Preface

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Seminar on Advances in Mathematics, Science, and Engineering for Elementary Schools (SAMSES) 2018 is hosted by Universitas Pendidikan Indonesia. The seminar took place in Grand Mercure Hotel, Yogyakarta, Indonesia on 16 August 2018. Under the theme "Promoting STEM Instructions in Elementary Education", the conference has served as a scientific forum involving researchers, experts, and practitioners of STEM in particular to exchange ideas and research results among each other.

This volume consists of 206 papers which have gone through a peer-review process and will be published as a conference proceedings. The papers include a wide range of topics which include Teaching and Learning in STEM, STEM-based classroom management, Robotic and game teaching in elementary school children, Instructional technology and application in elementary schools, Training and professional development for STEM teachers, STEM curriculum in elementary schools, Computer-based learning, Innovations in instructional training and elementary education, and Design and implementation of technology-rich learning environment.

We would like to extend our best gratitude to all participants and contributors who have shared insights on the STEM application at elementary schools. We would also like to extend my deep appreciation to the committee members and reviewers for their hard work and commitment to review the papers. We hope that this volume could be an excellent outlet to communicate ideas and acquire best practices and knowledge in applying better STEM instruction in elementary schools.

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CONFERENCE PHOTOGRAPH


Innovation of Teaching
To be involved in study of the content of subject matters
Strive to integrate theory into practice
To know the knowledge of students' understanding and their way of thinking
To strengthen self competency
To implement professional knowledge
To encourage students to be a good
solver
To create the
discussion
students' activ
To foster
learning by


Conference vs. Journal Paper
Conference Paper (Proceeding
ilmiah pendek dan hanya berisi
penelitian.
paling menarik dari hasil
Journal papers,
berisi informasi yang lebih
secara utuh dari hasil
ilmiah panjang,
pemahaman


SAMSES
Promoting STEM Instructions


SAMSES
Seminar on Advances in Mathematics, Science, and Engineering for Elementary Schools 2018
Promoting STEM Instructions

Peer review statement

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Peer review statement

All papers published in this volume of *Journal of Physics: Conference Series* have been peer reviewed through processes administered by the proceedings Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

Integration Borg & Gall (1983) and Lee & Owen (2004) models as an alternative model of design-based research of interactive multimedia in elementary school

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Integration Borg & Gall (1983) and Lee & Owen (2004) models as an alternative model of design-based research of interactive multimedia in elementary school

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Abstract. Interactive multimedia has different development characteristics with other media. This article aims to form an interactive multimedia development model in elementary schools by integrating the development model of Borg & Gall and Lee & Owen. The formulation of these steps is the integration of the development model of Borg & Gall (1983) and Lee & Owen (2004). Borg & Gall focuses on developing new research-based, ready-to-use research products and Lee & Owen that are more specific in developing interactive multimedia products. Through the analysis of the advantages and limitations of each stage of Borg & Gall and Lee & Owen models can be formulated integration steps become as follows: (1) Research and Information Collecting; (2) Planning; (3) Development of Preliminary Form of Product; (4) Expert Evaluation; (5) Revisions Based on Expert Evaluation Results (Revision 1); (6) Preliminary Field Testing; (7) Main Product Revision (Revision 2); (8) Main Field Testing; (9) Operational Product Revision (Revision 3); (10) Operational Field Testing; (11) Final Product Revision (Revision 4); (12) Dissemination and Implementation. The considerations of the researchers to formulate the 12 stages are: (1) advantages of the comprehensive Borg & gall model, with a research-based product development stage and very rigorous testing phases, (2) the advantages of Lee & Owen's model that focuses on development principles interactive multimedia, (3) the trend of interactive multimedia development research in the scope of elementary schools, and (4) the development of the era that increasingly demands technology-based media for students. The twelve stages formulated by the author above can be adjusted or modified by reducing/adding/changing according to the need to maximize research activities by other.

1. Introduction

Changes in the world are now entering the era of industrial revolution 4.0 where information technology has become the basis of human life. Since 2011, Indonesia has entered the era of industrial revolution 4.0, which is marked by increasing connectivity, interaction and boundaries between humans, machines, and other increasingly convergent resources through information and communication technology [1].

The Industrial Revolution 4.0 can be a threat. However, this industrial revolution can also be a great opportunity for Indonesia if it is observant and ready to use it [2]. The Indonesian government sees this opportunity quite sharply and is considered to contribute to more job creation and new technology-based investments [3]. This is in line with Nielsen's research on Indonesian society shows that information technology-based media (ICTs) are the main means by which people obtain and access information, even their use is increasing year by year.

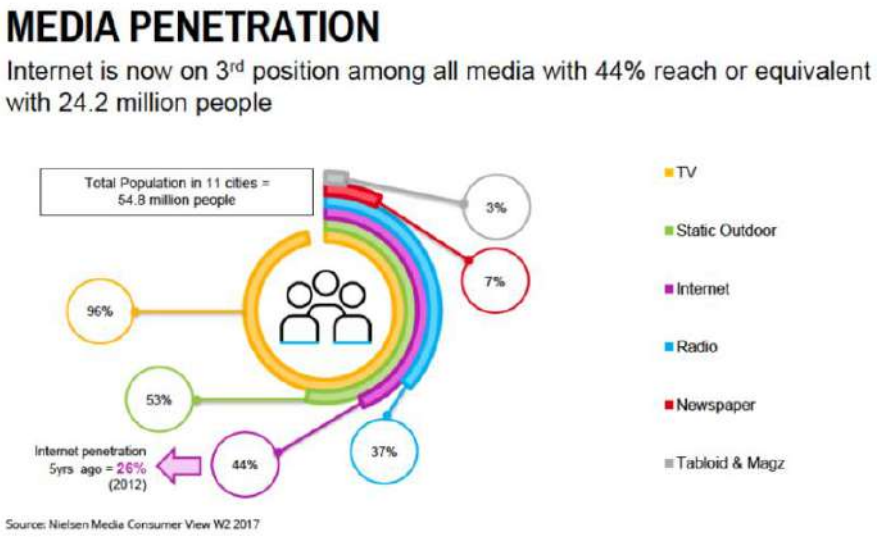

Figure 1. The new trend among Indonesia's netizen. Media penetration [4].

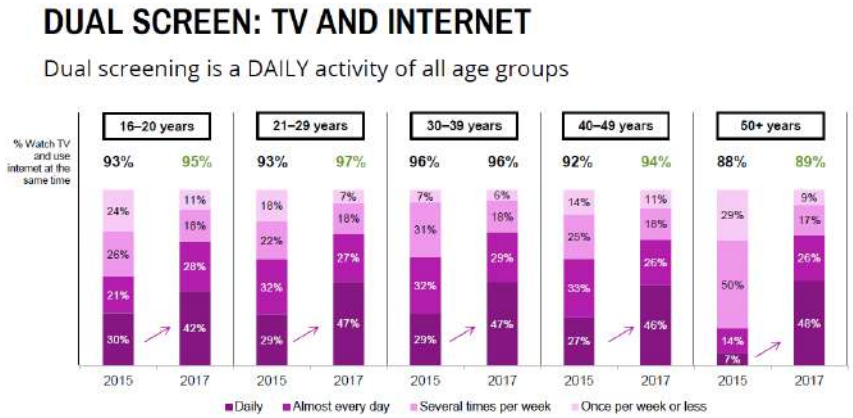

Figure 2. The new trend among Indonesia's netizen. Dual screen: TV and internet [4].

From the above conditions, it can be interpreted that the Indonesian people of all generations cannot be separated from ICT-based media. The above phenomenon has been welcomed by various parties, especially among academics, such as researchers from lecturers or students, especially in the field of educational media. They began to welcome the situation a lot by innovating and developing information technology-based educational media, such as interactive multimedia. As a follow up to the above situation, in this study a discussion on the development model related to the development of interactive multimedia is needed. The development model discussed in this article is expected to be an alternative study of researchers planning to develop interactive multimedia. In developing technology-based educational media such as interactive multimedia certainly requires a development model. Each type of media has different characteristics including interactive multimedia. Many models of technology-based development are offered in the world of education, such as ASSURE [5] or ADDIE [6], but Borg & Gall model (1983) and Lee & Owen model (2004) are used in this study [7, 8].

As according to Prasetyo, the Borg & Gall model (1983) can produce research-based educational products, which are fully prepared to be used in the field [9]. The steps of the Borg & Gall model (1983), namely (1) research and information collecting, (2) planning, (3) development of prelminary form of

product, (4) preliminary field testing, (5) main product revision, (6) main field testing, (7) operational product revision, (8) operational field testing, (9) final product revision, (10) dissemination and implementation [7]. From the above steps, it can be observed that the focus of this model is in the development of new research-based products, while the steps for product development that are more specific about interactive multimedia are not yet visible.

Different from the Borg & Gall model there are other models whose stages of development are more specific to interactive multimedia, namely the Lee & owen model. The steps of the Lee & Owen (2004) model are (1) multimedia needs assessment and analysis, (2) multimedia instructional design, (3) multimedia development & implementation, (4) multimedia evaluation [8]. Look at the advantages and focus of the two models, then the Borg & Gall model needs to be modified with Lee & Owen model that are more specific in developing interactive multimedia products. Therefore, this article aims to form an interactive multimedia development model in elementary schools by integrating the development model of Borg & Gall and Lee & Owen.

The two models above are modified and synergized to complement the limitations with the advantages of each model to development an a interactive multimedia in elementary school environment. The Borg & Gall model is more in its research, but less specific in developing interactive multimedia products and Lee & Owen's models that are more specific to the development of interactive multimedia. The discussion on the integration of the two models above as an alternative interactive multimedia development model can be studied below.

2. Method

The approach to this study is qualitative research with a literature study design. Literature study is a record of past events in the form of writings, drawings, or monumental works of someone [10]. The object of research used in the study of literature can come from textbooks, journals, scientific articles, literature reviews that contain the concepts under study [11], meaning that in this study the object of research was a book from Borg & Gall (1983) with the title Educational Research. An Introduction (4th ed.) And a book from Lee & Owen (2004) under the title Multimedia-Based Instructional Design, the focus of the study discusses the model of developing instructional materials from each theory of the two books.

From the above, it can be said that the literature study research activity this time is to describe, interpret a concept of both models, then connect it, and form conclusions as the purpose of this study, namely to form an interactive multimedia development model in elementary schools. In the process of formulating an alternative interactive multimedia development model in elementary schools, the researcher not only mentions each concept of the two books, but also provides sufficient explanation and understanding.

The procedure of this study includes (1) the preparation stage, namely the reading of the two books, other relevant literature studies, identifying and inventorying discussions that focus on the stages of developing teaching materials in each book, (2) the implementation stage, namely analyzing concepts from each stage of the two models, through the stages of describing the steps of each development model, analyzing the delivery and finally drawing conclusions, (3) formulating a concept of elementary schools multimedia development interactive in the results of the integration of the two development concepts from Borg & Gall and Lee & Owen by paying attention to the advantages and applicability of each step to be used as an interactive multimedia development guide.

3. Result and discussion

3.1. Borg & Gall Model (1983)

Through the literature review, the steps in the Borg and Gall model can be seen that the steps are as follows: *first*, Research and Information Collecting: At this stage includes product selection, literature review and class observation [7]. At the beginning of the R & D activities, it is necessary to describe the outline of the product to be developed and the tentative outline of the product.

Second, Planning: at this stage is how the researcher must ensure that the specific product objectives or types of products are truly appropriate and can solve the problems and needs that have been determined at the information collection stage [7]. Estimated financing, manpower, and product development time must be designed as well as possible.

Third, Development of Preliminary Form of Product: After the planning activities are complete, the next activity is to develop a preliminary product form which will be tested in the next stage. At this stage detailed activities can be carried out including draft or product-specific material and evaluation tools [7].

Fourth, Preliminary Field Testing: Preliminary field testing can be done in about 1 to 3 schools, which use 6 to 12 users. The purpose of the preliminary field testing is to get an evaluation or feedback qualitatively on the product by the user (teacher and student) [7]. The user is taken his opinion through an interview, observation or questionnaire that focuses on product usage problems and suggestions for improvement efforts.

Fifth, Main Product Revision: At this stage various revisions are made based on preliminary field testing [7]. The development team can use the data results in the Preliminary field testing to replan the product development and revise the product.

Sixth, Main Field Testing: Main field testing aims to ascertain whether the product is in accordance with the expected specific performance. Main field testing can be done in around 5 to 15 schools with 30 to 100 users and at this stage is quantitative data collection through experimental activities [7]. This pre-post design to determine its success and it should also be necessary to compare the results of the effectiveness of the product with the control group data. In addition, interview data, observations or questionnaires can also be used to support these main field testing activities.

Seventh, Operational Revision Products: In general this stage is the activity of revising the product based on suggestions for improvement and findings at the main fied testing stage [7]. If quantitative data is found that the product is ineffective or not in accordance with the development objectives, it is necessary to do repairs and re-perform the main field testing activities to meet the minimum criteria quantitatively. If at the second stage of the main field testing there is no good progress, then the product development should not be continued [7].

Eighth, Operational Field Testing: Operational field testing can be done in 10 to 30 schools with 40 or 200 users [7]. The purpose of operational field testing is to ensure that after this stage the product is completely ready to be used on the field without the presence of the developer or staff. To achieve this condition, the product must be thoroughly tested in every aspect. Operational field testing is more directed at activities that approach regular learning. User suggestions at this stage are collected using a questionnaire whose results are delivered to the developer via message/mail, or in other words the product is tested and executed by the user by minimizing the presence of the developer, to run naturally, and user input can also appear natural.

Ninth, Final Product Revision: After operational field testing and getting suggestions on the event, final product revision is conducted [7]. After this stage the product is ready to be mass produced by a publisher and can be used for the next stage. As long as the product is produced by the publisher, the developer can also revise it based on the advice of the relevant input from the publisher.

Tenth, Dissemination and Implementation: The last stage is dissemination and implementation [7]. Dissemination is more about disseminating products at professional meetings and journal publications. Implementation is more towards the production of products with publishers for the purpose of widespread use or commercial purposes. In addition, at this stage, it is also necessary to carry out activities to monitor product distribution to produce quality control.

From the literature review above it was found that The Borg & Gall model is not only aimed at developing an educational product alone, but this model also raises the concept of research in product development. Therefore, this model is very suitable if used as a basis for product development by students and lecturers who are conducting development research. The Borg & Gall model has very comprehensive and sequential steps. The stages started from information gathering, planning, product development, three times the form of testing and revision at the end of each trial, up to dissemination

and implementation activities. As can be seen in the Borg & Gall Model, the stages of information gathering, planning, and product development are still general. The aim is to find a solution to the problem of learning components whose solutions can be in the form of teaching materials, media, or models. The Borg & Gall model requires a product trial. At this stage, the Borg & Gall model coherently divides it into three stages, from a small scale to a broad scale, from qualitative data collection to quantitative data collection. The first test is more to collect qualitative suggestions/responses from users of products, the second trial is more to test the effectiveness of the product quantitatively on student learning outcomes, then the third trial is more on testing the condition of the product if done as real as possible (as natural as possible, without the presence/intervention of the developer). In addition, this model clearly and coherently includes the revision stage at each completion of the trial. In the final stage the Borg & Gall model is a mass production of products that can be assisted by a publisher. At this stage Borg & Gall advised developers to still be able to make revisions if there were inputs or suggestions in terms of publishers. This model also requires the dissemination of product results through publication activities of the results of development research. This publication can be through seminars or publications in journals.

3.2. Lee & Owen Model (2004)

Through the literature review, the steps in the Lee & Owen model can be seen that the steps are as follows: First, Multimedia Needs Assessment and Analysis, at this stage there are stages of need assessment and front-end analysis, the following is a description: (1) Need assessment, need assessment is an activity to identify differences in real conditions and ideal needs; (2) Front-End Analysis, Front-end analysis activities can include: (i) audience analysis, (ii) technology analysis, (iii) situational analysis (iv) task analysis, (v) critical incident analysis, (vi) objective analysis, (vii) media analysis, (viii) extant data analysis, and (ix) cost-benefit analysis [8].

Second, Multimedia Instructional Design, at this stage including project schedule, project team, media specification, content structure, configuration control and review cycles [8]. At the design stage in this model it is very characteristic of the concept of interactive multimedia development, where at the stage of composing the content structure strives to achieve the principles of interactive multimedia content that must be present in the product.

Third, Multimedia Development & Implementation, the process of developing computer-based multimedia includes: (1) creating story boards, (2) creating and building media elements, (3) online performance reviews, (4) delivering and implementing the course. The process of developing web-based multimedia includes: (1) determining the type of product and platform, (2) assemble components, (3) conduct reviews, (4) rehearse the presentation, (5) conduct the session. The process of developing distance-broadcast multimedia includes (1) developing script and material, (2) shoot and edit videos, (3) rehearse the presentation, (4) broadcast the session [8]. Whatever the type of multimedia (computer-based multimedia, web-based multimedia, and interactive distance-broadcast multimedia), the development process is the same, first establish a framework, develop the media element, then review and revise, finally, implement the finished product.

Fourth, Multimedia Evaluation, There are three activities to complete an evaluation strategy: (1) writing an introduction to the philosophy, purpose, and need for evaluation; (2) determining the requirements for evaluation, how to implement the strategy, what to measure, how to measure it, how the data will be validated, how the data will be collected, analyzed, and used, and the system that will be used to analyze the data, (3) determine source (books, journal, conference, vendor) that everyone know about this process. There are also seven type of validity that have levels ranging from low to high. The following types of validity can be used in activities to evaluate interactive multimedia products is (1) Face Validity (Level: Low), (2) Content Validity (Level: Low), (3) Concurrent Validity (Level: Medium), (4) Construct Validity (Level: Medium), (5) Test Item Validity (Level: Medium), (6) Predictive Validity (Level: High), (7) Inter-rater Agreement (Level: High) [8].

In contrast to the Borg & Gall model which is more common in the development of its types of products, Lee and Owen's model places more emphasis on the production of interactive multimedia

products for learning. Therefore the stages of developing the Lee & Owen model are very identical to the interactive multimedia prerequisites.

In the Need assessment and Front-End Analysis phases this model directly focuses on gathering and analyzing information from the perspective of interactive multimedia or ICT. In the following stages, such as the multimedia instructional design and multimedia development & implementation model stages, that discuss interactive multimedia principles, from what the story board, specifications and material principles to interactive multimedia are. At the end of the Lee & Owen model, namely the evaluation phase, it is also very identically with evaluating interactive multimedia products.

4. Purpose model as an alternative R & D of interactive multimedia model in elementary school

From the discussion of the two models above, and aimed at formulating a study of interactive multimedia development models in elementary schools, the authors offer several steps below. Of course the steps below require further study by other authors. The main objectives of the integration formulation of these two models are as an alternative to interactive multimedia research and development by lecturers and students of elementary school teacher education.

The concept of integration in the formula compiled by the author is that the Borg & Gall model is a framework for the stages of model integration, because the Borg & Gall model is more comprehensive and sequential (three trials and then revisions at the end of each trial, and ends with product dissemination) research & development of a learning product. Then in the framework of the stages of the Borg & Gall model, the stages of the Lee & Owen model are inserted at the stages of information collection, planning, product development, and expert evaluation which are more focused on the stages of interactive multimedia development. The following formulation of the stages of integration of the two models is shown in Table 1.

Table 1. Integration of Borg & Gall Model (1983) and Lee & Owen Model (2004).

No	Stage Framework	Step and Target Each Step
1	Research and Information Collecting	**Need Assessment:** determine (1) the current conditions in the elementay school, (2) the ideal needs, (3) make a list of the most important ideal needs, (4) list the differences in current conditions with predetermined ideal needs, (5) the potential or the ability of an organization that enables it to resolve current and ideal conditions, (6) devine the impact of solutions related to time, cost and user satisfaction, and make recommendations for solutions. **Front-End Analysis:** determine (1) audience analysis, (2) technology analysis, (3) situational analysis, (4) task analysis, (5) critical incident analysis, (6) objective analysis, (7) media analysis, (8) extant data analysis, (9) cost-benefit analysis:
2	Planning	Determine (1) project schedule, (2) project team/team roles, (3) media specifications, (4) design/outline/content structure of multimedia, (5) configuration control and review cycles
3	Development of Preliminary Form of Product	(1) creating story boards, script and material, (2) creating and building media elements; (3) reviews; (4) and implementing the course.
4	Expert Evaluation	In evaluation activities arranged: (1) evaluation grid, (2) evaluation tools (eg questionnaire), (3) evaluation techniques, (4) evaluation procedures, (5) evaluation results of: (i) validity of the material related to the suitability of the material in interactive multimedia with the material determined by the government and the stage of development of elementary school students, (ii) validity of material related to the suitability of objectives, contents, and test items, (iii) validity of the interactive multimedia principle, (iv) test item validity, (v) predictive validity (reliability)

Table 1. Cont.

No	Stage Framework	Step and Target Each Step
5	Revisions 1 Based on Expert Evaluation	Valid multimedia according revisions based on (1) material expert, (2) multimedia expert, (3) test item validity, (4) predictive validity test questions (reliability)
6	Preliminary Field Testing	To get an evaluation or feedback qualitatively on the practicality and attractiveness product by the user (teacher and student). In this stage it can be be done in about 1 to 3 schools, which use 6 to 12 users.
7	Main Product Revision (Revision 2)	Revisions are made based on preliminary field testing. The development team can use the data results in the Preliminary field testing to replan the product development and revise the product
8	Main Field Testing	Found quantitative data about product effectiveness based on pre-post experimental design or compare the results of the effectiveness of the product with the control group data. Main field testing can be done in around 5 to 15 schools with 30 to 100 users.
9	Operational Product Revision (Revision 3)	Revisions are made based on main fied testing stage. If quantitative data is found that the product is ineffective, it is necessary to do repairs and re-perform the main field testing activities to meet the minimum criteria quantitatively. If at the second stage of the main field testing there is no good progress, then the product development should not be continued.
10	Operational Field Testing	Found relevant data for product improvement. Operational field testing can be done in 10 to 30 schools with 40 or 200 users at the realistic learning condition and minimizing the presence of the developer
11	Final Product Revision (Revision 4)	Revisions are made based on operational field testing stage. Products have been revised in a final manner and are ready to be disseminated and implementation
12	Dissemination and Implementation	Disseminating products at professional meetings, journal publications, and Implementation the production of interactive multimedia with publishers

Source: Borg & Gall (1983) and Lee & Owen (2004).

5. Conclusion

Based on the results of the study of the two models above, researchers have formulated 12 stages of interactive multimedia development in elementary schools. In essence the 12 stages use the basic framework of the Borg & Gall model then at the initial information gathering stage, planning, product development and evaluation using the Lee & Owen model, and then continue the stages of the Borg & Gall model. The formulation of these stages is as follows: (1) Research and Information Collecting; (2) Planning; (3) Development of Preliminary Form of Product; (4) Expert Evaluation; (5) Revisions Based on Expert Evaluation Results (Revision 1); (6) Preliminary Field Testing; (7) Main Product Revision (Revision 2); (8) Main Field Testing; (9) Operational Product Revision (Revision 3); (10) Operational Field Testing; (11) Final Product Revision (Revision 4); (12) Dissemination and Implementation. The considerations of the researchers to formulate the 12 stages are: (1) advantages of the comprehensive Borg & gall model, with a research-based product development stage and very rigorous testing phases, (2) the advantages of Lee & Owen's model that focuses on development principles interactive multimedia, (3) the trend of interactive multimedia development research in the scope of elementary schools, and (4) the development of the era that increasingly demands technology-based media for students. From the 12 stages above, other readers can take advantage of the above steps according to the needs of each research condition (eg with consideration of time and costs, not conducting mass production activities), but the authors suggest that the steps of information gathering, development interactive multimedia according to principle, expert evaluation and product testing by users is absolutely necessary (although product trials can be simplified in such a way). With all the limitations of the author, the 12 stages that have been formulated above are expected to get input from other readers.

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