Improving Student Learning Outcomes through Mobile Assessment: A Trend Analysis

Herwin Herwin, Anwar Senen, Riana Nurhayati, and Shakila Che Dahalan

***Abstract*—The integration of technology in learning is one of the popular issues today which is an alternative to solve the problems experienced in the difficulty of achieving maximum learning goals for students. This study aims to examine the effectiveness of the application of mobile assessment in learning activities in elementary schools. This research is a quantitative study using descriptive type. The respondents of this study were elementary school students who were at the fifth-grade level. Data were collected through learning outcomes tests using mobile assessment technology. The data analysis technique used is trend analysis. Research findings indicate that there is a positive trend in student learning outcomes when using mobile assessments in learning activities. Based on the model fit, the findings show that the Quadratic Trend Model is the best model with the smallest measurement error.**

***Index Terms*—Learning outcomes, mobile assessment, trend analysis.**

I. Introduction

The development of science and technology has an impact on various aspects of human life. One aspect that must adjust to these developments is the education aspect. The learning process at this time must be done with the integration of technology to keep up with the times [1]. Digital technology innovation is an effort made to improve the quality of learning in the classroom [2], [3]. Technology is very much needed in learning activities and its presence is very useful for the success of learning activities [4]–[6].

Learning activities and technology integration are two things that are currently interrelated and will not be separated. Since post-pandemic learning has been accustomed to being integrated with technology [7]–[10]. Currently, the modification of online learning has become a familiar thing both by teachers and by students [11], [12]. Therefore, making various modifications to the use of technology in learning activities is no longer a difficult thing for both teachers and students.

One of the efforts to integrate technology in learning is the use of mobile facilities. Through mobile assistance, teachers make it possible to take advantage of various application media sources that allow students to learn more easily and achieve the expected learning goals [13]. Mobile learning is one of the new innovations in learning. As a new technology, the presence of mobile learning provides opportunities for students to learn more effectively and have a more varied learning experience [14].

One part of mobile learning is mobile assessment. Because learning activities are integrated with mobile technology, the assessment should also be integrated with mobile technology. The results of previous research found that mobile assessment can have a significant effect on students' motivation when participating in online learning activities [15]. This shows that there is a great benefit to the use of mobile assessments for the success of learning activities.

Since the pandemic, distance learning is another way of presenting learning that is different from usual in the field [16]. This forces teachers to integrate technology dominantly in learning activities. Since then, teachers have started to use mobile technology in teaching their students. This is the urgency of this study. The need for a more in-depth analysis of how this mobile technology can be maximized in learning activities.

This study focuses on the use of mobile assessment to improve student learning outcomes in elementary schools. Learning assessment is arranged in a mobile application model to be given to students in the hope of improving their learning outcomes. Although this is not the first study to examine mobile assessment in learning, the novelty of this study focuses on a more in-depth analysis of trends (through repeated measurement) of student achievement with the help of mobile assessment. This is different from previous studies that looked at the effectiveness of mobile assessments only once measured and once observed.

Therefore, this study was conducted with the aim of analyzing the trend of improving student learning outcomes when implementing mobile assessments in learning activities. This study is expected to be a model for measuring and predicting student learning outcomes by implementing mobile assessments in future learning.

II. Literature Review

A. Mobile Learning

Mobile learning is a learning strategy with the help of mobile technology to support distance learning systems and reduce educational boundaries [17]. Mobile learning is a new paradigm of education that can be adopted in the implementation of education in elementary schools [18]. This is different from traditional e-learning even mobile technology is much cheaper than personal computers. In addition, mobile learning also allows students to learn in different places [19], [20].

Specifically, this study focuses on the application of mobile assessment in learning. Mobile assessment is an

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Herwin Herwin, Anwar Senen, and Riana Nurhayati are with the Faculty of Education, Universitas Negeri Yogyakarta, Indonesia (e-mail: herwin89@uny.ac.id, senen@uny.ac.id, riana_nurhayati@uny.ac.id).

Shakila Che Dahalan is with the Faculty of Human Science, Universiti Pendidikan Sultan Idris, Malaysia (e-mail: shakilacd@fsk.upsi.edu.my).

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assessment technique that utilizes mobile technology in measuring students' abilities in mobile learning [15]. Mobile assessment exists to overcome the weaknesses of traditional assessments [21], [22]. This is very relevant to learning with various conditions, both conventional learning and distance learning because mobile assessments can overcome the problem of space and time of implementation [23]. This is thought to have a positive impact on the learning experience and student learning outcomes so that it has the potential to achieve educational goals in general.

B. Learning Assessment

One of the factors that triggers the quality of learning is the quality of the assessment carried out by the teacher [24]. Learning assessment is an activity carried out by teachers to photograph students' profiles in achieving the competencies set by the curriculum [25]. Assessment can be done to measure student achievement and teacher performance in learning to improve the learning process [26].

Assessment is very important in learning activities. This is a demand for the pedagogic competence of teachers in carrying out their profession. The most known assessments are formative assessment and summative assessment. Formative assessment is an assessment carried out to monitor student learning and progress. This assessment is carried out to find out the learning has met expectations and improve further learning [27]. Summative assessment reflects what students have learned in the past [28].

Summative assessment aims to record or report student achievements and then inform students' successes and failures [29], [30]. Summative assessment as an assessment that summarizes all evidence of student learning at a certain time [31]. The assessment in this study focused on a formative approach through identifying trends in student learning outcomes for the purpose of improving learning.

III. Method

This study is quantitative research with a descriptive type of research. The research approach used is a time series approach through a focus on trend patterns of data findings [32]. The respondents of this study were elementary school students. Respondents were selected purposively by considering the suitability of the content and level of material developed in the mobile assessment. Data were collected through learning outcomes tests using mobile assessment technology. The content of the material included in the test is the content of thematic material in fifth-grade elementary school.

The data analysis technique used is trend analysis. This is a statistical analysis method that is intended to make an estimate or forecast at a certain time. This research data processing using Minitab 16. This study compares four trend analysis models, namely: LTM, QTM, GCM and SCTM. These four models are the guides and focus of researchers in analyzing and interpreting the data obtained from the field. In the following, the equation formulas for the four models are presented.

Linear Trend Model (LTM)

$$Y_t = a + b_t$$

Quadratic Trend Model (QTM)

$$Y_t = a + b_t + c_t^2$$

Growth Curve Model (GCM)

$$Y_t = a \,.\, b_t$$

S-Curve Trend Model (SCTM)

$$Y_t = 10^a / (b_0 + b_1 . b_2^t)$$

To choose the best analytical model, this study uses estimation error considerations. These considerations include: Mean Absolute Percentage Error (MAPE) with the following formula [33].

$$MAPE = \Sigma\, [(y_t - \dot{y}_t) / y_t] / n \text{ x } 100 \quad (y_t \neq 0)$$

with y_t is the value at time t, n is the number of observations, and $\dot{y}_t$ is the fitted value. Another error consideration is Mean Absolute Deviation (MAD). To identify this coefficient can be done with the following formula.

$$MAD = \Sigma_{t=1}\, [y_t - \dot{y}_t] / n$$

with y_t is the value at time t, n is the number of observations, and $\dot{y}_t$ is the fitted value. The final error consideration is Mean Square Deviation (MSD). It can be calculated by the following formula [33].

$$MSD = \Sigma_{t=1}\, [y_t - \dot{y}_t]^2 / n$$

with y_t is the value at time t, n is the number of forecasts, and $\dot{y}_t$ is the forecast value [33].

IV. Results

This study was conducted on fifth grade elementary school students. The activity that is the focus of this research is the application of mobile assessment in the learning process. The application of this mobile assessment was implemented seven times according to the schedule of student learning activities without disturbing the regular student learning curriculum agenda. The contents of the material included in the mobile assessment content are thematic material content in accordance with the applicable curriculum in Indonesia. The following in Fig. 1 presents an example of a sample mobile assessment used in this study.

Fig. 1 shows a sample mobile assessment screen accompanied by questions and answer options. The situation in the picture represents all the questions used in the learning process. All questions that have been prepared by the teacher are responded to by students using each student's mobile phone. At each opportunity given to students, the results are recorded and averaged to be documented in the research data. In the following, Table I is presented which describes the data set used in this study.

Fig. 1. Assessment page view.

TABLE I: DATASETS USED IN THE STUDY

Trend	Average Student Learning Outcomes
1	65
2	70
3	69
4	76
5	80
6	81
7	81

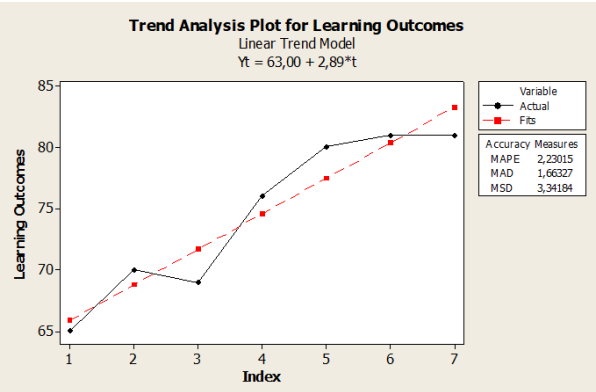

Fig. 2. Analysis results for linear trend model.

After all the data has been collected, the next thing to do is to conduct an analysis related to the trend of the collected data. Based on the previous study planning, the data were analyzed using four different trend analysis methods. The methods are LTM, QTM, GCM and SCTM. The following in Fig. 2 presents the results of data analysis based on the Linear Trend Model Method.

Fig. 2 presents the plot of the results of the analysis of student learning outcomes on the application of the mobile assessment. This plot depicts the Linear Trend Model. Based on the results of the analysis, it was found that the MAPE coefficient was 2.23, the MAD coefficient was 1.66 and the MSD coefficient was 3.34. In general, this plot shows that some actual data are quite close to the fit line. The second model used in this study is the Quadratic Trend Model. The results of the analysis on this model are presented in Fig. 3 below.

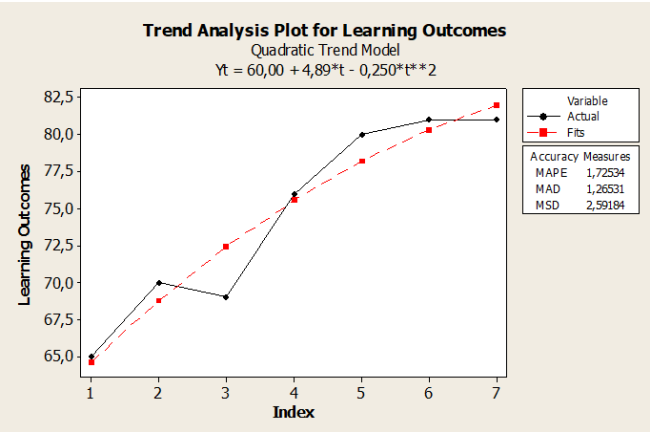

Fig. 3. Analysis results for quadratic trend model.

Fig. 3 provides information about the plot of the results of the student learning outcomes analysis on the application of the mobile assessment. This plot depicts the Quadratic Trend Model. Based on the results of the analysis, it was found that the MAPE coefficient was 1.72, the MAD coefficient was 1.26 and the MSD coefficient was 2.59. In general, this plot shows that some actual data are quite close to the fit line. The third model used in this study is the Growth Curve Model. The results of the analysis on this model are presented in Fig. 4 below.

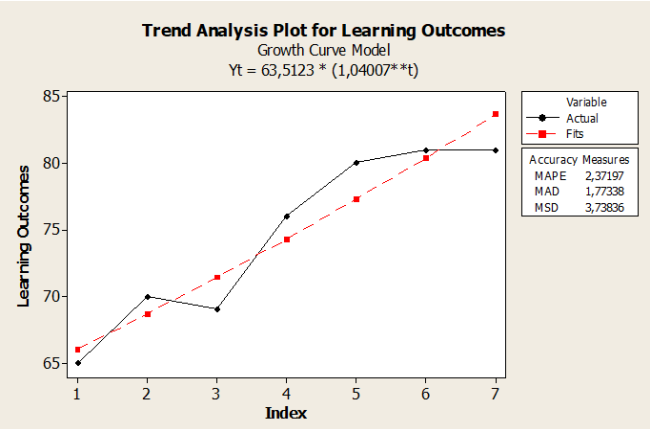

Fig. 4. Analysis results for growth curve model.

Based on the presentation of the information in Fig. 4, it can be explained that the plot of the results of the analysis of student learning outcomes in the application of mobile assessment is presented. This plot depicts the Growth Curve Model. Based on the results of the analysis, it was found that the MAPE coefficient was 2.37, the MAD coefficient was 1.77 and the MSD coefficient was 3.73. In general, this plot shows that some of the actual data are quite far from the fit

line. The fourth model used in this study is the S-Curve Trend Model. The results of the analysis on this model are presented in Fig. 5 below.

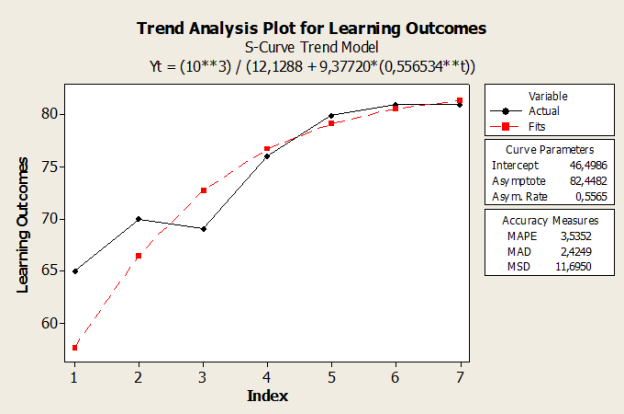

Fig. 5. Analysis results for quadratic trend model.

Fig. 5 describes the plot of the results of the analysis of student learning outcomes in the application of mobile assessments. This plot depicts the S-Curve Trend Model. Based on the results of the analysis, it was found that the MAPE coefficient was 3.53, the MAD coefficient was 2.42 and the MSD coefficient was 11.69. In general, this plot shows that some of the actual data are quite far from the fit line.

Based on several trend analysis models that have been used on student learning outcomes data while using mobile assessments, it can be explained that the results of the analysis show varied information for all models. To make it easier to understand the results, a summary of the results of the analysis is presented in Table II below.

TABLE II: SUMMARY OF TREND ANALYSIS RESULTS

Error Model	Trend Analysis Model				Best Model
	LTM	QTM	GCM	SCTM	
MAPE	2.23	1.72	2.37	3.53	QTM
MAD	1.66	1.26	1.77	2.42	QTM
MSD	3.34	2.59	3.73	11.69	QTM

Table II shows a summary of the results of the trend analysis of student learning outcomes using mobile assessments in learning activities. These results can be seen from the four trend analysis models used and the three measurement error estimation models that are taken into consideration.

Based on the summary of the analysis results presented in Table I, it can be explained that if viewed from the aspect of Mean Absolute Percentage Error (MAPE), the best model is the Quadratic Trend Model. The same thing is also found in the Mean Absolute Deviation (MAD) aspect, so the best model is the Quadratic Trend Model. As with the previous two error considerations models, on the aspect of Mean Square Deviation (MSD) the results found are also the same, namely the best model is the Quadratic Trend Model.

Based on the summary of the results of the trend analysis, it is found that the best model in this case study is the Quadratic Trend Model. This is based on the three estimation error considerations used, the Quadratic Trend Model is the model that has the smallest measurement error. This shows that the Quadratic Trend Model has empirical data that is closer to the expected data distribution. In general, this model can be formulated as follows.

$$Y_t = 60 + 4.89_t + 0.25_t^2$$

V. DISCUSSION

The findings of this study generally explain that there is a tendency for positive trends in student learning outcomes in elementary schools when learning is combined with mobile assessment. This shows that the mobile application shows a positive effect on student learning success, including the successful implementation of the assessment. This is in line with previous findings which say that mobile integration in learning can make the learning atmosphere more enjoyable [34], [35]. This is certainly very useful for teachers and students for the purposes of achieving learning objectives.

Another thing that is an advantage of using mobile technology in learning activities is that teachers and students can carry out learning activities without being limited by space, distance and time [36], [37]. This makes learning more flexible and has the potential to create a sense of comfort for both teachers and students. In addition, the three-dimensional visualization display makes the presentation of the material attractive for students to learn [38]. This is very suitable for the world of children's play.

Mobile technology has become a part of children's daily lives [39]. In the practice of learning, in recent years smart phones have become a device used by teachers to make learning more efficient [40], [41]. The smart phone function will be maximized if it is applied intelligently in pedagogical activities in learning [42], [43]. Even several previous studies have reported that the use of mobile technology in learning has a positive influence on student learning outcomes [44], [45].

Evaluating learning is one of the activities to follow the development of students in which there is an assessment activity. Teachers should use innovative ways to check whether students have achieved the expected knowledge. For this purpose, technology is not only used in learning activities but also in assessment activities [46]. This is in line with the findings of this study which shows that mobile assessment provides a positive trend towards improving student learning outcomes in primary schools.

Several large studies show that assessment that is integrated with mobile technology has a beneficial impact on student learning [47], [48]. This is triggered by mobile technology presenting new learning potential for students. They can learn in a variety of contexts, locations, interactivity, and collaborative communication between teachers and students in both formal and informal learning [49]. Mobile devices such as smart phones, laptops and other digital aids provide convenience in learning activities both inside and outside the classroom.

The importance of technology development in learning is an issue that is quite often studied from various previous studies [50]–[54]. This issue should be a serious concern for teachers because it is their responsibility in managing learning [55], [56]. This issue is very important because education must keep up with the times and education is a strong asset for the future success of the nation's next

generation [57]. Therefore, the development of the quality of learning must be in line with the development of technology, one of which is the application of mobile technology in learning activities.

The study findings show that the Quadratic Trend Model is the best measurement model. This is in accordance with the instructions of various previous studies that the best measurement model is a measurement model that has the smallest measurement error. In addition, the best measurement model also shows the correspondence between the actual empirical data and the distribution of the theoretical fit [58]–[60].

The integration of mobile technology in learning activities strongly supports sustainable development goals, especially in the field of education in Indonesia. It must be admitted that since the pandemic began until now the integration of technology has become very important in learning activities and tends to become a major requirement. In addition, mobile phone technology is no longer a foreign item for the community because all people have at least one mobile phone in their family. Therefore, this is a long-term issue in the implementation of education, especially in Indonesia.

In the end this study outlines the findings about the good effects of mobile assessment in learning. This is corroborated by findings related to the trend of learning outcomes that show a positive movement. This empirical basis is also supported by various theoretical bases on several previous research findings. Mobile assessment is a learning innovation that brings benefits for both teachers and students. This is recommended in student learning activities to achieve maximum learning outcomes.

VI. Conclusion

This research concludes that there is a positive trend towards student learning outcomes in the use of mobile assessments in learning activities. This can be shown through an increase in student learning outcomes with learning that utilizes mobile assessments. Based on the model fit, the findings show that the Quadratic Trend Model is the best model with the smallest measurement error.

This research recommends the application of mobile assessment in learning activities. This technology is very suitable to be applied to elementary school students because in addition to being useful for student learning outcomes, this technology is also suitable for children's world because it is integrated with games. Because this mobile assessment is very useful for learning activities, it is expected to be applied continuously to the material or subject matter in elementary schools.

Limitations of The Study

This study uses a sample that still needs to be developed. Therefore, it is highly recommended for future studies to consider a larger and more varied sample.

Theoretical Contribution and Practical Significance of The Study

This study provides a theoretical contribution in the form of a model for forecasting student learning outcomes by using mobile assessments in learning activities with relatively small errors. Practically this study is very useful for both teachers and students. This finding can increase the confidence of teachers in providing a variety of learning to their students. In addition, for students this finding is an alternative model to maximize their learning achievement at school.

Conflict of Interest

Authors point out that no conflict of interest.

Author Contributions

Herwin Herwin developed the issues, made instruments, verified data and drew conclusions. Anwar finds research collaboration partners and collects data. Riana Nurhayati develops mobile assessment and edits language. Shakila Che Dahalan was involved in data analysis and finalization of findings.

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Herwin Herwin was born in Macanre, South Sulawesi, Indonesia on April 3, 1989. The doctoral education in research and educational evaluation was obtained in 2017 at Universitas Negeri Yogyakarta, Indonesia. Currently, he is a lecturer at Universitas Negeri Yogyakarta in the Department of Elementary School Education. He has an area of expertise in educational measurement and evaluation.

Currently, the author has been actively researching and publishing his research results in various international journals. The author's work can be seen in the Scopus database as follows: https://www.scopus.com/authid/detail.uri?authorId=57219338399

Anwar Senen is an active lecturer in the Faculty of Education, Universitas Negeri Yogyakarta. He has expertise in social studies education in elementary school. Apart from teaching, he is also active in conducting various research related to social studies in elementary schools and character education for children. He currently holds the position of Head of the Department of Elementary School Education.

Riana Nurhayati is a lecturer in the Department of Education Policy. She has expertise in the field of educational evaluation. Currently, her research project focuses on bullying in schools. In addition, she is also researching technology issues in the field of education, especially the issue of learning technology since the COVID-19 pandemic. She is currently undertaking doctoral studies at the same university as her institution.

Shakila Che Dahalan is a lecturer in the Faculty of Human Sciences, Universiti Pendidikan Sultan Idris, Perak, Malaysia. She is currently working on several projects related to the field of history education. In addition, she also has an interest in technology topics in learning such as online learning, distance learning and other learning technology issues.