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GRAVI-STEM MODULE'S VALIDITY AND RELIABILITY

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Abstract

The purpose of this study was to determine the validity and reliability of the Gravi-STEM Module, which was developed by employing Sidek's Module Development Model. Three experts in the fields of teaching and learning (T&L) and STEM education evaluated the content validity of the module. A pilot study was carried out on 30 students in a secondary school where the students participated in all of the Gravi-STEM Module's specified activities to examine the reliability of the Gravi-STEM Module. Then, the students' feedback was evaluated by filling out a module's reliability questionnaire. From the viewpoint of experts' consensus, the module had good content validity and excellent reliability, with content validity coefficients of 0.88 and module reliability coefficients of 0.95, respectively. All of the experts' suggestions and comments were taken into account, and modifications were made so that it could be used as an effective STEM teaching module. This module is intended to be an addition to the present STEM integration module and to effectively contribute to teachers and students conducting T&L using a STEM approach. Moreover, this study intends to provide an insight into the application of STEM T&L based on an Inquiry-Based Learning (IBL) strategy that can assist the students in rectifying alternative concepts, improving Higher Order Thinking Skills (HOTS), and stimulating their interest specifically in the gravitation topic in the Standard Based Curriculum for Secondary Schools (KSSM) Physics subject.

***Keywords**: STEM; module; physics; gravity; reliability*

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INTRODUCTION

The poor level of performance in Science and Mathematics, as well as the declining enrolment of students in STEM majors in Malaysia, is a sign of students' lack of grasp of basic concepts in Science topics, particularly in Physics (Halim & Meerah, 2016; MOE, 2016; MOE, 2020) in which large numbers of secondary school students perceive physics to be a boring and tough subject (Farrell & Ventura,1998). Additionally, students' perceptions that fully comprehending a concept in physics demands the ability to solve mathematical problems has resulted in a loss of interest in the subject. This viewpoint is supported by Khalijah et al. (1995) supporting that physics disciplines are often described as tough since they are related to complex mathematical ideas among excellent, medium, and weak students (Chiu, 2016). Particularly in gravitation, the prerequisites that students must be able to explain the gravitation concept with the involvement of an "invisible" force adding the severity for students to grasp the concept of gravitation (Kavanagh & Sneider, 2007; Halloun & Hestenes,1985). Furthermore, issues such as physics teachers' lack of integration of computer interactive simulations (Fuller, 2006), ignoring the fact that most of them were already available on internet platforms (Andaloro et. al., 1997), as well as the lack of quality of teaching and learning (T&L) strategy (Mohd Shahali et al., 2019), are among the factors preventing students from becoming interested in gravitation topic.

Surprisingly, there are secondary school students and pre-university students who can tackle questions that need calculations yet have alternate ideas about gravitation (Kavanagh & Sneider, 2007). It is found that Malaysian students believe gravity only exists on Earth, and they also believe that gravity and the atmosphere are correlated, and that anything will not have weight on the Moon given the lack of atmosphere (Pablico, 2010). In addition, there is a lot of conceptual confusion among Malaysian students, especially when it comes to gravitational forces (Ismail & Ayop, 2016). Among the misconceptions identified include heavier objects fall faster than light objects and the assumption that gravitational pull that only acts on heavy objects. As such, educators, particularly physics teachers, should have a special tool that needs to be incorporated into their T&L strategy to rectify alternative concepts or ideas that are presented as prior knowledge for the topic of gravitation. Learning dynamic concepts such as bodily movement under the influence of gravitational forces theoretically through static 2D visual screening is no longer effective (Wahid, 2019). This is because students have a hard time grasping the concept of gravitational forces, which are abstract in nature and appear to contradict natural facts in everyday life. Thus, it is understandable if some physics students wonder, "Why, if gravitational force exists between two bodies, yet things on the Earth's surface aren't attracted to one another?" (Baldy, 2007. p.1770).

Thus, other than utilising the PDEODE*E-Based Conceptual Change Model (Zhou et al., 2015), applying the constructivist approach (Kavanagh & Sneider, 2007), implementing the philosophy of 'teach less-learn more' in formulating and implementing teaching processes (Beh, 2011), applying multimedia through computer simulations to illustrate the interaction between bodies when gravitational forces exist (Mufit, 2018), applying STEM-based Physics learning (Surya & Wahyudi, 2018; Boyle, 2019), several scholars have come to agree that implementing hands-on activities through IBL approach is one of the best T&L strategy specifically on the topic of gravitation (Karpudewan et al., 2017; Alghamdi & El-Hassan, 2020; Self et al., 2013, Moore & Dawson, 2015; Baldy, 2007). IBL, as defined by Pedaste and Sarapuu (2006), is an approach in which students use their research capabilities to solve problems in building knowledge yet utilising the same procedures and practices as expert scientists (Keselman, 2003). Through IBL approach, students formulate hypotheses, test them, and conduct experiments and observations while conducting the inquiry process (Pedaste et al., 2012) where ultimately students can correlate their past knowledge to scientific definitions of ideas since the IBL approach provides a learning climate that fosters students to ask questions, do research, establish hypotheses, and collect data (Panasan & Nuangchalerm, 2010) thus reconstructing the theoretical knowledge into practical implications (Colburn, 2000). The IBL approach have been proven to not only facilitate students in grasping the concept of gravitation, but also rectify the alternative concepts of gravitation (Alghamdi & El-Hassan, 2020; Self et al., 2013, Moore & Dawson, 2015). This approach is also in line with Malaysia Education Blueprint (PPPM) 2013–2025, an initiative to strengthen the foundation of learning by enhancing students' success and interest through innovative learning approaches and strengthening the curriculum (MOE, 2013) in achieving meaningful learning objectives for students. However, in Malaysia, most teachers face time constraints when preparing teaching strategies and selecting the best learning materials, particularly for topics involving abstract concepts such as gravitation, which leads to stereotypical teaching techniques being used every time a class is held (Abd Rahman et al., 2018; Seman et al., 2017). As a result, teachers' final recourse is to simply incorporate exercises and questions from the school textbook as well as solely adopting textbook-based learning.

Nonetheless, by using school textbook-based instruction primarily for teaching gravitation topic has some disadvantages. This is because, according to the KSSM Physics Form 4 school textbook, students should first be introduced to the pivotal concept of gravitational force between two distant bodies, which is the Newton Universal Law of Gravitation. There is, however, little if any constructivist activity suggested in the textbook that could help students effectively grasp this concept through hands-on activities for the Newton Universe's Gravitational Law subtopics (Chia et al., 2019). This not only fails to change the students' alternative conceptions, but possibly could cause a misunderstanding of the concept of gravitation (Demirci, 2005; Moore & Dawson, 2015). Furthermore, when the fundamental concept of gravitation is not acquired, the implicit consequence is that they will have difficulties in solving problems requiring high order thinking skills (HOTs) such as applying, analysing, evaluating, and constructing.

Based on IEA report by Neidorf et al. (2020), it has exposed the level of students' ability in solving problems related to HOTS questions, especially in the gravitation topic, where the Trends in International Mathematics and Science Study (TIMSS) data shows Malaysia is among the countries where at least one-third of its students have not been able to solve problems, including HOTS questions, due to misunderstanding of the concept. This report supports the results of AKEPT (2011), which were reported in PPPM 2013-2025 (MOE, 2012), that the learning strategy incorporating HOTS in Malaysia has not yet reached satisfactory levels. To make matters worse, most teachers do not know how to integrate HOTS and do not have enough time to integrate HOTS into their pedagogy, which is among the problems regarding the implementation of HOTS in teaching and learning as reported by Kamarudin et al. (2016), Lee et al. (2017), Baharin et al. (2018), and Maruthai (2017). This clearly demonstrates that teachers lack the ability to blend hands-on and mind-on activities into their pedagogy, and most students could miss the opportunity to enhance their innovation, creativity, and HOTS. On the other hand, it is predicted once students acquire poor concepts of gravitation while facing problems in solving HOTS questions, they will eventually get bored and lose interest in the subject, resulting in a loss of motivation to continue studying the entire topic. The term "interest," according to Regan and DeWitt (2015), reflects the quality of the requirement to provide selective needs to key aspects such as activity, purpose, and subject. Student interest is one of the issues that scholars have long addressed in physics, notably in gravitation topic. The concept of "unseen force," which relates to gravitational force, is one of the concerns that contributed to students' lack of interest in this subtopic. According to Kavanagh and Sneider (2006), establishing this force was a difficult undertaking because some students still believed that free fall movement of any object was due to a "natural phenomenon" that did not include any force (Halloun & Hestenes, 1985).

In this study, the researcher took the initiative to develop and study the effectiveness of the Gravi-STEM Module on alternative concepts, HOTS, and the interests of Form Four students in gravitation topic by incorporating the Inquiry-based Learning (IBL) approach and STEM T&L strategy. Utilising the second stage of the module development in the Sidek Module Development Model, this study was conducted to obtain aspects of content validity and reliability of the Gravi-STEM module.

METHODOLOGY

The Module's Evaluation in the Second Stage of the Sidek Module Development Model

The Gravi-STEM Module is adapted from the Sidek Module Development Model and the module is intended for use in the field of education. The evaluation procedure involved determining the validity and reliability of the module must follow the procedure in the second stage of the model (Mohd & Ahmad, 2005; Nawi et. al., 2015) after going through the first stage which consists of nine steps aimed in preparing the draft module by the module developer. The steps involve in the first stage beginning with planning the goals, theory, rational, philosophy as well as concept of the module. Followed by outlining the targeted user, time period, devising the needs study and objectives, contents, strategies, logistics, media selection and lastly combining the module into a "draft module". Figure 1 shows the procedure for evaluation of the effectiveness of Gravi-STEM Module in the Second Stage of Sidek Module Development Model.

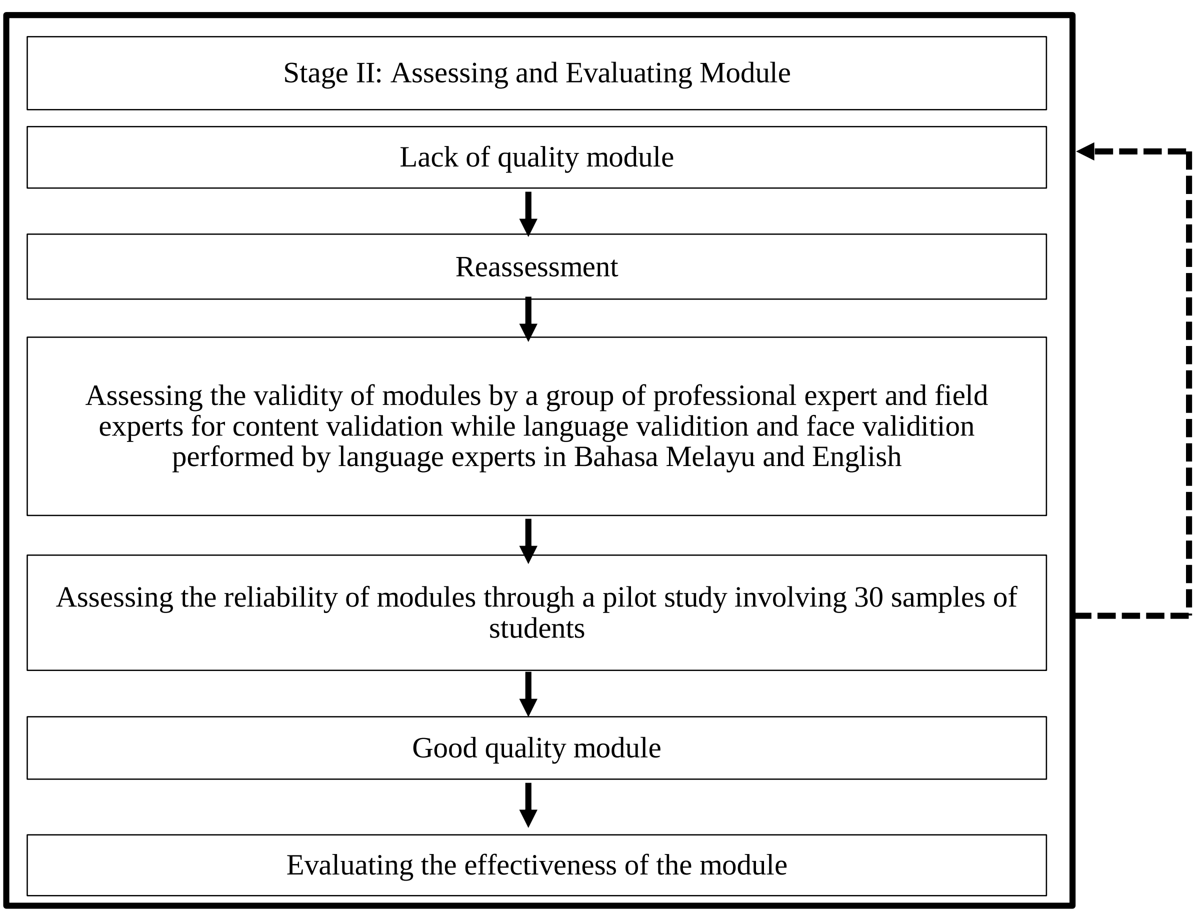

Figure 1: Procedure for Evaluation of Gravi-STEM Module's Effectiveness Employing the Second Stage of Sidek Module Development Model

Validity and Reliability of Module

Ahmad and Mohd (2005) describe the second stage of the Sidek Module Development Model as a vital stage that is often overlooked by module developers, as shown in Figure 1. The validity of the modules is defined in this model by Ahmad and Mohd (2005) as, "How well the module produces what it should produce?" (Ahmad & Mohd, 2005). Whereas, in terms of module reliability, it is defined as, "A consistent module is one that can produce consistent outcomes" (Ahmad & Mohd, 2005).

Because of the similarity between measurement tools and modules, modules are referred to as a tool for measuring in the Sidek Module Development Model. Both can be used by module developers as tools, sources, and reference resources for obtaining crucial information and data for field studies (Ahmad & Mohd, 2005). Hence, the next section examines aspects of determining the validity of Gravi-STEM module's validity from the expert's consensus among content language experts while the aspect of Gravi-STEM module's reliability was examined through the pilot study.

Determining Validity and Reliability of Gravi-STEM Module

In terms of module validity, Ahmad and Mohd (2005) strongly suggest that module developers adopt Russell's (1974) view, which states that a module is considered valid if it meets the five requirements specified below:

i. It is necessary to achieve population requirements.
ii. The T&L scenario, as well as the module's implementation aspect, must be met.
iii. Enough time for the targeted group of the modules, whether teachers or students, to implement the modules.
iv. The improvement of students' performance can be attained.
v. The impact of employing modules can make a significant difference in students' attitudes.

To ensure that the contents of a module have the intended impact, Ahmad and Mohd (2005) suggest that the method proposed by Mohd Majid Konting (1998) can be utilised by acquiring feedbacks before modules are used by targeted groups. For the expert-rated modules using the Likert-scale questionnaire tool, Ahmad and Mohd (2005) adopt the views of Tuckman and Waheed (1981) and Nordin (1995) that 70% indicates the minimum score utilising the Percentage Calculation Method (PCM) in order to ensure the validity of a module.

Furthermore, to obtain expert validity of Gravi-STEM module content, the Content Validity Questionnaire was adapted from Jamaludin Ahmad (2002) and Nor Tutiani Ab. Wahid (2019). A total of three panels of experts were involved in assessing the suitability of content and activities based on the objectives set by the modules. Lectures in science and physics education, STEM fields, and physics teachers are among the appointed content validity expert panels. For the validity of the Gravi-STEM Module in terms of language content, the Language Content Validity Questionnaire was adapted from Jamaludin Ahmad (2002) and Nor Tutiani Ab. Wahid (2019), covering aspects of the suitability of size and type of writing, grammar and spelling, layout and presentation of the module, and the structural aspects of the language. A total of three expert panellists were involved in the validation of language content, consisting of Bahasa Melayu teacher, a SISC+ officer of Bahasa Melayu, and an instrument panellist (Bahasa Melayu and English) at the Malaysian Examinations Syndicate (LPM).

Jamaludin Ahmad and Sidek Mohd Noah (2005) also have highlighted a model in determining the reliability of modules through modifications to the Vale's Engineering Reliability Model (Vale, 1998), which consist of parallel models and series models for a rocket engine. The similarities between a rocket engine and modules are described as follows:

When scientific thinking processes related to this engineering model involve induction and deductible processes, it is clear that this model can also be applied in the field of social sciences, especially in relation to the study of modules. If the modules in engineering have submodules, components, and procedures, those in the field of social sciences have submodules, activities, and procedures. (Jamaludin Ahmad and Sidek Mohd Noah, 2005. p. 52)

In this model, Jamaludin Ahmad and Sidek Mohd Noah (2005) interpret the reliability of modules as module capabilities in helping students achieve various objectives that have been set because a good module is referred to as a module that is capable of achieving its objectives and students are able to successfully follow all the steps in the module activities based on the objectives of the modules. Therefore, two methods recommended to determine the reliability of the modules are by developing questionnaires based on module objectives or based on the module steps and activities. In order to obtain the module's reliability coefficient, Jamaludin Ahmad and Sidek Mohd Noah (2005) recommended the Alpha Cronbach method (Cronbach, 1990) utilising the IBM SPSS software as recommended by Norusis (1993). Data from a pilot study of 30 Form Four students were analysed using IBM SPSS software version 25.0 to determine the Alpha Cronbach values.

RESULTS AND DISCUSSION

Content Validity of Gravi-STEM Module and Experts' Comments

Table 1 shows the validity of the contents of the Gravi-STEM Module using the PCM method in this study. From Table 1, it shows that the Gravi-STEM module achieved a content validity percentage of 88.05% with a content validity coefficient of 0.88. With both values exceeding 70% and above 0.70, the researchers conclude that the Gravi-STEM Module had reached a good level of content validity. Two experts have left positive comments where expert 1 noted that the module can add to the resource of IBL T&L materials that can be benefited by physics teachers while expert 2 congratulated the author by noting that module has been systematically and thoroughly developed.

Table 1: Determination of Gravi-STEM Module's Content Validity

Dimensions/ Items	Expert 1	Expert 2	Expert 3
Face Validity			
1	10	9	10
2	9	9	9
3	9	9	9
Content Validity			
1	9	10	10
2	9	10	9
3	8	8	9
4	9	10	9
5	9	8	9
6	9	7	6
7	9	8	6
8	10	8	6
9	10	10	9
Total	110	106	101
Percentage of Content Validity Achievement (100%)			88.05
Content Validity Coefficient (1.00)			0.88

However, all experts did suggest several improvements to refine the contents of the Gravi-STEM Module. The comments on improvement by each panel of expert are shown in Table 2.

Table 2: Experts' Comments on Improvement of Gravi-STEM Module's Content

Experts	Comments
1	• The contents are suitable according to the KSSM physics form 4 on condition that the author makes a slight improvement.
2	• Most of the procedures are provided by the teacher or the author of the module. If a procedure is given, then this module should be categorised as "structured inquiry."
3	• Each activity has utilised the 5E phase and should be diversified for each subtopic. • Some procedures in the module must be revised in order to utilise the Guided Inquiry attributes. • Although the Gravi-STEM module is suitable for use, the author should refine it first.

Thus, based on the expert comments, several modifications have been made by the researcher to improve the category of inquiry featured in the module, the use of materials such as replacing papers with rubber corks, the number of planet rotations proposed to be 10 times or more rather than 5 times as referred to 3.2b of the Kepler III Law activities as well as the addition of teachers' instructions for the use of Exit Card

Language Validity of Gravi-STEM Module and Experts' Comments

The Gravi-STEM Module was constructed in a bilingual format to meet the needs of both teachers and students. Consequently, the Gravi-STEM Module underwent a language validation process including grammar and tenses as well as physics terminologies. The determination of the validity of the language content of Gravi-STEM Module employing the PCM method is shown in Table 3.

Table 3: Determination of Gravi-STEM Module's Language Validity

Dimensions/ Items	Expert 1	Expert 2	Expert 3
Face Validity			
1	10	10	10
2	8	9	10
3	9	10	10
Content Validity			
1	9	10	10
2	8	9	10
3	9	10	10
4	9	10	10
5	9	10	10
6	10	10	10
7	10	10	10
8	9	10	10
9	8	9	10
Total	91	98	100
Percentage of Language Validity Achievement (100%)			96.33
Content Validity Coefficient (1.00)			0.96

From Table 3, it shows that in terms of language validity, the Gravi-STEM Module achieved a 96.33% Language Validity Achievement with a Content Validity Coefficient of 0.96, both of which have exceeded 70% and 0.70. Overall, these findings indicate that the Gravi-STEM Module had excellent content validity in terms of language usage. However, a few minor spelling errors and the use of inappropriate terminologies as well as sentence structures were highlighted through the comments of the expert panels. Table 4 show the summary of comments and suggestions for language improvement in the Gravi-STEM Module. Based on the comments of language experts, researcher have refined the module on minor errors in terms of spelling and punctuation as suggested.

Table 4: Experts' Comments on Language Aspect of Gravi-STEM Module

Experts	Comments
1	• This document uses an interesting layout, easy to understand and simple yet appropriate language. • However, there are some minor errors that may affect the message's contents.
2	• Very minimal language errors. • Interesting and neat module presentation.
3	• The use of language is appropriate. • Suitable and easy-to-understand choice of words in explaining the module's activities. Well done!

Reliability of Gravi-STEM Module

Table 5 shows the reliability coefficient value of the Gravi-STEM Module and the degree of reliability for the module.

Table 5: Gravi-STEM Module's Reliability Coefficient Value and Degree of Reliability

Module	Reliability Coefficient Value	Degree of Reliability
Gravi-STEM	0.95	Excellent

Based on the Alpha Cronbach method (Cronbach, 1990), the result in Table 5 shows that the Gravi-STEM Module has a Reliability Coefficient Value of 0.95, indicating that Gravi-STEM has an excellent degree of reliability. This result also suggests that Gravi-STEM capable of achieving its objectives, in condition that the students successfully complete all steps in the module's activities following the objectives. Thus, Gravi-STEM Module is a ready-to-use module and the effectiveness of the module can be evaluated in the next phase.

CONCLUSION

In general, the Gravi-STEM Module has good content validity and excellent reliability. Based on the experts' consensus and pilot study, the Gravi-STEM Module was successfully developed through rigorous phases utilising the Sidek Module Development Model in which both the IBL and STEM strategy were well incorporated. Equipped with subsections such as IBL guideline, teachers' daily lesson plan (RPH), illustrations of STEM-based models' construction, worksheet and formative assessment, teachers could utilise this module in implementing Classroom Assessment (PBD) to evaluate the students' Performance Level (TP) in Content Standard (BP) 3.0 Gravitation as enclosed in the Curriculum and Assessment Standard Document (DSKP) KSSM Physics Form 4 and could facilitate especially inexperienced physics teachers on implementing T&L with IBL and STEM integration. Moreover, the module not only can be utilised as a resourceful module, adding to the existing STEM integration module in guiding teachers as well as students to carry out T&L environment through IBL and STEM implementation, but the included guideline of model construction and hands-on activities can be employed by students to carry out-of-class activity through STEM Club's exhibitions in inculcating interest among the students from different backgrounds towards the topic of gravitation and STEM education at the school level. For further research, the Gravi-STEM Module will be evaluated through experimental methods, employing pre and post tests for treatment and control groups to determine its effectiveness on alternative concepts, HOTS, and students' interest in gravitation topic.

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