The acceptability of concrete mathematics manipulative by children

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Abstract. Concrete Mathematics manipulative (APM) are developed to assist children in learning Mathematical concepts and facilitate children's Mathematics activities to support children's higher-order thinking skill (HOTS) development. As a stage in development research, one of the study’s objectives was to find out concrete APM product’s acceptability by children. Acceptability was measured by the TAM approach. The research subjects were Primary School-Junior High School children who were allowed to use these products in schools, learning groups, and playgroups, totaling 170 children. The variables studied were perceived ease to use, perceived usefulness, attitude toward using, and behavioral intention. The statistical analysis applied was Covarian Based Structural Equation Modelling (CB-SEM) with a hybrid model (a CFA and model structural) and used Maximum Likelihood estimation. The CFA first-order model's estimation and evaluation results showed that the research model had fulfilled good fit criteria, and a reliable variable is PEU. Meanwhile, Estimation and Structural Model Evaluation showed that the most significant influence was on PU and PEU’s relationship towards ATU. The conclusion was that the usefulness and ease of use perceived by children affected the attitudes, which further mediated using, which was quite high (87%).

1. Introduction

School mathematics presentation in the primary education level (Primary school – Junior High School) involves concrete, static visual, and virtual (electronic-dynamic) representations. Concrete representations can be modeled with concrete manipulative [1]. The use of concrete manipulative helps children understand concepts [2], problem-solving skills [3], as well as positive attitudes towards mathematics [4], and also creating an enjoyable learning environment [5]. With concrete manipulatives designed for children's activities that can facilitate children's exploration, children must be motivated to explore [6] and give-feedback on their activities [7]. Followed by a series of questions using concrete manipulatives, connections, and contradictions by the teacher to help students mastering concept understanding [8]. Even concrete manipulatives assist students' thinking processes to settle problem solving [9]. The use of manipulatives is widely accepted as an effective way of learning mathematics, even though the teacher has tried to make a connection between manipulatives and concepts within students appropriately [10]. This concrete manipulative was developed to overcome the problems faced by teachers and children in implementing mathematics learning.
according to the applicable curriculum demands (Curriculum 2013). There are 2 classifications of concrete manipulative, namely, to build concepts and to practice thinking skills. Concrete manipulative is development research products that will be mass-marketed. Previous research has conducted measurements to determine teachers’ predictive factors in adopting or using concrete manipulative products. The results showed that the contribution of mathematics teachers’ predictive factors towards the perceived product the ease of use was 74%, perceived benefits were 72%, intention to use (behaviour) was 58%, attitudes were at 52%, and consequence factors (actual use) were at 42% [11]. Although the teacher was one of the determinants for the product to be used by children, it was important to conduct research to determine product acceptability by children. This study aims to describe the effect of the indicators shaping children's acceptability variables on concrete manipulative.

2. Research Methods

2.1 Research Design

This study was part of development research carried out with a Research & Development design [12]. The acceptability analysis of concrete manipulative uses the TAM approach, with the variables of perceived usefulness (PU), perceived ease of use (PEU), attitude toward using (ATU), and behavioral intention to use (BIU). This TAM approach refers to several studies with similar objectives, such as LINE instant messaging users in Indonesia [13] and the technology acceptance model for understanding travelers' adoption of variable message signs [14]. TAM is a model that is widely used in the study of technology acceptance. This model has been adopted and developed in many studies in various types of technology and its validity is proven high [15]. Perceived usefulness is someone's belief that the use of technology will increase productivity. Perceived ease of use is the extent to which people believe that they will be free from difficulties using technology. Attitudes mediate behavior to use technology. Behavioral intention to use is a behavioral interest to do something [16]. This research uses Covarian Based Structural Equation Modeling (CB-SEM) analysis with a hybrid model (a model consisting of CFA and structural models) [17]. Data analysis was used with the assistance of the LISREL 8.80 program. Data analysis steps are presented in Figure 1 [18].

![Figure 1. Data Analysis Stages](image)

2.2 Participants

Respondents in this study were 170 children of primary education age (Primary school- junior high school) with Primary School (72%), Junior High School (26.5%), and others (1.2%). Another category is Junior High School aged children who were not in formal schools. The manipulative teaching that has been developed can be used by children anywhere and anytime, not limited to class.

2.3 Data Collection Procedure

Data obtained was using a questionnaire. The filling out of the questionnaire was carried out after the intervention of the children’s use of concrete manipulative. In accordance with the types of concrete
manipulative for planting concepts and skills (puzzles), intervention in the use of concrete manipulative was carried out in the classroom (V grade primary school, grade VII and eighth grade junior high school), high grade primary school study groups (4,5,6), and children with formal and non formal education forums.

3. Result and Discussion
3.1 Model Specifications
The model specification stage described the relationship between latent variables and manifest variables based on the prevailing theory. In this study, the model analyzed was the Hybrid Model that was presented in Table 1.

| Variables Type | Variables                  | Indicators         |
|----------------|---------------------------|--------------------|
| Exogenous      | perceived usefulness (PU) | X1, X2, X3, X4, dan X5 |
|                | perceived ease to use (PEU) | Y1 dan Y2          |
| Endogenous     | attitude toward using (ATU) | Y3, Y4, Y5, Y6, dan Y7 |
|                | behavioral intention to use (BIU) | Y8, Y9, dan Y10 |

3.2 Identification Model
To identify the model, information was needed about data amount and the number of parameters estimated. The amount of known data can be calculated with an equation

\[
\frac{n(n + 1)}{2}, \text{with } n = \text{the number of indicators}
\]

Based on the data analysis, it was found that the model in this study was over identified. The total amount of data was \((15 \times (15 + 1)) / 2 = 120\) while the estimated number of parameters was 39. The number of estimated parameters can be calculated by identifying the number of coefficients \(\Lambda_x, \Lambda_y, B, \Gamma\) and 4 covariance matrices \(\theta_e, \Phi, \psi\) [19].

From these results, it could be obtained that the resulting degree of freedom was 120 - 39 = 81. Because the degree of freedom value was 81> 0, so the model could be estimated (over identified).

3.3 Model Estimation and Evaluation
The estimation results of the hybrid model were shown in Figure 2 and further evaluated for the suitability of the full model, CFA, and structural equations.

**Figure 2. Hybrid Model Estimation Results**

Based on GOF (Goodness of Fit) results, of 18 GOF measures, 7 sizes indicated good fit criteria, 6 sizes indicated marginal fit criteria, and 5 sizes indicated less fit criteria, so it could be concluded that
the research model regarding perceptions of the use of teaching manipulative is applied to the samples of Primary School, Junior High School, and others had achieved good criteria. After it was concluded that the model had a good level of fit, the next step was to test the suitability of the measurement model / CFA (a model that describes the measurement of indicators against their latent variables).

**Measurement model fit test (CFA)**

The results of the estimation and evaluation of the first order CFA model (the measurement model between the indicators and their respective variables) were shown in following Table 2 below.

| Variable                      | Indicators | Error Var | Std. Loading | CR    | VE       | Validity | Reliability |
|-------------------------------|------------|-----------|--------------|-------|----------|----------|-------------|
| perceived usefulness (PU)     | X1 0.73    | 0.52      |              |       |          | Valid    |             |
|                               | X2 0.63    | 0.61      |              |       |          | Valid    |             |
|                               | X3 0.7     | 0.55      | 0.67         | 0.335475 | Valid    | unreliable |             |
|                               | X4 0.86    | 0.37      |              |       |          | Invalid  |             |
|                               | X5 0.61    | 0.63      |              |       |          | Valid    |             |
| perceived ease to use (PEU)   | Y1 0.63    | 0.61      |              |       |          | Valid    |             |
|                               | Y2 0.23    | 0.88      | 0.720788     | 0.57325 | Valid    | reliable  |             |
| attitude toward using (ATU)    | Y3 0.91    | 0.31      |              |       |          | Invalid  |             |
|                               | Y4 0.8     | 0.44      |              |       |          | Invalid  |             |
| behavioral intention to use (BIU) | Y5 0.56 | 0.66      | 0.61         | 0.29315 | Valid    | unreliable |             |
|                               | Y6 0.64    | 0.60      |              |       |          | Valid    |             |
|                               | Y7 0.72    | 0.53      |              |       |          | Valid    |             |
|                               | Y8 0.63    | 0.61      |              |       |          | Valid    |             |
|                               | Y9 0.63    | 0.61      | 0.541551     | 0.37  | Valid    | unreliable |             |
|                               | Y10 0.78   | 0.47      |              |       |          | Invalid  |             |

Table 2 shows the validity and reliability of the research model construct. There were 4 invalid indicators (small loading factor values and large enough error values), namely X4, Y3, Y4, and Y10 so that the related latent variables were unreliable. Invalid indicators were possible due to the respondents' condition who were mostly in the age range 10-13 years, so respondents might not understand and answer incorrectly. Invalid and unreliable indicators are a concern to accelerate product adoption.

**Structural model fit test.**

The structural model fit test included examining the significance of the estimated coefficients, namely the t-value, the structural equation coefficient and the overall coefficient of determination (R^2). The estimation results of the structural model provided the structural equations presented in Table 3.

| No. | Path            | Estimate | t-Value | R     | R^2    | Result          |
|-----|-----------------|----------|---------|-------|--------|-----------------|
| 1   | PU -> PEU       | 0.13     | 1.21    | 0.13  | 1.69%  | Not Significant |
| 2   | PEU -> ATU      | 0.28     | 2.5     | 0.4   | 16%    | Significant     |
| 3   | PU -> ATU       | 0.85     | 3.54    | 0.89  | 79.21% | Significant     |
| 4   | PEU -> BIU      | 0.086    | 0.77    | 0.31  | 9.61%  | Not Significant |
| 5   | ATU -> BIU      | 0.57     | 2.84    | 0.61  | 37.21% | Significant     |

The calculation results showed that in the structural equation evaluation the relationship that was formed between PU with ATU, PEU with ATU, and ATU with BIU was a positive and significant relationship, meaning that PU had a positive and significant effect on ATU, PEU had a positive and
significant effect on ATU and ATU had a positive and significant effect on BIU. Meanwhile, the relationship between PU and PEU and PEU and BIU was positive but insignificant relationship. This meant that PU had a positive effect on PEU but the value was less significant, as well as PEU on BIU.

The magnitude of the structural equation model influence was explained by R2 value. In the structural equation simultaneously, PEU and PU to ATU were 87%, and in the equation PEU and ATU to BIU were 38%. While the greatest individual influence was found in the relationship between PU and ATU, 79.21%, followed by the influence of ATU on BIU was 37.21%. It was said that attitude was a behavior mediator for using technology [20]. This analysis's results were in accordance with the results of previous studies which stated that an individual's main beliefs about technology (perceived benefits and perceived ease of use) determined attitudes towards using a given technology [13]. There were 2 core beliefs in TAM analysis, namely usability and ease of use which influence behavior to adopt as a direct or indirect effect [15].

4. Conclusion
Based on the results and discussion, it could be concluded that concrete manipulative as a product of development research were accepted in the behavior to use them. Taken together, the perceived usefulness and ease of use of children affected attitudes which further mediated the use behavior was quite high (87%). Individually, the perceived usefulness had a greater effect (79.21%) on the attitude to use the product than the ease of using it (16%).

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