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# Teachers' Attitudes Level Towards the Use of Microcontroller Development Boards in Secondary Schools

**Azlina Muhammad Noor[1] & Jamalsafri Saibon**
[1,2] Universiti Sains Malaysia

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***E-mail adress:***

**corresponding Author:*
**jamalsafri@usm.my*
*azlyyna9@gmail.com*

## Abstract

*The study was aimed to study the usage level of smart electronic device microcontroller development boards as teaching aids (BBM) for teaching and learning the subject of Design and Technology (RBT) in Penang secondary schools. The efficiency of microcontroller development boards usage as teaching tools and aids (BBM) based on digital technology can improve the quality of teaching and learning electronic design by RBT teachers. Therefore, this article explains findings regarding to RBT teachers' attitude on fuel usage based on microcontroller development board. The study used questionnaires which was directly distributed to 128 RBT teachers who are teaching electronic design to Form 2 and Form 3 students in secondary schools. Data was descriptively analyzed by using Statistical Package for the Social Sciences (SPSS) Version 26 software to obtain the frequency distribution, percentage and mean comparison. In addition, t-tests was also conducted to see the difference in terms of gender. Results shows that Form 2 and Form 3 RBT teachers were moderate toward the use of microcontroller board with an average value of 3.93. Meanwhile, the t-test results found there is no significant difference between the RBT teachers' use of microcontroller board regarding gender. The same research questions were suggested to be further expanded to students in the future and study the relation between teachers' attitudes and microcontrollers usage through the behavioral perspective during school in Malaysia.*

**Keyword:** Microcontroller, Attitude, Design and Technology (RBT) teachers, teaching tools and aids

## Introduction

The Industrial Revolution 4.0 challenge in using the Internet and popular automation robots worldwide is impacting the social, political, economic, and educational demands of the evolving global landscape (Klaus Schwab, 2016; Prisecaru, 2016; Anne Marie, 2018). Consequently, almost all equipment in the industry has used automation in the production process, therefore, mainly contributor to the smooth function of robotic automation electronic process is by using a Microcontroller. Appropriately, microcontroller can automatically manage, organize, and monitor the input and output processes of an electronic hardware (Nethravathi.S, & R.S.Geetha, 2016). It is known as a sophisticated smart device control system which provides many benefits in the industrial and hardware design world electronics to solve various daily life problems (Mallik & Rajguru, 2018; Moshe Barak, 2013).

Microcontrollers are categorized as digital electronics and abstract in nature, containing hardware and software learning outcome, such as analog electronic circuits, digital circuits, computer theory, programing languages, a variety of sensors and circuits, which are still relatively complicated to learn because a high level of theoretical knowledge and skills logical thinking and high hands-on ability to control is required such as FPGA (Field Programmable Gate Array) and AVR (El-Abd, M., 2017; Qin, Y., & Yu, B., 2011). Past studies showed that the microcontrollers are technology becoming ubiquitous in daily life used as a control system in smart electronic. It has gained global attention as it can significantly contribute to advances in various industrial and manufacturing fields, programing, STEM education robotics, and Industrial Revolution 4.0 (IR 4.0) (Bruce, R., Brock, D., & Reiser, S., 2013; Lu, Y., 2017; Minister of Education (MOE), 2016; Nugent et al., 2019).

Precisely, in the year 1998 to 2017, various research study articles journals on microcontrollers were actively published. Studies indicate microcontroller is used by teachers and students all over the world as a teaching tools to learn programming, creating and simulated learning activities (Bolanakis, 2019). The development of world technology in electrical and electronic engineering today provides an alternative solution to microcontroller learning in education. Most countries in the world, including Malaysia, practise learning the microcontroller in embedded system education, starting at tertiary levels, such as in universities and colleges in preparation for students to work as electronic design engineers (Ibrahim, Ali, Zulkefli, & Elfadil, 2015).

The implication is that various types of microcontroller development board designs were invented and designed, growing like mushrooms are in the market to attract and provide convenience to novice and non-engineering to master the microcontroller skills. In fact, the low price of microcontrollers being offered in the market impacts its usage expansion among the world community (Cruz, 2017). They have attracted different age groups and are involved in designs, as well as open source development board designs with do-it-yourself (DIY) based, such as Sparkfun, Adafruit, arduino, and microbids (Bolnakis, 2019; Lima et al., 2018; Vostrukhin & Vakhtina, 2016; Mabbott, 2014; Moshe Barak, 2013) In addition, the production of various kit designs was created to master the learning of microcontrollers, such as Thames & Cosmos Microcontroller Computer Systems Engineering Kit, PICDEM Lab Development Kit, Nerdkits Microcontroller Kit and BeagleBone Black Kit were produced (Alexander Ronald Dymek & Steven Thomas Murdy, 2016).

The development and widespread use of microcontroller technology has led to its integration in all levels educational sectors, resulting in the concept of invention learning (robotic). Microcontrollers is a relatively hardware and software learning concept approach are part of Science, Technology, Engineering and mathematics (STEM) education. The elements of STEM highlight the characteristics and concepts of physics, mathematics, engineering and design, as well as control system analysis that are available on the microcontrollers generate it to be actively studied in electrical and electronic learning approach in education (García et al., 2018; Mabbott, 2014; Moshe Barak, 2013; Sell, 2012).

## Literature Review

In Malaysia, the development of microcontroller usage in the education system began known among students and teachers since in secondary and primary schools who are involved in robotics clubs or participated in robotic competitions (Hafzan Ibrahim et al., 2014). However, in alignment with the booming digital technology advancement impact and recent global post-IR 4.0 attendance, in year 2017, there was a reshuffle in the secondary school syllabus (Mariano Garduno Aparicio, Juvenal Rodriguez Resendiz, Gonzalo Macias Bobadilla, & Suresh Thenozh, 2018). The Ministry of Education Malaysia (MOE) has been launched extensive improvement in education and sustained progress in teaching and learning microcontroller by implementing a new curriculum (KSSM) and introducing a new subject STEM-based known as Design and Technology (RBT) to replace the subject of Integrated Living Skills (KHB) (Ministry of Education, 2016). It is believed that microcontroller has become an emerging new trend learning as a smart digital technology.

The aim Design and Technology (RBT) subject introduced were to be practiced by teachers as a teaching tool to enhance the learning level of Form 2 and Form 3 students to solve Engineering problems by inventing smart electronic designs in their practical projects (Bunyamin, 2018). Working with approaches of developing project-based learning (PBL) by assembling the hardware such circuit components including light-emitting diodes (LEDs), interfacing keyboard, switches, batteries, DC motor, stepper motor, LCD display, sensors, and writing small programs like assembly language and C Programming as a command can supplement students with creative thinking skills, with a higher global thinking level in understanding and practice utilizes the latest digital technology smart devices to solve future problems (Chan, Pondicherry, & Blikstein, 2013).

To facilitate a holistic assessment of learning, MOE, urgent to develop students' computational thinking abilities by evaluating student performance with problem-based projects-based on the Form 3 assessment course work (PT3) (Ministry of Education, 2016). Recognizing the essentials of microcontroller learning, RBT teachers as educators and facilitators need to afford with a high level of teaching method and crucial skills of technology, enable them to face all challenges that will appear in the process of teaching and learning electronic design effectively and efficiently in the classroom (Sharaf, Ahmed, Adel, Abdennadher, 2019; Al-Awidi & Aldhafeeri, 2017).

Despite the benefits of this new curriculum implementation, various problems emerged based on findings from previous studies. According to the reflection of this RBT curriculum and syllabus change, past studies revealed that problems in terms of challenges and stress when studying these microcontrollers exist (He, Zhang, & Shen, 2015). Such features of microcontroller learning were a combination of various disciplines such as computer science, computer engineering, automatic control and electrical engineering have become a polemic issue among non-engineering or novice undergraduates at tertiary level to study it (He et al., 2015; Ibrahim et al., 2015; Cruz, 2017). In addition, teachers have some problems in terms of knowledge level, training and courses, insufficient microprocessor teaching allocation time for students to produce projects, lack of facilities and additional teaching modules, including insufficient tools and teaching aids usage in class (Zamri Sahaat & Nurfaradhilla Nasri, 2020).

Through the results study of Zamri Sahaat and Nurfaradhilla Nasri, (2020), on 418 RBT secondary school teachers in Sarawak (mean value = 2.23), the teachers argue there were existed shortage of microcontroller materials and teaching aids (ABM) in electronic design teaching and it is categorized as being at a low level. Although the study findings showed that teachers' participation in using the teaching aids (BBM) was at a high level (mean value = 3.71), the mastery of teaching skills for each RBT application topic, including the of microcontrollers usage was at a low level (mean value = 2.2). Even though the study results there were constraints in terms of teaching time appropriation and implementing practical work, whereby students setting up electronic projects was not enough (mean value = 2.15) (Zamri Sahaat & Nurfaradhilla Nasri, 2020). This was because the method of learning the use of microcontrollers based on hardware and software technology required more time allocation to be practically studied as compared to the time to master its theory (Nethravathi. S & R.S.Geetha, 2016). This clearly proved that there were problems in the implementation of RBT teaching.

Research by Ertmer, Ottenbreit-leftwich, Sadik, Sendurur, & Sendurur (2012) identified that the application of technology integration became difficulty due to impact of teachers' negative attitudes and beliefs, as well as fear of being intimidated by technology during teaching. This is because attitude is a crucial factor for a person to accept a technology (Davis, 1989). An earlier study exposed that 100 teachers in robotics can be generated every year nationwide because they had a positive attitude and were obsessed and striving to learn the use of a microcontroller board through activities conducted in robotics basic courses, either directly or as massive online courses (MOOCs) (Filippov, Ten, Shirokolobov, & Fradkov, 2017). Similarly, students demonstrate a positive attitude reaction towards microcontrollers usage, and show the capability to design a variety of smart electronic hardware with multiple functions into their problem-solving project in electronic teaching and learning (Mabbott, 2014).

While, Fisher (2006), stated the agent to transform the use of a technology depend on the teachers' attitude and belief not technology, these two key factors brought for a technology success to become more efficient. These statements were strongly supported by past researchers that teachers' attitudes and beliefs are mainly factors influences of a successful integration of new technologies in the classroom learning development and the likelihood of their benefiting from training (Kluever, Lam, Hoffman, Green, & Swearinges, 1994; Mumtaz, 2000; Blackwell, Lauricella, Wartella, Robb, & Schomburg, 2013). Whereby, if teachers display positive reaction using technology, they will strive to upgrade themselves and technology in teaching (Zacharia, 2003). Similarly, when they show a negative attitude, feelings influence of dislike will arise so as not to try to acquire the skills to adapt to the use of technology well (Harrison & Rainer, 1992).

Therefore, the role of attitude is important as a benchmark to know whether there is rejection or barriers in self or if there is acceptance or allows an individual to use the technology (Zacharia, 2003; Kriek & Stols, 2010).

However, according to Chien, Wu, & Hsu, (2014), although teachers showed a positive attitude toward technology, it was not necessarily that teachers would exhibit good performance to use the technology in a classroom. This is because the establishment of attitudes to adopt the use of technology requires a longer period application to adapt the technology better (Jimoyiannis, 2008). Many studies were conducted to find out teachers' attitude toward the use of various types of technologies in teaching and learning. However, no study was conducted to evaluate the level of teachers' attitude in using the microcontroller technology to teach. For example, a study conducted by Lazar and Irena (2015) in Malaysia, on 143 primary and secondary school teachers found that teachers were positive toward the implementation of Internet teaching in education. Similarly, the perception of 16 teachers in primary schools showed that the teachers had a positive attitude toward the use of life skills multimedia software (Fadila & Chiew, 2014).

Gender is one of the demographic characteristics found in the influences by attitudes and skills on the use of technology (Cooper, 2006). The teachers' involvement in terms of gender is the most important factor to be considered because there is no exception to the use of technology in teaching (Kutluca & Ekici, 2010). The results of the independent t-test analysis showed that female teachers had a higher positive attitude than male teachers toward the use of mobile learning (M-learning). However, the study results showed by Uzunboylu & Ozdamli, (2011) were the opposite, whereby male teachers were more dominant in their positive attitude on the use of such technology than female teachers.

In Malaysia, the use of information aids based on information technology among history teachers showed that there was no significant relationship in terms of gender with the attitude of technology usage (Jayalatchumy, 2006). On the other hand, the findings of other studies showed that teachers had a positive attitude toward teaching electrical design (mean value = 4.53) and found that there was no significant difference (p = 0.491) between male and female teachers' attitude toward the field of electricity or male and female teachers had the same positive attitude (Mohd Akmal, 2017). Therefore, there is a need to identify whether this problem was also influenced by the RBT teachers' attitude, by explore the perceptions RBT teachers' attitude level toward microcontrollers technology usage in teaching and learning electronic design at secondary school level. Subsequently, based on discussions above, this study aims to determine: I) Identify, teacher understanding about microcontroller concept II) Identify the level of attitude (AT) RBT teachers in practical teaching and learning in using microcontroller and III) Identify whether there is a difference in the level of attitude aspects of RBT teachers teaching using microcontroller in gender-based.

## Research Question

1. Do the RBT teachers understand Microcontroller?
2. What is the attitude level of RBT teachers in teaching and learning using the Microcontroller as a teaching tools and aid (BBM)?
3. Is there a difference in attitude level of RBT teachers teaching in using the microcontroller based on gender?

## Research Hypothesis

$H_o$ There is no significant difference in the Attitude level of RBT teachers in using microcontrollers based on gender

## Methodology

In this research, descriptive and comparative study designs were selected to answer the research questions. Survey studies by using questionnaires were used for data collection because of their advantages that could measure the perception, opinion, or behavior of RBT teachers on the use of technology. A total of 128 questionnaires were collected from RBT teachers who taught microcontrollers on the same day as the questionnaires were distributed. Each item was assessed by using a Likert scale from 1 to 6, or a 6-point asymmetric scale, by placing a value indicator of 1 (Strongly Disagree) to 6 (Strongly Agree). The items on each questionnaire constructed in this study was designed by adapting instruments from the related international journals literature review. It was found that some existing questionnaires were developed and used by previous researcher, such as by Lin & Williams (2015), Sadaf, Newby, & Ertmer (2016) and, Taylor & Todd (1995). The questionnaire of this study consisted of five sections, namely Section A to Section E. However, to answer the research questions, only Section A (demographics of respondents) and C (attitudes) were discussed. Profile and demographic section have six items adapted from a study by Sadaf et al. (2016). Besides that, attitude has eight items, the first four items are adapted from a study by Sadaf et al. (2016), while the next two items were adapted by Lin. K and Williams (2015), whereby item reliability of Cronbach's alpha exceeded 0.5 (Drost, 2004). In this study, all instruments containing items were constructed, modified, and adapted according to the context of microcontroller technology usage.

These attitude items were originally in English. However, these items were translated by an appointed linguist. Five experts, consisting of two teachers (language experts) and three lecturers (design & technology experts), were appointed to review and validate the contents of item. Then, improvements and modifications were made to the instruments for use in the study. The research found that all eight items in the study obtained a high value of Cronbach's alpha coefficient, which was 0.764. Descriptive analysis and comparison of RBT teacher attitudes based on gender were done by using SPSS software Version 26. Before the analysis, the data were checked to avoid any missing data (missing value). In this study, data were analyzed to find the mean value of teachers' attitude level in using microcontroller boards. It was interpreted the six Likert scale to six points were adapted from Ghazali Darusalam & Sufean Hussin (2018) and Nunally, J.C., (1978), namely *very low*, *low*, *moderate*, *high,* and *very high*.

**Table 1**. Mean Interpretation of Six Likert Scales of Teacher's Attitude Level in Using Microcontroller Boards

| Min value | Interpretation |
|---|---|
| 1.01 - 2.00 | Very Low |
| 2.01 - 3.00 | Low |
| 3.01 - 4.00 | Moderate |
| 4.01 – 5.00 | High |
| 5.01 – 6.00 | Very High |

Source: Rudzi Munap (2003), *Evaluation of Executive Secretarial Diploma Program at MARA Technology University*, PhD Thesis, UKM Bangi and Nunally, J.C. (1978). Psychometric Theory. New York: Mc. Graw Hill book Company

# Results

## Findings of The Study from The Demography of Teachers
### *Demographic Profile of Teachers?*

Table 2 below, summarize the distribution of respondents consisted of RBT teachers from a Penang secondary school in Malaysia of the total (N = 128) individual respondents that reported their gender, 92 female teachers (72%), was more than 36 male teachers (28%) RBT who teach Form 2 and Form 3 were of various races. A total of 112 RBT teachers were Malays (88%), nine teachers were Chinese (7%), six were Indian (5%) and only one teacher was of other (1%).

**Table 2**. Demographics profile of RBT teachers

| Category | | Frequency | percentage |
|---|---|---|---|
| Gender | Men | 36 | 28 % |
| | Women | 92 | 72 % |
| Race | Malays | 112 | 88 % |
| | Chinese | 9 | 7 % |
| | Indians | 6 | 5 % |
| | Others | 1 | 1 % |

### *Do Teachers Understand Microcontroller Concept?*

Demographic data result from the question "*Do you attending Microcontroller Training Course?*" can refer to table 3. The study found that many respondents who were involved in microcontroller-related training courses were 119 (93%) as compared to those who have never attended the microcontroller training courses, which were only 9 respondents (7%). The presence of RBT teachers in the training courses using microcontroller boards was very valuable to obtain teaching aid utilization skills based on hardware and software. Also, guidance and teaching techniques needed to teach using microcontroller boards.

**Table 3**. Attending Microcontroller Training Course

| Attendance | Frequency (*f*) | Percentage (%) |
|---|---|---|
| Yes | 119 | 93 % |
| No | 9 | 7 % |

**Table 4**. Programing language Using by RBT teacher's

| language | Frequency (*f*) | Percentage (%) |
|---|---|---|
| Scratch | 3 | 2 % |
| Python | 1 | 1 % |
| C/C+ | 75 | 59 % |
| Others | 49 | 38 % |

Similarly, outcomes acquired in Table 4 to answering the question "*What type programming language using by RBT teacher's?*", summarizing, selection towards types of using programming teaching in the classroom, indicate a positive response by teachers. Almost overall (59%) or 75 RBT teachers are more interested in utilizing the C/C++ programming language in the teaching and learning of a microcontroller, followed by other types of programming.

**Table 5**. Distribution of RBT Teachers Using Microcontroller Board

| Microcontroller boards | Frequency (*f*) | Percentage (%) |
|---|---|---|
| Arduino | 59 | 46 % |
| Microbid | 11 | 9 % |
| Magnetcode | 46 | 36 % |
| Raspberry Pi | 8 | 6 % |
| Adafruit Flora | 1 | 1 % |
| Makeblock Mbot Robot Kit | 3 | 2 % |

Then, table 5 shows there are assorted types of microcontroller boards in the market that are the choices for RBT teachers to use in teaching and learning to answer the question of "*What type of Microcontroller Board RBT teacher's use in teaching?*". The Majority of 59 RBT teachers (46%) choose to use an open-source Arduino microcontroller board, followed by a Magnetcode of 46 (36%) Meanwhile, the microcontroller board was less preferred by teachers was of the Microbid type. As many as 11 RBT teachers used Raspberry Pi (9%), and eight RBT teachers used Makeblock Mbot Robot Kit (6%), while only one teacher (1%) used the Adafruit Flora type microcontroller board. Besides, though teachers show satisfactory responses to understanding the concept of a microcontroller with attending training and decide the most matching hardware and software of microcontroller in teaching. Teachers still couldn't improve their utilization competency level because the frequency of using microcontrollers in the classroom is inadequate.

Table 6 from the question "*How many times RBT teacher's using Microcontroller board in the classroom?",* reveals teachers are not frequently applied to teach using microcontroller board in the classroom, there is an increasing number of 85 respondents (66%) rarely (1–5 times) used microcontrollers in practical teaching, followed by 20 respondents who never used microcontroller (16%) in teaching and learning. Meanwhile, 19 respondents (15%) sometimes (6–10 times) used microcontrollers and only four respondents (3%) used microcontrollers frequently (more than 10 times) in teaching and learning.

Furthermore, table 7 proves in detail the result from the question "*RBT teacher self-skills level is?*", 98 respondents (66%) were in the new learner category level in using microcontrollers in the teaching and learning practical classroom, followed by 19 respondents (15%) were in the moderate self-skills category. Meanwhile, six respondents (16%) admitted that they did not have the skill to use a microcontroller, while five (3%) respondents confess having advanced self-skills in using a microcontroller.

**Table 6**. Frequency Using Microcontroller Board in Classroom

| Frequency in 10 Week | Frequency *(ƒ)* | Percentage *(%)* |
|---|---|---|
| 0 times (Never) | 20 | 16 % |
| 1–5 times (Rare) | 85 | 66 % |
| 6–10 times (sometimes) | 19 | 15 % |
| More than 10 times (often) | 4 | 3 % |

**Table 7**. RBT Teachers Mastering the Skills Using A Microcontroller Board

| Self-skills Frequency (ƒ) | Frequency (ƒ) | Percentage (%) |
|---|---|---|
| Not existed | 6 | 16 % |
| New beginner | 98 | 66 % |
| Moderate | 19 | 15 % |
| Advance | 5 | 3 % |

***Distribution of Respondents by Attitude Level***

This section refers to the study findings on the level of RBT teachers' attitude in using microcontrollers in teaching and learning, whether in a very high position, high, medium, low, or very low level of attitude. Table 8 below shows the distribution of respondents of RBT teachers according to the level of attitude. A total of 36 people (28%) consisted of men and 92 people (72%) of the other respondents were women.

The table shows that the mean distribution of respondents is at a moderate level of 3.93. Overall, the level of attitude of RBT teachers toward the use of microcontroller was at a moderate level, whereby the majority of 121 RBT teachers (94.6%), (mean = 4.18, SD = 0.524) had a high level of attitude, agreeing to state "teaching electronic design in using microphone controller excellent". Meanwhile, the lowest item with the approval of 61 RBT teachers (47.7%), (mean = 3.38, SD = 0.922) was "like to use a microcontroller to teach electronic design practical classes". This means that, by taking a percentage between 94.6% and 83.6%, mean = 4.20 to 4.01 as a cut off indicator of a high level of teachers' attitude, it could be stated that the majority of RBT teachers agreed with the aspects of benefits, benefits, and importance of using microcontrollers in teaching. Meanwhile, the percentage between 78.1% and 47.7%, mean = 3.98 to 3.38 as a cut-off indicator of the level of RBT teachers' attitude was moderately agreed that microcontrollers could help students to complete their practical projects and teachers were also less fun and like to teach by using microcontrollers in the classroom.

**Table 8**. Distribution of RBT teachers' respondents by attitude level

| Items | Scale | | | | | | Total | Mean | SD | Level |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 SD | 2 | 3 | 4 | 5 | 6 SA | | | | |
| For me, teaching electronic design using a Microphone is very beneficial | 0 (0.0) | 8 (6.3) | - | 87 (68.0) | - | 33 (25.8) | 120 (93.8) | 4.20 | .533 | High |
| For me, teaching electronic design by using a Microphone is very important | 9 (7.0) | - | - | 90 (70.3) | - | 29 (22.7) | 119 (93) | 4.16 | .524 | High |
| For me, teaching electronic design by using a Microphone is a lot of fun | 1 (0.8) | 15 (11.7) | 50 (39.1) | 44 (34.4) | 17 (13.3) | 1 (0.8) | 62 (48.5) | 3.50 | .922 | Moderate |
| For me, teaching electronic design by using Microphone is an excellent idea | - | - | 7 (5.5) | 92 (71.9) | 28 (21.9) | 1 (0.8) | 121 (94.6) | 4.18 | .524 | High |
| For me, the use of microcontrollers helps to teach the translation of schematic and pictorial drawings to students | - | 1 (0.8) | 20 (15.6) | 83 (64.8) | 22 (17.2) | 2 (1.6) | 107 (83.6) | 4.03 | .651 | High |
| For me, the use of microcontrollers facilitates the teaching of programming languages to students | - | - | 19 (14.8) | 89 (69.5) | 20 (15.6) | - | 109 (85.1) | 4.01 | .554 | High |
| For me, the use of microcontrollers helps teach students design practical projects | - | 2 (1.6) | 26 (20.3) | 74 (57.8) | 25 (19.5) | 1 (0.8) | 100 (78.1) | 3.98 | .704 | Moderate |
| I like to use microcontrollers to teach electronic design practical classes | - | 26 (20.3) | 41 (32.0) | 48 (37.5) | 13 (10.2) | - | 61 (47.7) | 3.38 | .922 | Moderate |
| Overall | | | | | | | | 3.93 | 0.666 | Moderate |

### *Distribution of Respondents by Attitude Level by Gender*

Independent sample t-test was used to see the difference in attitude level among RBT teachers in implementing teaching by using the microcontroller based on gender. Therefore, the study results were as below:

**Table 9**. Test of differences in the level of RBT teachers' attitude by using microcontroller based on gender

| Construct | Gender | **N 128** | **Mean** | **SD** | **T** | **df** | **Sig (2-tailed)** |
|---|---|---|---|---|---|---|---|
| Attitude | Men | 36 | 3.97 | 0.41673 | 0.870 | 64.847 | 0.388 |
| | Women | 92 | 3.90 | 0.42293 | | | |

**Significant level at 0.05

Table 9 above shows the results of attitude level differences among RBT teachers in implementing the teaching and learning on the use of microcontrollers based on gender. Levene test for equality of variance, and thus, the value of F = 0.383, sig, 0.537, exceeded p> 0.05. Then, it could conclude that both samples (gender) came from the same population or homogenic. Meanwhile, the t-test for the comparison of the attitude level between men and women found that the value of t (64.847) = 0.870, p = .388. Since this p value indicated a significant level of greater than 0.05 (p <0.05), the null hypothesis was accepted. Therefore, there was no significant difference between the male and female gender in the teachers' attitude. The difference in mean value was also not significant, whereby RBT men teachers have a mean value = 3.97, which was slightly higher than female teachers with a mean value = 3.90.

## Discussion

### Do teachers understand Microcontroller concept?

Overall, RBT teacher's insufficient knowledge and skills and be in early stages of teaching using microcontroller board as a newcomer as this new curriculum has been launched since 2017 and start officially teaching microcontroller in 2018. Even teachers have good performance in training courses brought them to increase their practicing skills in using and teaching microcontroller. The result indicates teacher's poor in practicing practically microcontroller in their teaching period regularly. Despite, teachers show good attitude in using suitable hardware and effective software in the classroom such as microcontroller Arduino and C/ C+ assembly language to understand the structure of microcontroller such as instruction formats, the flow of control structure and the hardware stack operations as well as the interrupts (He et al., 2015). Ertmer et al., (2012), has been claimed, attitudes, and trust as a major factor application of technology integration in the classroom. However, effectively adapting the utilization of technology in the classroom not fully depends on a positive attitude only (Chien et al., 2014). To confirm these factors, the researcher continues to explore and dig the level of attitude RBT's teachers using microcontroller in the next session to identify the probability result.

### What is the Level of Attitude (AT) RBT's Teachers in Practical Teaching and Learning Using Microcontroller?

Overall, the level of RBT teachers' attitude in using microcontrollers in the practical teaching and learning of electronic design was at a moderate level with a mean score of 3.93. The score range was also at a moderate level, which was between 3.38 and 3.98.

This modest attitude level indicated that RBT teachers were still not confidence in utilizing the microcontrollers fully while teaching practical projects to students. Even though RBT teachers were highly positive and have awareness of the advantages, importance of teaching the use of microcontrollers and benefits gained from such smart devices in their teaching and daily life. They were still not interested, unhappy teaching and thought that the use of microcontroller did not fully help students to produce practical projects with completion. Which is probability causally related with application microcontrollers was not very easy to learn and required more effort to make it easier for use. It was due to its hardware-based nature and software which involved problem solving approach in digital electronics circuit and needed an in-depth understanding of the structure inside and operation of a microcontroller device (He et al., 2015; Mallik & Rajguru, 2018). The overall study findings were in line with the statement by Norashid Othman & Hamzah Md Omar (2014). Although the teachers had a positive attitude toward the use of visual aids teaching aids, the level of application in the classroom was at a moderate level.

In contrast, different findings from most previous studies showed that teachers and students had a positive attitude and felt that learning the use of microcontrollers was fun (Filippov et al., 2017; Sharaf et al., 2019). It was also found that the attitude and knowledge of teachers increased when they use arduino microcontrollers after following the content of teaching in the course organized (Slavko Kocijancic, 2019). This was because the computerized thinking learning method presented through the concept of a game teaching environment had attracted students to learn (Sharaf, Ahmed, Adel, Abdennadher, & Berkling, 2019). Therefore, in this study, the teachers' attitude was a major predictor for the use of new technologies as has been discussed in many studies based theoretical such as Technology Acceptance Model (TAM) and Theory of Planned Behavior (TPB) as an important tool for measuring teachers' attitudes toward technology development which influence by teachers intention intention (Kao, Lin & Chien, 2018; Scherer, Siddiq & Teo, 2015; Kao & Tsai, 2009; Almusalam, 2001).

### Is There Any Difference in Attitude Level of RBT Teachers Teaching Using Microcontroller Based on Gender?

Some studies have provided evidence that gender impact attitude (Venkatesh et al., 2000; Venkatesh & Morris, 2000; Venkatesh et al., 2003). Teachers' characteristics (e.g. individual's educational level, age, gender, educational experience, experience with the computer for educational purposes, and financial position) can influence the adoption of an innovation (Rogers, 1995; Schiller, 2003). Therefore, a comparative analysis of attitude levels of RBT teachers' teaching in using microcontroller based on gender showed that had no significant difference. These findings were in line with the study conducted by Al-Emran, Elsherif, & Shaalan (2016), which stated that there was no difference between gender on the use of mobile learning in teaching and learning. Although male and female RBT teachers had similar perceptions of both aspects of attitude, the mean score difference indicated that female teachers who showed high attitude aspects were concerned with the use of microcontrollers in teaching as compared to male teachers. The high attitude further strengthens the findings of a study by Cooper & Heaverlo (2013), which stated that women were more interested in STEM activities in problem solving and creativity as well as design skills.

## Conclusion

This study was conducted to determine the level of attitude use of microcontrollers among RBT teachers in practical assignments. In addition, this study was conducted to identify whether there was a comparison of attitudes with the RBT teachers' gender. The study findings showed that the level of RBT teachers' attitude was moderate. In other words, the attitude of RBT teachers refers to the feeling of liking and interest to teach microcontroller teaching by cooperating and striving to make the practical teaching more interesting so that students can be creative in producing designs.

The implication is that attitude is an urgent factor for teachers to increase the use of microcontrollers in teaching and learning, which is impact individuals' affective, cognitive and behavior (Van Acker, Vermeulen, & Van Buuren, 2013). As a result, it can improve teachers' achievement in teaching and learning so that students can design various creative and innovative microcontroller-based smart electronics technology projects in the practical classroom. In addition, the results of the analysis revealed that only a small percentage of RBT teachers did not take the microcontroller course, which was 7%. Even so, the analysis showed that RBT teachers thought that their skills in using microcontrollers are still a new level or just beginning.

In fact, the frequency of microcontrollers usage among teachers is still at a rare level, 1–5 times (66%) only with a time allocation of 10 hours in the microcontroller syllabus (Zamri Sahaat & Nurfaradhilla Nasri, 2020) as compared to the experimental study time conducted by Pao (2018), who used it for 3 hours in 16 weeks or 28 hours Pao (2018). Meanwhile, the choice of teachers in terms of hardware and software microcontroller found that Arduino microcontroller became the main choice (46%) and C programing language (59%) as compared to Python (1%) and Scratch (2%). The results of this analysis can help stakeholders to produce a policy on whether there are additional needs in improving the level of teachers' attitude of RBT teachers in terms of teaching and learning facilities.

As suggested by (Zamri Sahaat & Nurfaradhilla Nasri, 2020), that there was a need for stakeholders, such as the Curriculum Development Division in the Ministry of Education Malaysia and the Institute of Teacher Education, to enhance the teaching time and improve equipment facilities in the workshop to facilitate the teaching process to students. Therefore, based on previous studies, RBT workshops can be upgraded to "makerspace" or "Collaborative Environment", a space with the technology prototyping concept of STEM teaching tools that can process various teaching techniques to cultivate digital technology for developing an idea for constructing physical and digital invention through teamwork involving educators and students (Sheridan, Halverson, Litts, Brahms & Jacob Pribe, 2014; Tan, 2019). In addition, to cover a wide spectrum of fulfilling teaching objectives in science, technology, mechanical engineering, electrical and electronics to the arts, it is also used as future innovative space for students to develop problem-solving skills and successful practical teaching activities of RBT teachers to students (Pao, 2018).

Studies have proven, through this concept, that there has been an increase in knowledge and problem-solving skills in computer programming, and electrical engineering among teachers and students (Pao, 2018). However, in the future it is proposed to examine the same questions by covering all schools in Malaysia and involving students, with further expansion to study the relationship of teacher behavior to the use of microcontrollers in the teaching and learning of electronic design.

## References


Al-Awidi, H., & Aldhafeeri, F. (2017). Teachers' Readiness to Implement Digital Curriculum in Kuwaiti Schools. *Journal of Information Technology Education: Research*, *16*(2), 105–126

Al-Emran, M., Elsherif, H. M., & Shaalan, K. (2016). Computers in Human Behavior Investigating attitudes towards the use of mobile learning in higher education. *Computers in Human Behavior*, *56*, 93–102. https://doi.org/10.1016/j.chb.2015.11.033

Alexander Ronald Dymek, & Steven Thomas Murdy. (2016). Embedded Instruction Kit Steven Murdy, (June).

Almusalam, S. N. (2001). Factors related to the use of computer technologies for professional tasks by business and administration teachers at Saudi technical colleges. (Doctoral Dissertation, the Ohio State University, 2001). ProQuest Digital Dissertations (UMI No. AAT 3011019).

Anne Marie Engtoft Larsen (2018). Knowledge Lead, Science and Technology Studies, World Economic Forum Geneva, Online available from https://www.weforum.org/events/world-economic-forum-annual-meeting

Blackwell, C. K., Lauricella, A. R., & Wartella, E. (2014). Factors influencing digital technology use in early childhood education. Computers & Education, 77,82–90

Blikstein, P. (2017). The History and Prospects of the Maker Movement in Education. In *Springer International Handbook of Education* (pp.1–19). https://doi.org/10.1007/978-3-319-38889-2

Bolanakis, D. E. (2019). A Survey of Research in Microcontroller Education. *IEEE Revista Iberoamericana de Tecnologias Del Aprendizaje*, *14*(2), 50–57. https://doi.org/10.1109/RITA.2019.2922856

Bruce, R., Brock, D., & Reiser, S. (2013). Teaching programming using embedded systems. *Conference Proceedings - IEEE SOUTHEASTCON*. https://doi.org/10.1109/SECON.2013.6567401

Bunyamin, M. A. H. (2018). Pendidikan STEM Bersepadu: Perspektif Global, Perkembangan Semasa di Malaysia, dan Langkah Kehadapan, (November 2015).

Chan, J., Pondicherry, T., & Blikstein, P. (2013). LightUp: an augmented, learning platform for electronics. Proceedings of the 12th International Conference on Interaction Design and Children.

Chien, S. P., Wu, H. K., & Hsu, Y. S. (2014). An investigation of teachers' beliefs and their use of technology-based assessments. Computers in Human Behavior, 31, 198-210. https://doi.org/10.1016/j.chb.2013.10.037

Cooper, R., & Heaverlo, C. (2013). And Design: What Influence Do They Have on Girls' Interest in STEM Subject Areas? *American Journal of Engineering Education*, *4*(1), 27–38.

Cruz, M. (2017). Exploring the Open Source Hardware phenomenon: Empirical essays on the role of user communities in the creation of innovation, organizations and market. City, University of London Institutional Repository.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology, MIS quarterly, 13(3), 319–340.

Dimosthenis E. Bolanakis. (2019). A Survey of Research in Microcontroller Education. *IEEE Revista Iberoamericana de Tecnologias Del Aprendizaje*, *14*(2), 50–57. https://doi.org/10.1109/RITA.2019.2922856

Drost, E. A. (2004). Validity and Reliability in Social Science Research. *Education Research and Perspectives*, *38*(1), 105–123.

El-Abd, M. (2017). A Review of Embedded Systems Education in the Arduino Age: Lessons Learned and Future Directions. *International Journal of Engineering Pedagogy (IJEP)*, *7*(2), 79–93. https://doi.org/10.1016/j.proeng.2011.11.2723

Ertmer, P. A., Ottenbreit-leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Computers & Education Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, *59*(2), 423–435. https://doi.org/10.1016/j.compedu.2012.02.001

Everett M. Rogers. (1995). *Diffusion of innovations* (4th ed.). United States of America: Simon and Schuster.

Fadila, N., & Chiew, K. W. (2014). Persepsi Guru terhadap Penggunaan Perisian Multimedia Dalam Proses Penagajaran dan Pembelajaran Mata Pelajaran Diakses pada Mei 20, 2016 Online available: http://core.ac.uk/download/pdf/11785861.pdf

Filippov, S., Ten, N., Shirokolobov, I., & Fradkov, A. (2017). ScienceDirect Robotics in Secondary School Teaching Robotics in Secondary School. *IFAC-PapersOnLine*, *50*(1), 12155–12160. https://doi.org/10.1016/j.ifacol.2017.08.2143

Fisher, T. (2006). Educational transformation: is it like 'beauty' in the eye of the beholder, or will we know it when we see it? Education and Information Technologies, 11(3/4), 293–303. http://dx.doi.org/10.1007/s10639-006-9009-1.

García, M., Vargas, J., & Isaza, L. (2018). Virtual Object of Learning for Driving Through Virtual Reality with Development of Peripherals and Glasses for Virtual Reality. *International Journal of Applied Engineering Research*, *13*(11), 9382–9386.

Ghazali Darusalam, & Sufean Hussin. (2018). *Metodologi Penyelidikan dalam Pendidikan: Amalan dan Analisis Kajian* (2nd ed.). Kuala Lumpur: Penerbit Universiti Malaya.

Hafzan Ibrahim, Mohammad Bilal Ali, Fatin Aliah Phang Abdullah, & Norazrena Abu Samah. (2014). Robotik dalam Pendidikan di Malaysia, 530–538.

Halverson, E. R., & Sheridan, K. M. (2014). The maker movement in education. Havard Educational Review, 84(4), 495-504.https://doi.org/10.17763/haer.84.4.34j1g68140382063

Haron, H. N., Hussain, N. H., & Mohammad, R. (2019). Grooming Future Scientists and Engineers from the Root through Fun Learning Concept. *Journal of Physics: Conference Series PAPER*. https://doi.org/10.1088/1742-6596/1174/1/01200

Harrison, A. W. & Rainer, R. K. (1992). The Influence of Individual Differences on Skill in End-User Computing. Journal of Management Information Systems, 9(1), 93-111.

He, S., Zhang, Y., & Shen, F. (2015). Microcontrollers for Non-Electrical Engineering Students - Do We Need to Teach Assembly Language? Microcontrollers for Non-Electrical Engineering Students - Do We Need to Teach Assembly Language? *American Society for Engineering Education*.

Intisar Ibrahim, Rosmah Ali, Mohamad Zulkefli, & Nazar Elfadil. (2015). Embedded systems pedagogical issue: Teaching approaches, students' readiness, and design challenges. *American Journal of Embedded Systems and Applications*, *3*(1), 1–10. https://doi.org/10.11648/j.ajesa.20150301.11

Jayalatchumy Subramaniam. (2006), Penggunaan Bahan Bantu Mengajar Berasaskan Teknology Maklumat di Kalangan Guru Sejarah. Thesis sarjana yang tidak diterbitkan). Malaya University

Jimoyiannis, A. (2008). Factors determining teachers' beliefs and perceptions of ICT in education. In A. Cartelli & M. Palma (eds.), Encyclopedia of Information Communication Technology (pp. 321-334), Hershey, PA: IGI Global

Joshua Chan, Tarun Pondicherry, & Paulo Blikstein. 2013. LightUp: An Augmented, Learning Platform for Electronics. In Proceedings of the 12th International Conference on Interaction Design and Children (IDC '13). ACM, New York, NY, USA, 491–494. http://dx.doi.org/10.1145/2485760.2485812

Kao, C.-P., & Tsai, C.-C. (2009). Teachers' attitudes toward web-based professional development, with relation to Internetself-efficacy and beliefs about web-based learning. Computers & Education, 53(1), 66-73. https://doi.org/10.1016/j.compedu.2008.12.019

Kao, C.P., Lin, K.Y. & Chien, H.M. (2018). Predicting teachers' behavioural intentions regarding web-based professional development by the theory of planned behaviour. *EURASIA Journal of Mathematics, Science and Technology Education, 14*(5), 1887-189

Klaus Schwab (2016). The fourth industrial revolution. Geneva: World Economic Forum.

Kluever, R. C., Lam T. C., Hoffman, E. R., Green, K. E., & Swearinges, D. L. (1994). The Computer Attitude Scale: Assessing Changes in Teachers' Attitudes Toward Computers. *Journal of Educational Computing Research*, 11 (3), 251-261.

Kutluca, T. and Ekici, G. (2010) 'Examining teacher candidates' attitudes and self-efficacy perceptions towards the computer assisted education', Journal of Hacettepe University Education Faculty, Vol. 38, No. 2010, pp.177–188.

Kriek, J., & Stols, G. (2010). Teachers' beliefs and their intention to use interactive simulations in their classrooms. South African Journal of Education, 30(3), 439-456.

Kreijns, K., Van Acker, F., Vermeulen, M., & van Buuren (2013). What stimulates teachers to integrate ICT in their pedagogical practices? The use of digital learning materials in education. Computers in Human Behaviour, 29(1), 217–225

Lazar & Irena (2015). Perceptions of teachers regarding the implementation of the internet in education. *Computer in Human Behavior*, 53. 462-468.

Lima, M. M., Martín-ramos, P., Jo, M., Gomes, P. E. B., Pereira, P. S., & Silva, M. R. (2018). Computers in Human Behavior Reprint of 'First exposure to Arduino through peer-coaching: Impact on students' attitudes towards programming' *, *80*, 420–427. https://doi.org/10.1016/j.chb.2017.12.011

Lin. K, & Williams. (2015). Taiwanese Preservice Teachers' Science, Technology, Engineering, and Mathematics Teaching Intention. *International Journal of Science and Mathematics Education*, 1–30. https://doi.org/10.1007/s10763-015-9645-2

Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. *Journal of Industrial Information Integration*, *6*, 1–10. https://doi.org/10.1016/j.jii.2017.04.005

Mabbott, G. A. (2014). Teaching Electronics and Laboratory Automation Using Microcontroller Boards. *Journal of Chemical Education*, (91), 1458–1463.

Mallik, A., & Rajguru, S. B. (2018). Fundamental: Analyzing the Effects of a Robotics Training Workshop on the Self-efficacy of High School Teachers Fundamental: Analyzing the Effects of a Robotics Training Workshop on the Self-Efficacy of High School Teachers. *American Society for Engineering Education*.

Mariano Garduno-Aparicio, Juvenal Rodriguez-Resendiz, Gonzalo Macias-Bobadilla, & Suresh Thenozh. (2018). A Multidisciplinary Industrial Robot Approach for Teaching Mechatronics-Related Courses. *IEEE Transactions on Education*, *61*(1), 55–62. https://doi.org/10.1109/TE.2017.2741446

Minister of Education (MOE). (2016). Dokumen Standard Kurikulum dan Pentaksiran Tingkatan 2, Reka bentuk dan teknologi.

Mohd Akmal Firdaus Mohamad Hamim. (2017). Kompetensi Guru Reka Cipta Dalam Bidang Elektrik Di Sekolah Menengah Harian di Johor.

Moshe Barak. (2013). Teaching Electronics: From Building Circuits to Systems Thinking and Programming. https://doi.org/10.1007/978-3-319-38889-2

Mumtaz, S. (2000). Factors Affecting Teachers' Use of Information and Communications Technology: A review of the Literature. *Journal of Information Technology for Teacher Education*, 9(3), 319-342

Nethravathi.S, & R.S.Geetha. (2016). Learning by Doing: Implementing In Microcontroller Course. *Journal of Engineering Education Transformations*, eISSN 2394-1707.

Norashid Othman, & Hamzah Md Omar. (2014). © Universiti Malaysia Sabah, 2014. *Jurnal Pemikir Pendidikan*, *5*(2008). https://doi.org/pp. 19-33, ISSN 1985-3637

Nugent, G., Barker, B., Lester, H., Grandgenett, N., Valentine, D., Barker, B., & Lester, H. (2019). Wearable Textiles to Support Student STEM Learning and Attitudes.

Nunally, J. C., & Bernstein, I. H. (1994). *Psychometric Theory*. *McGraw-Hill* (3rd Editio). New York: McGraw-Hill Book Company.

Pallant, J. (2005). *Spss Survival Manual* (2nd Edition). Sydney: Allen & Unwin.

Pao, N, -C., (2018). Skill Development and Knowledge Acquisition Cultivated by Maker Education: Evidence from Arduino-based Educational Robotics. *Researchgate.Net*, *14*(10). Retrieved from https://www.researchgate.net/profile/Pao_Nan_Chou/publication/326411462_Skill_Development_and_Knowledge_Acquisition_Cultivated_by_Maker_Education_Evidence_from_Arduino-based_Educational_Robotics/links/5b4c2c2745851519b4c02a2c/Skill-Development-and-Knowled

Prisecaru, P. (2016). Challenges of the fourth industrial revolution Petre Prisecaru. *Knowledge Horizons - Economics*, *8*(1), 57–62.

Qin, Y., & Yu, B. (2011). Heuristic education of Microcontroller Unit Principle and Applications. In *Procedia Engineering* (Vol. 24, pp. 708–712). https://doi.org/10.1016/j.proeng.2011.11.2723

Sadaf, A., Newby, T. J., & Ertmer, P. A. (2016). teachers' intentions and integration of Web 2.0 tools. *Educational Technology Research and Development*, *64*(1), 37–64. https://doi.org/10.1007/s11423-015-9410-9

Scherer, R., & Siddiq, F. (2015). Revisiting teachers' computer self-efficacy: a differentiated view on gender differences. Computers and Human Behavior, 53, 48e57. http://dx.doi.org/10.1016/j.chb.2015.06.038.

Schiller, J. (2003). Working with ICT Perceptions of Australian Principals. Journal of Educational Administration, 41(2), 171-185.

Sell, R. (2012). Microcontroller Based Intelligent Platform for Research and Education in Mechatronics, (January 2014). https://doi.org/10.1109/MECATRONICS.2012.6451007

Sharaf, N., Ahmed, G., Adel, A., Abdennadher, S., & Berkling, K. (2019). Koding4Kinder: Teaching Computational Thinking to Pupils Using a Combination of Programming and Electronics Platforms Nada. *2019 IEEE Global Engineering Education Conference (EDUCON)*, 634–638.

Sheridan, K., Halverson, E. R., Litts, B., Brahms, L., Jacobs-Priebe, L., & Owens, T. (2014). Learning in the making: a comparative case study of three makerspaces. Harv Educ Rev, 84(4), 505–531

Shirley Taylor, & Peter A. Todd. (1995). Understanding Information Technology Usage: A Test of Competing Models.

Sıtkı Kocaoglu, Eray Yilmazlar, & Harun Gezici. (2017). Understanding the Concept of Microcontroller Based Systems to Choose the Best Hardware for Applications, *6*(9), 38–44.

Slavko Kocijancic. (2019). Contemporary Challenges in Teaching Electronics to STEM Teachers. In *Conference Paper in AIP Conference Proceedings*. https://doi.org/10.1063/1.5080021

Syahrial, A., Sabil, H., & Arsil. (2020). Attitudes, Self-confidence, and Independence of Students in Thematic Learning. *Universal Journal of Educational Research*, *8*(1), 162–168. https://doi.org/10.13189/ujer.2020.080120

Tan, M. (2019). When Makerspaces Meet School: Negotiating Tensions Between Instruction and Construction. Journal of Science Education and Technology, (28), 75–89.

Teo, T. (2015). Comparing pre-service and in-service teachers' acceptance of technology: assessment of measurement invariance and latent mean differences. Computers & Education, 83,22e31.

Uzunboylu, H., & Ozdamli, F. (2011). Teacher perception form?learning: scale development and teachers' perceptions. Journal of Computer Assisted Learning, 27(6), (pp. 544-556).

Venkatesh, V., Davis, F. D., & College, S. M. W. (2000). Theoretical Acceptance Extension Model: Field Four Studies of the Technology Longitudinal. Management Science, 46(2), 186–204

Venkatesh, V., & Morris, G. M. (2000). Why don‟t men ever stop to ask for directions? Gender, social influence and their role in technology acceptance and usage behaviour. MIS Quarterly, 24(1), 115– 139.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Towards a Unified View1. Management Information System Research Center, University of Minnesota, 27(3), 425–478.

Vostrukhin, A., & Vakhtina, E. (2016). Studying digital signal processing on arduino based platform. In *Engineering for Rural Development* (Vol. 2016-Janua, pp. 236–241).

Zacharia, Z. (2003). Beliefs, attitudes, and intentions of science teachers regarding the educational use of computer simulations and inquiry-based experiments in physics. Journal of Research in Science Teaching, 40(8), 792-823. https://doi.org/10.1002/tea.10112

Zamri Sahaat, & Nurfaradhilla Nasri. (2020). Cabaran Challenges in the Implementation of Design and Technology Subject in Secondary School. *Jurnal Pendidikan Malaysia*, *45*(1), 51–59.