effective teaching and learning of electronic design topics, particularly due to the practical nature of the subject. To ensure alignment with module content, it is essential to develop learning kits that meet the requirements of the curriculum.

Select a suitable microcontroller for electronic design appropriate for secondary school students. The study enlisted participants with expertise in the field, who identified three characteristics that require consideration:

- 1) the type of microcontroller,
- 2) programming language utilized for the microcontroller, and;
- 3) ease of access to relevant references.

Experts have recommended the use of Arduino-type microcontrollers due to their versatility and wide availability. Arduino is a widely popular, user-friendly, and powerful open-source programmable board that has gained significant recognition in both the hobby and professional markets (Kaswan et al., 2020). The Arduino community is also vast and supportive, with many online resources, tutorials, and sample codes available for learners. In addition, Arduino boards are relatively affordable and easily accessible, making them a suitable option for secondary school students with limited resources.

When selecting the programming language for a learning kit, it's important to consider its universal applicability across various platforms and devices. The open-source programming language also enables students to access a wealth of online resources, including code examples, tutorials, and forums, which can help them deepen their understanding and apply their skills in a broader context. Open-source implementations facilitate the portability of models, reuse of tools, and wider deployment (Buffoni et al., 2021). Additionally, open-source programming languages are typically free to use, making them more accessible to schools and students. The analysis of the necessary features of the learning kit for the electronic design module in Design and Technology (D&T) education was conducted using Atlas.ti 9 software, and the results were illustrated in Figure 3.

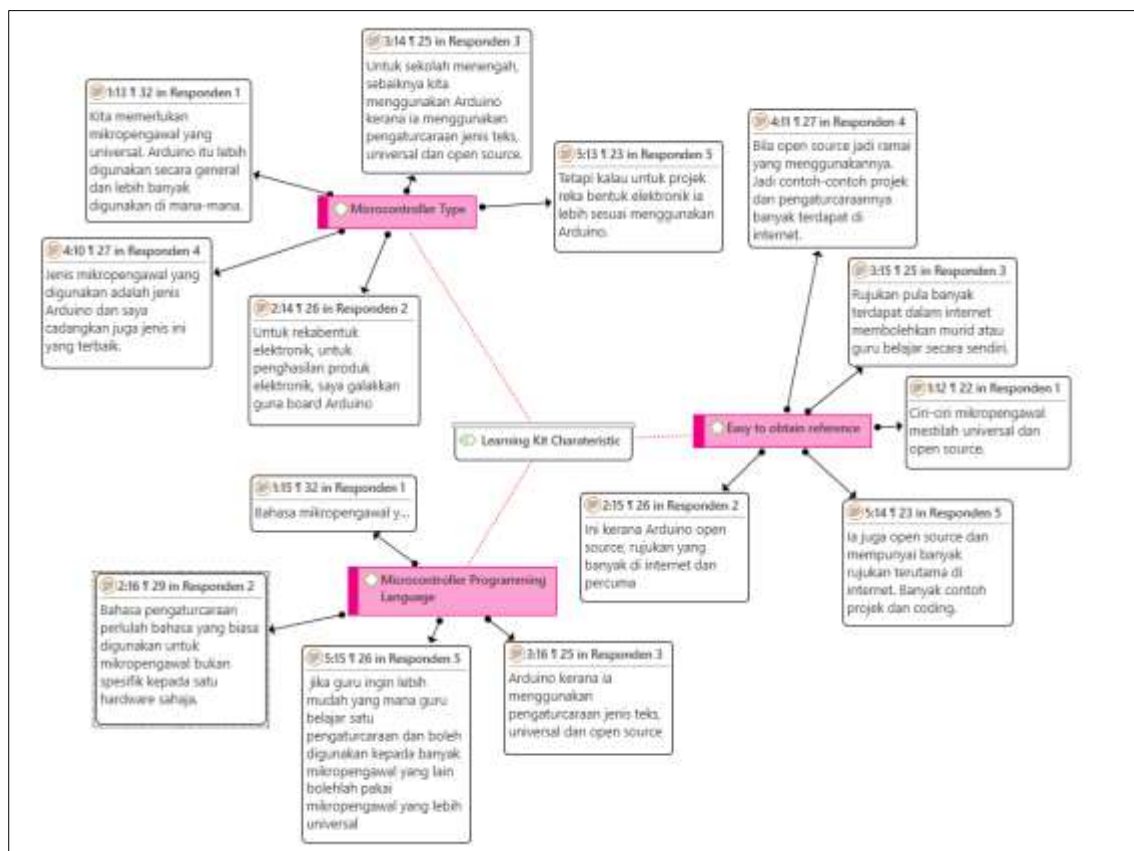


Figure 3: Characteristic learning kit Needed for Electronic In D&T Subject

Sub-theme (2) focuses on the essential characteristics the learning kit for Electronic Design in Design and Technology (D&T) education must possess. Here are some of the supporting evidence related to this topic

"We need a universal microcontroller. Arduino is more widely used in general and is used more widely everywhere." (GR1)

"The programming language used should be commonly used for microcontrollers, not specific to only one hardware." (GR2)

"It should also be open source and have many references, especially on the internet, with plenty of examples of projects and coding." (GR5)

(3) Simulation Software

Simulation has great importance in the field of application of Electronics engineering, where electronic engineers or students can check their models or their models or theory before applying for development practically (Mandal, 2017). It can help identify potential problems, optimize performance, and save time and resources in the development process. Simulation is essential for complex projects involving multiple components or systems, as it allows for a comprehensive analysis of the entire system before any physical implementation occurs. Utilizing virtual simulation software to simulate circuits can offer several advantages, including independence from the experimental site and instrumentation limitations, avoidance of component damage and personal injury risks, and enhanced safety (Li et al., 2020). Therefore, electronic design modules must include a subtopic on simulation and provide learners with the necessary tools to simulate their designs. By mastering simulation skills, students can become better equipped to tackle real-world design challenges and contribute to the advancement of technology in various industries. The study enlisted participants with expertise in the field, who identified two characteristics that require consideration: (1) Real Work Simulate and; (2) Easy to use.

Real work simulation in electronic design refers to the ability to simulate electronic projects, such as circuit connections and hardware usage, in a way that mimics the actual physical implementation. This is important because it allows designers to test their designs before implementing them in the real world, saving time and resources. Simulation tools enable designers to identify and correct errors or inefficiencies in their designs, such as signal interference or power consumption, which can be difficult to diagnose once the project is built.

In addition to the ability to simulate real work scenarios, simulation tools must also be easy to use. This means they should have a user-friendly interface, intuitive controls, and clear instructions. Electronic design can be a complex process, and designers need software to streamline the process and make it accessible to a wide range of users, from beginners to experts. Easy-to-use simulation tools can help to democratize electronic design and make it more accessible to a wider audience, including students and hobbyists.

Simulation is a crucial subtopic in electronic design, enabling designers to test their projects virtually, detect and rectify errors, and optimize their designs before physical implementation. Simulation tools that offer real-work simulation and user-friendly interfaces can help designers create more efficient and effective electronic projects at all levels. All experts recommend using TinkerCAD as a simulation software because it meets the necessary

characteristics highlighted in the sub-theme (3). Tinkercad is easy to use because it does not need to be installed on a computer (Husin, Ramli, and Alwi, 2022). TinkerCAD provides a realistic simulation environment with features such as circuit connections and hardware usage, and its user-friendly interface makes it easy to learn and use. With TinkerCAD, designers can simulate and test their projects before implementing them, reducing the risk of errors and improving project efficiency. The necessary features of the simulation software for the electronic design module in Design and Technology (D&T) education were analyzed using Atlas.ti 9 software, and the findings are presented in Figure 4.

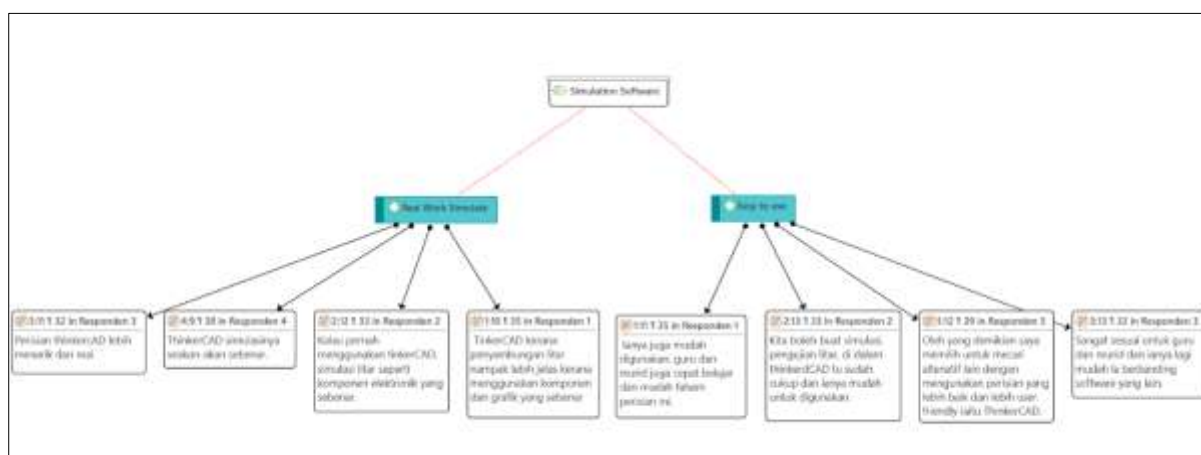


Figure 4: Characteristic Simulation Software Needed for Electronic In D&T Subject

Sub-theme (3) centers on the essential attributes required for electronic design simulation software in Design and Technology (D&T) education. The following is some relevant evidence supporting this theme:

"If you have used TinkerCAD, the circuit simulation is just like real electronic components." (GR2)

"Therefore, I chose to search for alternative software by using a more advanced and user-friendly software, namely TinkerCAD." (GR2)

Conclusion

In conclusion, electronic design is an important aspect of Design and Technology (D&T) education. To develop a successful module in this subject, conducting a thorough needs analysis is essential to identify the necessary characteristics of the learning kit and simulation software. The learning kit is a crucial component of the module as it aids in achieving the objectives of the module. The findings of this research can serve as a reference for researchers and educators in developing teaching aids or modules suitable for D&T subjects. Ultimately, by utilizing the needs analysis results, educators can create more effective and efficient learning experiences for students in electronic design. Furthermore, this research will provide important data to the Ministry of Education Malaysia (KPM) regarding the specific needs and requirements of the D&T subject, particularly in relation to technology-related elements. This data can inform policy decisions and curriculum development initiatives, ensuring that the D&T subject adequately addresses the technological aspects relevant to students' future careers and the demands of the industry. The development and implementation of the learning module and kit in electronic design education will contribute to enhancing the level

of understanding in electronic design concepts and further contribute to early exposure to the importance of technology among school students.

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