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THE DEVELOPMENT AND USABILITY OF A BRAGG'S LAW CRYSTALLOGRAPHY MODEL AS A TEACHING AID IN SOLID STATE PHYSICS COURSE AMONG UNDERGRADUATE STUDENTS IN UNIVERSITI PENDIDIKAN SULTAN IDRIS

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ABSTRACT

This quantitative study was aimed to develop and determine the usability of a Bragg's law crystallography model as a teaching aid in Solid State Physics course among undergraduate students in Universiti Pendidikan Sultan Idris (UPSI). The usability of Bragg's law crystallography model in attracting students' interest towards the learning area and the perception of students towards the usability were evaluated. A total of 101 UPSI undergraduate students were taken as the respondents in the study via the cluster probability sampling method. A questionnaire with four points Likert scale was used to collect the data. The instruments including the model and the questionnaire were verified by evaluation experts. Pilot test was carried out to measure the reliability of instruments. The data was analysed by using the descriptive statistics. The findings showed that the developed Bragg's law crystallography model was valid and reliable for undergraduate students in UPSI. Positive result of the students' interest towards the learning area by using the Bragg's law crystallography model and the usefulness of this model was showed. Students showed great interest during the lecture learning about Bragg's law. Thus, Bragg's law crystallography model enabled students to be more interested in the learning area and helped the educators to create better learning environment in Solid State Physics course as the implications of this research.

Keywords : Model usability; teaching aid; learning interest

I. INTRODUCTION

Physics remained the least favoured subject among students even though physics was the basics for understanding many of the natural phenomena [1]. Thus, teaching aids were needed to facilitate physics learning. This supplied verbal explanation so that the lesson could be real to students [2]. Developing teaching aids to accommodate the mastering of 21st century skills was essential in order to improve the learning effectiveness [3]. Teaching and learning could be supported by developing models related to the topics as teaching aids [4]. Besides, the using of model in education was making the learning environment interesting [5].

A. Problem Statement

Bragg's law is one of the fundamental concept under crystallography in Solid State Physics. Many students considered crystallography as a difficult subject [6]. Difficult concepts made students lost interest in physics learning [7]. Educators were not using instructional materials adequately in teaching physics. The lacking of using interesting materials affected the quality of teaching and learning process [2]. The developing of Bragg's law crystallography model was to attract students' interest and assist students for better understanding. Thus, this study was aimed to develop a Bragg's law crystallography model and evaluate the usability of this model in attracting students' interest towards the learning area and the perception of students towards the usability of model.

B. Research Purpose and Objectives

The purpose of this study was to develop and determine the usability of a Bragg's law crystallography model as a teaching aid in Solid State Physics course among undergraduate students in UPSI. The first research objective was to develop a Bragg's law crystallography model. The second research objective was to evaluate the usability of Bragg's law crystallography model in attracting students' interest towards the learning area and the perception of students towards the usability of Bragg's law crystallography model.

C. Research Question

- Is the developed Bragg's law crystallography model valid and reliable for undergraduate students in UPSI?
- Is the Bragg's law crystallography model useful?

D. Research Scope and Significance

The research scope in this study was focusing on the development and usability of Bragg's law crystallography model in the teaching and learning process and the students' interest after using the model.

Research regarding developing model was done either in Malaysia or other countries [8-10]. However, few studies about the integration of developing model in physics education regarding the topic of Bragg's law were found. Thus, this research regarding the development and usability of Bragg's law crystallography model as a teaching aids material was significant for educators and students.

E. Limitations and Delimitations

The delimitation of this research was the involvement of undergraduate students who learned Bragg's law in Solid State Physics course in UPSI. The limitation for this research was the limited involvement of students. The respondents were limited to a part of physics students in UPSI. Thus, the data gathered was limited. Besides, cluster sampling method was applied as the respondents elected as sample were Semester 1 session 2020/2021 students who were taking Solid State Physics course. Another limitation was this cluster might not homogeneous among all students. In this context, all the undergraduate students who were taking Solid State Physics course in UPSI, which was the population for this research might not having the same characteristics. Thus, the sample might not be representative of the population [11].

II. METHOD

A. Research Design

In this study, the research designs were Design and Development Research (DDR) and survey research designs. Analysis, design, development, implementation, and evaluation (ADDIE) model was used for the development aspect. This research was a quantitative research for determining the usability of Bragg's law crystallography model as a teaching aid in Solid State Physics course among undergraduate students in UPSI. The usability was determined by using survey method to generalize the findings. One single method was applied as data collection method, which was quantitative method. The data collection was current and survey method was conducted to collect data from respondents elected.

B. Population and Sample

Respondents involved in this research were sample selected from the undergraduate students who were learning Bragg's law in Solid State Physics course as population. Cluster probability sampling method was used for election. There were 36 male and 65 female students from Semester 1 2020/2021 participated as respondents. All groups in this course were selected.

C. Instruments

The instruments involved in this research were the validity form, reliability form, consent form, Bragg's law crystallography model and survey questionnaire. The validity and reliability forms were prepared to evaluate the validity and reliability respectively of the instruments. The concrete mode of representation was applied to build the model, which was three-dimensional and made of resistant materials. Questionnaire was used to collect data. The usability of the model was measured by two constructs, which were students' interest towards the

learning area by using the Bragg's law crystallography model (ILB) and usefulness of Bragg's law crystallography model (UM). The questionnaire consisted ten items adapted from the interest scale in the study made by Harackiewicz, Barron, Carter, Lehto, and Elliot [12], Harackiewicz, Barron, Tauer, Carter, and Elliot [13] and also the study made by Cēdere, Jurgena, Helmane, Tiltiņa-Kapele, and Praulīte [14]. Besides, ten items were adapted from the usefulness scale in the study made by Bangor, Kortum, and Miller [15]. Four-point Likert scale from 1-strongly disagree to 4-strongly agree was applied. The validity of the instruments was evaluated by two lecturers from UPSI and determined by using percentage agreement. A pilot test was carried out to measure the reliability of instruments based on Cronbach's alpha.

D. Data Collection Procedures

The data collection was carried out after all the research instruments were prepared. The Bragg's law crystallography model was developed and the questionnaire was prepared to collect data. The items in the questionnaire were adapted from the previous researches done by the investigators to fulfill the research purposes. This was to ensure that the research result was relevant to the research objective. Moreover, the research instruments including the model and the questionnaire were reviewed and verified by evaluation expert in the field of research and physics education. A pilot study was also carried out to measure the reliability of the instruments. This was to ensure that the instruments could be implemented in this research.

Then, the study was conducted by using the sample elected in UPSI. Before conducting the study, a video with link https://youtu.be/BwfuiiAoclI regarding the Bragg's law crystallography model was made. Survey respondents were required to understand and fill the research consent form as an agreement to participate in this research. A teaching and learning session was conducted for respondents to learn the Bragg's law with the video watching of Bragg's law crystallography model. Survey respondents were asked to answer the questionnaire after lecture. The date for this session was discussed with the respondents for ensuring that this study did not interfere with their learning session and daily activities.

The questionnaire was prepared in the form of Google Form. Before starting to answer the questionnaire, respondents were briefed on the objectives of the research and how to answer the questions prepared in the questionnaire. Respondents were required to ensure that their demographic profile was filled and all the answer for each question were marked. Discussion or imitation was prohibited. Next, the questionnaire was submitted. All items in the questionnaire for the survey are analyzed descriptively by using Statistic Package for the Social Science (SPSS) software. Finally, the research findings was obtained and discussed.

E. Data Analysis

For determining the validity, 75% of agreement was the minimum cutoff [16]. Values above 0.6 of Cronbach's alpha were considered indicating satisfactory reliability [17]. All items in the questionnaire were analyzed descriptively by using SPSS software. This included the frequency, percentage, mean and standard deviation. The findings were discussed based on the interval and description showed in Table 1 from Pimentel [18].

Table 1. Likert Scale, Interval and Description

Likert Scale	Interval	Description
1	1.00 – 1.75	Strongly Disagree
2	1.76 – 2.51	Disagree
3	2.52 – 3.27	Agree
4	3.28 – 4.00	Strongly Agree

The standard deviation which was less than one based on the data collected by using Likert scale was considered having a good concentration of preference by respondents [19]. Table 2 showed the data analysis that was carried out to answer the research question.

Table 2. Data Analysis

Research Question		Data Analysis Method
Is the developed Bragg's law crystallography model valid and reliable for undergraduate students in UPSI?	Validity	Percentage agreement
	Reliability	Cronbach's alpha
Is the Bragg's law crystallography model useful?	Interest in Learning Bragg's Law Usefulness of	Descriptive Statistic • Mean • Standard Deviation

model

III. RESULTS AND DISCUSSION

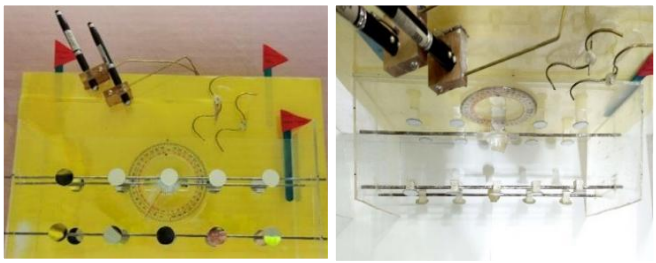
The results obtained based on data analysis has provided an explanation for the relevant data regarding the validity and reliability of the developed Bragg's law crystallography model. Besides, the data analysis was also focusing on the usability of Bragg's law crystallography model in attracting students' interest towards the learning area and the perception of students towards the usability of Bragg's law crystallography model.

A. The Development of a Bragg's Law Crystallography Model as a Teaching Aid in Solid State Physics Course

ADDIE model was used for the development aspect in this research. The five phases in ADDIE model which were Analysis, Design, Development, Implementation, and Evaluation were applied in this research. The Bragg's law crystallography model was built and developed based on these elements. In the analysis phase, instructional problem was identified along with learner characteristics in education. According to the studies done by few researchers, Bragg's law was one of the fundamental concept under crystallography in Solid State Physics and many students consider crystallography as a difficult subject. Thus, a model was needed for showing how the mechanism happened [4, 6, 20]. This was indicating that a need for creating an illustrative example for a better environmental condition based on behaviourism and cognitivism learning theory [21]. The necessary for developing the Bragg's law crystallography model was analysed before designing the model.

In the designing phase, instructional strategies were created. At the same time, the learning activities and assessment were determined. After making the literature review, all of the instruments were designed and prepared. The objectives of developing the Bragg's law crystallography model were also determined. The frame of the design for this model was determined, which were the size, cost, materials and layout. Solids were used to build this model and the model was three-dimensional.

Besides, the instruments used to collect data for evaluation purpose was designed. This was to determine the usability of Bragg's law crystallography model in attracting students' interest towards the learning area and the perception of students towards the usability of Bragg's law crystallography model. The usability of the model was measured by two constructs, which were students' interest towards the learning area by using the Bragg's law crystallography model (ILB) and usefulness of Bragg's law crystallography model (UM). In the development phase, Bragg's law crystallography model and the survey questionnaires were developed. The Bragg's law crystallography model was developed by using perspex sheets, laser pens, protractor, iron sticks, small mirrors, glue and papers as shown in Figure 1.



(a) (b)

Fig. 1. (a) Front view of model and (b) Top view of model

In the implementation phase, the Bragg's law crystallography model and survey questionnaires were validated by two lecturers as experts from UPSI. This was to ensure that these instruments were valid and could be implemented in this research for validity purpose. Comments and suggestions were given by the experts for improvements of the model and questionnaires. The percentage of face validity and content validity was calculated. Pilot test was carried out to test the reliability for this research. The data was analysed and the value of Cronbach's alpha was obtained by using SPSS. The comments obtained from the questionnaire were also analysed for improvement of the instruments. Then, the participating of respondents was carried out.

The evaluation phase occurred at the end of the implementation in the form of a summative evaluation, the data obtained from 101 respondents were collected by using survey questionnaires. The data was analysed quantitative descriptively by using SPSS. At the end of this study, suggestions and improvements that could be carried out in future studies were presented.

B. Analysis on Validity and Reliability Test of Instruments

The validity and reliability were considered for the development of an instrument [22]. Thus, the determination of the development of Bragg's law crystallography model was divided into two parts, which were the validity and reliability.

Face validity and content validity were evaluated by using percentage agreement of experts' responses. The validity level of Bragg's law crystallography model and questionnaire were 92.5% and 95.0% respectively as showed in Table 3. Both of the instruments were having validity level of higher than 75%. These values indicated that the instruments were valid to be used in testing the usability of Bragg's law crystallography model.

Table 3. Validity Score of Instruments

Validity	Validity Score (%)	
	Bragg's Law Crystallography Model	Questionnaire
Face validity	90.0	97.5
Content validity	95.0	92.5
Average score	92.5	95.0

Pilot test was then carried out to measure the reliability of instruments. In this research, 16 respondents were involved. This sample was UPSI undergraduate Solid State Physics course students who were not involving in the data collection. The value of Cronbach's alpha obtained in the pilot test for the first construct was 0.877. For the second construct, the value of Cronbach's alpha was 0.813. The overall value of Cronbach's alpha was 0.845 for both constructs as showed in Table 4. This showed that questionnaire was having good level of internal consistency and reliable to be used in order to obtain the required data. The findings answered the first research question that the developed Bragg's law crystallography model was valid and reliable for undergraduate students in UPSI.

Table 4. Reliability by Construct

Construct	Number of Items	Cronbach's Alpha
ILB	10	0.877
UM	10	0.813
Overall		0.845

C. Usability of Bragg's Law Crystallography Model

Table 5. Analysis of Students' Interest towards the Learning Area by Using the Bragg's Law Crystallography Model

	Item	Mean	Standard Deviation
ILB1	I think what we are learning in this class regarding Bragg's law is interesting.	3.68	0.468
ILB2	The using of this model in the learning lesson make me think regarding the Bragg's law.	3.70	0.459
ILB3	I am enjoying this Solid State Physics class very much.	3.75	0.456
ILB4	I think this field of crystallography is very interesting.	3.67	0.471
ILB5	This learning lesson has been a flourish moment of my time.	3.54	0.521
ILB6	I am glad I took this subject.	3.76	0.428
ILB7	I think this model as course material in this class is useful for me to learn.	3.76	0.451
ILB8	I desire to understand about Bragg's law.	3.69	0.505
ILB9	I am interested to explore about this learning area.	3.68	0.509

	Item	Mean	Standard Deviation
ILB10	I am interested in mastering this learning area.	3.64	0.521
	Total	3.69	0.345

Table 6. Analysis of Usefulness of Bragg's Law Crystallography Model

	Item	Mean	Standard Deviation
UM1	I think I would like to use this model frequently in the learning of Bragg's law.	3.64	0.521
UM2	I find the using of this model is simple to be understood.	3.58	0.515
UM3	I think this model is easy to use.	3.48	0.610
UM4	I think that I do not need the support of a technical person to be able to use this model.	3.14	0.762
UM5	I find the functions in the model is well integrated.	3.55	0.556
UM6	I think there is consistency in this model.	3.52	0.502
UM7	I imagine that most people would learn to use this model in learning very quickly.	3.59	0.533
UM8	I find this model very convenient to use.	3.55	0.538
UM9	I feel very confident in using this model.	3.50	0.541
UM10	I can get going with this model easily.	3.58	0.515
	Total	3.51	0.404

Table 5 and Table 6 above showed the mean and standard deviation of the respondents regarding the first construct and second construct respectively. In this context, usability was measured relative to certain users and certain tasks by having a number of test users to use the system to perform a task [23]. Besides, interested level was investigated in evaluating usability [24]. Thus, the evaluation of usability was divided into two parts, which were the usability in attracting students' interest regarding the learning area and the usefulness of the model.

For the first construct, the standard deviation for all items in this construct were less than one. Thus, there was a consensus among the respond given by respondent [19, 26]. Overall, the average mean and average standard deviation were 3.69 and 0.345 respectively. Therefore, the respondents strongly agreed regarding the students' interest towards the learning area by using the Bragg's law crystallography model with good concentration.

For the second construct, the standard deviation for all items in this construct were less than one. Thus, there was a consensus among the respond given by respondents [19, 26]. Overall, the average mean and average standard deviation were 3.51 and 0.404 respectively. Therefore, the respondents strongly agreed regarding the usefulness of Bragg's law crystallography model with good concentration.

Table 7. Analysis of Usability of Bragg's Law Crystallography Model by Constructs

Construct in Questionnaire	Mean Value	Standard Deviation
Total IBL	3.69	0.345
Total UM	3.51	0.404
Grand total	3.60	0.351

According to Table 7, the average mean and average standard deviation regarding the students' interest towards the learning area by using the Bragg's law crystallography model were 3.69 and 0.345 respectively. Therefore, the respondents strongly agreed regarding the students' interest towards the learning area by using the Bragg's law crystallography model with good concentration. Next, regarding the usefulness of Bragg's law crystallography model, the average mean and average standard deviation were 3.51 and 0.404 respectively.

Therefore, the respondents strongly agreed regarding the usefulness of Bragg's law crystallography model with good concentration.

Overall, the average mean and standard deviation for the usability of Bragg's law crystallography model were 3.60 and 0.351 respectively. Therefore, the respondents strongly agreed regarding the usability with good concentration of preference. The findings answered the second research question that the Bragg's law crystallography model was useful.

These findings aligned with many of the previous studies. One of the findings showed that students were interested towards the learning area by using the Bragg's law crystallography model. This was aligning with the study made by Jancaríková and Jancarík [5] that the learning environment was interesting with the using of model in teaching and learning process. Besides, the Bragg's law crystallography model was useful since the respondents strongly agreed regarding the usability of this model. This was aligning with the previous research regarding models were useful to be used in physics education [4]. Overall, the findings aligned with many of the previous researches where students were getting the positive outcome when applying models in learning [8][9].

IV. CONCLUSION

This research began with the determination of title and scope of the research for preparing proposal. The research instruments including the model and the questionnaire were verified by evaluation experts to determine the validity of the instruments. Pilot test was carried out to measure the reliability of instruments, which involved 16 undergraduate students from UPSI as respondents. The improvement for instruments was made based on the feedback of experts and also the pilot test. Then, this research was carried out in UPSI. Data was obtained by using four points Likert scale questionnaire with the participation of 101 undergraduate students from Solid State Physics course as respondents via the cluster probability sampling method. Finally, the data was analysed by using the descriptive statistics to determine the frequency, mean and standard deviation for every items of the students' interest towards the learning area by using the Bragg's law crystallography model and the usefulness of Bragg's law crystallography model.

The findings showed that majority of the respondents were female. At the same time, the number of Malay respondents was the majority in this research. Although the respondents were from different semester, respondents from Semester 5 was the majority in this research. Nevertheless, the representativeness of the sample results to the target population was ensured since all of the groups in Solid State Physics course were selected. The findings showed that the instruments were valid and reliable to be used. The using of valid and reliable instruments was important for research quality [25]. Next, the findings showed that students were interested towards the learning area by using the Bragg's law crystallography model and this model was useful. The findings answered both of the research questions of this research. First, the developed Bragg's law crystallography model was valid and reliable for undergraduate students in UPSI. Next, the Bragg's law crystallography model was useful since the respondents strongly agreed regarding the usability of this model with good concentration of preference. This aligned with the interesting learning environment was created by using model [5]. Besides, model was useful in physics education [4].

A. Research Implications

This research gives some implications for the development and usability of a Bragg's law crystallography model as a teaching aid in Solid State Physics course among undergraduate students in UPSI. The first implication is the using of Bragg's law crystallography model as a teaching aid in learning makes the learning environment more interesting. This is showed by findings that students are interested towards the learning area by using the Bragg's law crystallography model. The using of this model is crucial for the transformation of the learning to a more interactive learning.

Beside that, the using of Bragg's law crystallography model is enabling the practicing of 21st century skills by students. Students could apply wise judgment to produce a reasoned critique with the visual representing of concept in models. In this context, Bragg's diffraction is imagined as a reflection of X-rays on a surface of imaginary mirror formed by atomic plane. Thus, students understand by producing reasoned critique with the three-dimensional visual representing associated with Bragg's law. This is showed by the analysis of findings that the using of Bragg's law crystallography model in the learning lesson makes students think as well as desire to understand about Bragg's law. Moreover, findings has shown that students are interested to explore and master this learning area by using Bragg's law crystallography model.

Furthermore, the teaching and learning process is enhanced by the using of Bragg's law crystallography model. The learning of students about Bragg's law in Solid State Physics course is facilitated since students are able to have a better interaction with the content learned. The lesson could be real to the students because verbal explanation of the description is supplied by using this teaching aids. This is showed by the analysis of findings

that the Bragg's law crystallography model as course material in class is useful for them to learn. Bragg's diffraction is imagined as a reflection of X-rays on a surface of imaginary mirror formed by atomic planes. Thus, students are able to understand by producing reasoned critique with the three-dimensional visual representing associated with Bragg's law.

B. Recommendations

This research is a small research conducted in a specific area. Nevertheless, this study has the potential to be a significant part of that contribute to a larger study. This research focuses on the development and usability of a Bragg's law crystallography model as a teaching aid in Solid State Physics course among undergraduate students in UPSI. Thus, this research could be a starting point to examine related studies regarding the using of models in education which is still less focused by the educators. The teaching and learning method nowadays should be integrated with various new elements such as teaching aids for diversification purpose.

This research is only focusing on the development and usability, which includes the interest level and perception of students towards the usefulness by using the model. Thus, further studies examining the acceptance of students from various aspects such as motivation and achievement can be carried out in the future. This is important to provide additional information for ensuring effectiveness of the using of Bragg's law crystallography model as a teaching aid. In addition, different groups of respondents may be used and number of respondents may be increased. This is to collect data with higher reliability.

Furthermore, this research can provide guidance for further studies regarding the using of model in physics education. Moreover, further studies can be carried out to study the readiness of educators regarding the using of model in physics education. This is because the findings can provide information for educators to improve the implementation of teaching and learning. In conclusion, the findings illustrated the potential of Bragg's law crystallography model to be used in physics education as a teaching aid since the model was valid, reliable and useful.

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REFERENCES

[1] Erinosho, S. Y. (2013). How do students perceive the difficulty of physics in secondary school? An exp *Cross-disciplinary Subjects in Education (IJCDSE)*, *3*(3), 1510-1515.
[2] Aina, K. J. (2013). Instructional materials and improvisation in physics class: Implications for teaching and l
[3] Subhash, S. & Cudney, E. A. (2018). Gamified learning in higher education: A systematic review of the liter
[4] Besson, U. & Viennot, L. (2004). Using models at the mesoscopic scale in teaching physics: two experim *International Journal of Science Education*, *26*(9), 1083-1110.
[5] Jancaríková, K. & Jancarík, A. (2017). Teaching aids and work with models in e-learning environments. *Ele*
[6] Okuno, T. (2010). *A review of "The basics of crystallography and diffraction, by christopher hammond"*. O
[7] Salleh, M. H. & Sulaiman, S. (2010). *pembangunan multimedia berasaskan laman web bagi tajuk cahaya d* dissertation). Universiti Teknologi Malaysia, Johor, Malaysia.
[8] Budde, M., Niedderer, H., Scott, P. & Leach, J. (2002). 'Electronium': a quantum atomic teaching model. *Ph*
[9] Gilbert, J. K. (2004). Models and modelling: Routes to more authentic science education. *International J* 115-130.
[10] Samsudin, N. H., Wahid, P. R. A. & Ja'afar, S. (2018). Pengaplikasian model awal kit asas membaca pemulihan khas. *Jurnal Sains Insani*, *3*(1), 1-9.
[11] Barreiro, P. L. & Albandoz, J. P. (2001). Population and sample. Sampling techniques. *Management mather*
[12] Harackiewicz, J. M., Barron, K. E., Carter, S. M., Lehto, A. T. & Elliot, A. J. (1997). Predictors and classroom: Maintaining interest and making the grade. *Journal of Personality and Social psychology*, *73*(6),
[13] Harackiewicz, J. M., Barron, K. E., Tauer, J. M., Carter, S. M. & Elliot, A. J. (2000). Short-term and long- interest and performance over time. *Journal of educational psychology*, *92*(2), 316.
[14] Cēdere, D., Jurgena, I., Helmane, I., Tiltiņa-Kapele, I. & Praulīte, G. (2015). Cognitive interest: proble mathematics in schools of Latvia. *Journal of Baltic Science Education*, *14*(4), 424.
[15] Bangor, A., Kortum, P. & Miller, J. (2009). Determining what individual SUS scores mean: Adding an adj 114-123.

[16] Hardesty, D. M. & Bearden, W. O. (2004). The use of expert judges in scale development: Implications for constructs. *Journal of Business Research*, *57*(2), 98-107.
[17] De Oliveira-Filho, A. D., Morisky, D. E., Neves, S. J. F., Costa, F. A. & De Lyra Junior, D. P. (2014 Validation of a Brazilian–Portuguese version in hypertensive adults. *Research in Social and Administrative*
[18] Pimentel, J. L. (2010). A note on the usage of likert scaling for research data analysis. *USM R&D Journal*, *1*
[19] Wang, Y., Zhang, L., Zhang, C. & Jeeva, A. S. (2015). Drivers and obstacles of the remanufacturing i *Journal of Industrial Engineering*, *22*(1).
[20] Meyers, H. P. & Myers, H. P. (1997). *Introductory solid state physics*. Boca Raton, Florida: CRC press.
[21] Ertmer, P. A. & Newby, T. J. (1993). Behaviorism, cognitivism, constructivism: Comparing critical *Performance improvement quarterly*, *6*(4), 50-72.
[22] Berg-Beckhoff, G., Kutschmann, M. & Bardehle, D. (2008). Methodological considerations concerning the survey, validity and reliability. *Clinical Oral Investigations*, *12*(1), 51-58.
[23] Nielsen, J. (1993). *Usability engineering*. Burlington, Massachusetts: Morgan Kaufmann.
[24] Hilbert, D. M. & Redmiles, D. F. (2000). Extracting usability information from user interface events. *ACM*
[25] Kimberlin, C. L. & Winterstein, A. G. (2008). Validity and reliability of measurement instruments u *pharmacy*, *65*(23), 2276-2284.
[26] Moh'd Abu Bakir, S. (2019). Human resources development strategy and its role in promoting employees s information technology companies. *European Scientific Journal, ESJ*, *15*(4), 238-262.