Toward a model of traditional-technology resystemmed and aligned on concept exploration with smartphone sensor

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Abstract. Schools were expected to form a physics learning process that builds a scientific foundation through technological engagement. The involvement of traditional technology in physics learning potentially contributes to the preservation of local wisdom. Model of learning that concretely integrates harmoniously the involvement of traditional and modern technologies was still needed. In this research, the advance organizer model was combined with the concept attainment model to improve the students’ conceptual understanding and cultural knowledge in SMAN 7 Pontianak using non-equivalent control group design on the sound wave subject matter. The syntax of the applied model consists of five phases, namely: Presentation of the advance organizer; Presentation of learning material structure; Presentation of data, identification, and strengthening of the cognitive organization; Testing the achievement of the concept; and Analysis of thinking strategy. The whole phase involves smartphone technology with Dongle or Anycast mirroring combined with PowerPoint and spectrum analyzer in Spectroid applications based on Android. Traditional technologies presented in the learning including Sape’, Senggayang, Ntunikng, Tentawaq, Kangkuang, Tuma, Meriam Karbit, and Keledi. The result of n-gain calculation shows that learning using Traditional-Technology Resystemmed and Aligned on Concept Exploration with Smartphone Sensor Model could improve the students’ conceptual understanding and cultural knowledge better.

1. Introduction

Technological developments can bring much progress for improving the quality of physics learning. Physical learning should involve technology that can improve the quality of learning and benefit the community at large, the phase is cooperation between leaders, teachers, and policymakers by starting from stimulating students’ interest in science and technology, coordinating innovations in school learning settings, and accelerating technological innovation. At school, there is a central role for wider policy. In school, it is expected to form a physics learning process that builds a scientific foundation
through technological involvement that is followed up with an incubation process that is in harmony with required innovations and will generate the basis for further planned development [1]. This is not without obstacles, concretely, for example, many studies have revealed the potential of smartphones for physics learning, but on the other hand not a few studies have found a new blossom word in the culture of today's society, namely plumbing. This signifies that the world community welcomes the era of the 21st-century still needs communal values of society as a reference for good interaction in the global world, so as not to lose their humanitarian value [2-4]. In Indonesia is still needed a lot of studies related to the implementation of smartphone technology and smartphone sensors to cultivate students the use of this device to a more positive direction that supports understanding of the concept of physics, or even contribute to the preservation of Indonesian culture. Reviewing this issue, there must be an improvement or even innovation related to the physics learning model and its assessment, pre-service physics teacher education, physics education curriculum, and policy.

In the scope of learning model innovation, it cannot be denied that physics learning that does not involve interesting recent issues will be meaningless and lead to low student learning motivation [5]. Exploration of the physics concept of an indigenous knowledge in physics learning will be useful to create a more contradictory learning atmosphere, motivate students, and close to the sociocultural dimensions of students, so that learning outcomes will be better. If exploration of the physics concept of an indigenous knowledge in physics learning implemented in the context of modern science and students with low levels of cultural knowledge, this model will in addition improve learning outcomes, and also can rebuild students' understanding of the importance of preserving local wisdom values in the 21st-century era [6-8]. This is in line with the general characteristics of the learning model, which is: helping students to learn in what way they learn, constructive orientation, scaffolding the teaching process, assessment and formative adjustment, related to 21st-century competencies and skills, culture and literacy global awareness, encouraging collaborative and cooperative skills, and enabling students to think divergently and creatively [9]. The initial concepts found from the exploration of a sociocultural problem and subsequently will form an understanding of the holistic concept which will be useful in the stage of automation of knowledge as well as decision-making [10]. The concepts from which have been understood previously need to be associated with the new concepts that will be presented to the students. This effort is not easy with increasing information around students, so a learning model in the cluster of information processing models needs to be combined with other learning models.

Many research related to model and strategy of science learning (physics) which still focus on developing information processing teaching model cluster and various strategies that associate with it to reach conceptual understanding [11-15]. The information processing models cluster emphasizes the acquisition, transfer, and processing of data by recognizing the world, as well as experiencing problems and solutions. The information-processing teaching model, when associated with 21st-century competencies and skills, has the advantage of good chances when combined with the recent development of information and communication technology [9]. In the 21st-century students are expected to be able to manage a wide range of information, for example in relation to learning resources there is an agenda especially related to the conventional textbook revolution in order to form an accessible module online. Nevertheless, the current model of physics learning has not clearly shown the syntax, social system, reaction principles, support systems, instructional and nurturant effects that can facilitate the advancement of smartphone technology and its sensors and the potential of indigenous knowledge. In the information processing teaching model cluster through the concept of attainment model, it is possible to open new conceptual exploration and research in individuals and groups. This includes exploring concepts related to culture, even in the cultural structures of other people or different cultures. Students basically with this model are prepared to be sensitive to different cultures, including feeling the problems experienced by other humans on different cultural structures. This model can be initiated with a series of conceptual discoveries and is followed by a simulation of one of the materials of culture being the focus of exploration. The concept of attainment model can also serve its role as an excellent evaluation tool when the science teacher (physics) wants to know the
extent to which students are able to master the important concepts and ideas that have been gained in learning. This model provides related information into the mastery of concepts and reinforces the previously known concepts. The concept attainment model evolved on the initiative of Bruner, Goodnow, and Austin and what distinguishes it from the inductive model is on conceptual analysis that leads students to discover concepts. The emphasis on the technicality is that teachers develop data sets containing examples of concepts that show the characteristics of the concepts that are the focus of students' attention. The opposite object pair is presented so that the student is clear about the concept. The concept attainment model is efficient and effective in revealed concepts, presenting organized information on various topics, and suitable with stages of student development [9]. On the other side, the advance organizer model allows being modified with regard to the short learning time limitations at classical learning settings [16]. This model can harmonize the concept discovery activities in the classroom as well as outside the classroom with smartphone aids [17]. Therefore, this research will study the implementation of traditional-technology resystemmed and aligned on the concept of exploration with smartphone sensor (T-TRACESS) model which is a combination of two learning models in information processing clusters, the advance organizer model was combined with concept attainment model assisted smartphones and sensors to improve the students' conceptual understanding and cultural knowledge.

2. Method
The research was quantitative in approach and used non-equivalent control group design at sekolah menengah atas negeri 7 (SMAN 7) Pontianak Indonesia and involved two classes. One class is used as an experimental group given treatment in the form of the application of a T-TRACESS model and one other class used as a discovery learning model as a comparison. The research was involved students of grade XI in Semester 2 of the academic year 2017/2018 and the learning material used was about the sound wave subject matter. By means of random sampling, two classes, namely, Classes XI MIA4 and XI MIA1, were picked as participants. Class XI MIA4, which consisted of 39 students served as the experimental group and Class XI MIA1, which consisted of 39 students, served as the control group. The steps in the research were (1) giving a pre-test of conceptual understanding and cultural knowledge to both the experimental group and the control group, the test used multiple-choice items, (2) giving treatment by applying T-TRACESS model to the experimental group and the discovery learning on the control group, and (3) giving a post-test of conceptual understanding and cultural knowledge to both classes. The conceptual understanding and cultural knowledge test a data were analyzed by using gain factor. To calculate improvement in students' conceptual understanding and cultural knowledge from those occurring before the learning to those occurring after it, the gain was calculated according to the formula developed by Hake, the criterion of gain score \((g) \geq 0.70\) is high category \(0.30 \leq g <0.70\) is medium category, and \(g <0.30\) is low category [18,19]. The conceptual understanding test material was related to sound wave subject matter, including the theory of string, \textit{organa} pipe, sound intensity level, and Doppler Effect. The improvement in students' conceptual understanding of sound wave subjects is viewed from the point of various aspects of understanding. Aspects of understanding are divided into three sub-categories, which are, respectively, of translation, interpretation, and extrapolation, so the conceptual understanding of the test instrument is constructed with those aspects as the base. The cultural knowledge test material covered is knowledge related to traditional technologies in West Borneo, which includes the sound characteristics of the strings on musical instrument \textit{Sape’}, a column of air in musical instruments \textit{Senggayung}, sound intensity and sound intensity level of the sound produced by the \textit{Bandong} boat, \textit{Meriam Karbit}, \textit{Lasukung Duduk}, and \textit{Lasukung Tinyak}, as well as the sound of \textit{Keledi} musical instruments, if it being moved at certain velocity.

3. Results and discussion
In line with the research design, the implementation of T-TRACESS model in the experimental group and the conventional learning model with the discovery learning model in the control group obtained
the average of pre-test and post-test score of conceptual understanding related to sound wave material and cultural knowledge concerning traditional technology of West Borneo which is illustrated as shown in figure 1. The average of pre-test and post-test score on aspects conceptual understanding and cultural knowledge in figure 1 shows that after the learning the average of the post-test score in experiment and control group have increment from the average of pre-test score. Nevertheless, the difference in the average of pre-test and post-test score higher occurred at the experimental group on the aspects of conceptual understanding as well as cultural knowledge, whereas in the early before the learning, the average of pre-test score at the control group was higher in both aspects. This means that the control group initially has a better understanding of the concept of material and also cultural knowledge than the experimental group.

**Figure 1.** The average of pre-test and post-test scores, viewed from conceptual understanding and cultural knowledge aspects.

The experimental group also had an average of the post-test score in both aspects higher than in the control group. This means that the conceptual understanding of subject material and cultural knowledge foundation in the control group that was initially relatively better than the experimental group has not been optimally empowered on learning using discovery learning model. The visualization that can describe the results of the implementation of the learning model in both learning groups to improve the conceptual understanding and cultural knowledge reviewing the gain score is presented in figure 2. The graph in figure 2 shows the gain score at both groups on the conceptual understanding aspect in the medium category, but the experiment group gains score is higher than the control group. The interesting thing is the gain score in the experiment group on the cultural knowledge aspect in the medium category, while the control group is in a low category. This shows that learning process using T-TRACESS model can improve students' conceptual understanding and cultural knowledge higher than using discovery learning model. Reviewing the results in figure 2 does not rule out the results in the experiment class can be further improved if the students are familiar with T-TRACESS model, considering the utilization of the smartphone with the T-TRACESS model is new for students in SMAN 7 Pontianak. To clarify the results of learning in both groups can also review the changes in the minimum and the maximum score of pre-test and post-test as illustrated in figure 3.
Figure 2. The gain score on aspects of conceptual understanding and cultural knowledge in the experiment and control groups.

Figure 3 shows that the minimum score of post-test in the control and experiment groups on both aspects has increased from the minimum score of the pre-test. In both groups, the type of minimum pre-test score showed the same. On the other hand, the maximum score of post-test on cultural knowledge aspects in the experiment group showed a greater increase than the maximum score of pre-test when compared with the maximum score of post-test in the control group on the cultural knowledge aspect. The maximum pre-test post-test score for the conceptual understanding aspect has not changed in both groups. This can be a clearer indication that learning using the T-TRACESS model can improve cultural knowledge aspects higher.

Figure 3. The maximum and minimum score on aspects of conceptual understanding and cultural knowledge, in the experiment and control group.

Discovery learning in the control group include preliminary activities, core activities, and closing activities. Preliminary activities consist of the phase presentation of apperception, material-related motivation, and learning objectives. The core activities consist of phase stimulation, problem statement, data collection, data processing, data verification, and generalization. The closing activity contains summarizing the learning and task activities. Substantively, the word resystemmed means the traditional technology and conventional learning source reorganized into a blended form and it was
aligned to the concept attainment model using the advanced organizer, illustration to clarify the syntax of T-TRACESS learning model applied to the experiment group presented in Figure 4.

Figure 4. The syntax of the T-TRACESS learning model in each phase.

The syntax of the T-TRACESS learning model in each phase using smartphones as a learning tool and thematically in the advance organizer and exploration in practice is the involvement of traditional technologies that make this model in a more innovative context than the discovery model or the picture and word inductive model (PWIM). In phase 1 refers to figure 4 that is the presentation of the advance organizer, teachers clarify the learning objectives, furthermore teacher presents the organizer of traditional technology of West Borneo which has been formed and this organizer can be accessed offline and online, teacher encourages awareness of the knowledge and experience of students that are relevant to the learning objectives and problems of the existence of traditional technologies. In phase 2, there is the presentation of learning material structure, the teacher clarifies logically the sequence of learning materials and links the material to be studied with the organizer. Phase 3 involved activities such as the presentation of data, identification, and strengthening of cognitive organization, teacher presents examples labeled with traditional technology experimental systems so that students can compare the characteristics of samples in positive and negative, the impact students will generate ideas and hypotheses, then they can clarify, apply the ideas, and testing the hypothesis, for example by performing experiment using traditional technology of West Borneo experimental system and smartphone sensors, and at the end of this phase students are expected to define the concept according to essential characteristics. In phase 4, which is to review the achievement of concepts, students identify the essential characteristics of additional samples in the organizer, students confirm the hypothesis and strengthen the understanding of the concept according to essential qualities, and produce other examples. Finally, in phase 5 involved the analysis of thinking strategies, students generate more novel hypotheses and useful experimentation; explains the ideas, hypotheses, and essential characteristics consistent with learned concepts; and finally discuss the type and number of hypotheses.

The social system of T-TRACESS model related to the process which teachers play a role in controlling the order of competencies in organizer-assisted learning, the teacher can give opportunities to the theme exploration through dialogue that elicits more experimentation ideas at the end of the lesson. Students will learn to collaborate classically or in groups using appropriate sensors on smartphones and its applications to explore, acquire and process the physical quantities from phenomena and physical system models. Uniquely the cooperation between students and teachers at the time of learning allows the development of smartphone sensors and applications that used. In line with the implementation T-TRACESS model in the experimental group, the theme was raised related to traditional technology and the relevant smartphone sensors to uncover or revealed indigenous knowledge that correlates with the concept of sound waves. Traditional technologies correlate with the
concept of sound waves that are dominated by traditional musical instruments become models of physical systems that are explored using sound sensors of smartphone and visualized their output with Spectroid applications [20].

Principles of reaction related to the T-TRACESS model is alignment of the use of smartphones to present the organizer and the use of smartphones and sensors for real-time experimentation tool, so the model responsive in connecting the organizer with the material, provide support but still emphasize the natural hypothesis at the time of discussion; balancing hypothesis; focus on the special features or essential characteristics of the examples, and it can evaluate students' thinking strategies as increased media engaged will generate more information flow. The model scrolled according to the phases in syntax but with the presence of the organizer, students had the opportunity to repeat the learning resources material as needed. The sophistication of today's smartphones to support mirroring the smartphone screen to other devices is essential to support the principles of reaction, illustrations related to this shown in figure 5.

![Figure 5. (a) Advance organizer and mirroring using the application stream over HTTP, (b) mirroring using Dongle or Anycast, (c) example of Spectroid application output on the advance organizer to clarify the phenomenon of Doppler effect.](image)

Illustration in Figure 5 (a) shows an example of an advanced organizer and mirroring of a smartphone's display to other devices such as a netbook using a screen stream over HTTP application [21]. This is in line with the wise use of Internet networks in schools for physics learning. Assisted by this application students have the flexibility of the means used for learning, i.e. computers, tablets, and smartphones. Teachers can create advance organizer only by using Ms. Power Point, and it currently supports video visualization, sound, animation and button features to operate on Android-based smartphones. In phases 3 of the T-TRACESS model, teachers develop data sets containing examples of concepts that show the characteristics of the concepts that are the focus of student's attention. The opposite object pair (as the experimental method in labs) is presented so that the student is clear about
the concept. Due to the sophisticated instrumentation of the recent smartphone sensor in accordance with its application and the advanced organizer are in one device, the practical presentation of the advanced organizer and the concept identification by the teacher can occur alternately and reinforced directly by the exploration of the physical system model. Learning should not take place in physics labs or computer labs. Teachers can also present advance organizers and experimentally experimenting without relying on computer devices or student smartphones as in Figure 5 (b) which shows samples of mirroring using classically projected Dongle or Anycast. In line with Figure 5 (c) in order to balance the hypothesis and focus on the particular features of the examples, the teacher before the learning should prepare first the good form of analysis resulting from smartphone sensor application output that has identified the characteristics of the physics concepts clearly in the advance organizer. The increasingly sophisticated smartphone technology today also allows students to explore the physical system model in a context more realistic and different from conventional physics experiment kits in labs. Students will learn that there is an output characteristic read in the smartphone sensor and its application where it is a response of the treatment given to the physical system which is the focus of the observation and the concept or physical quantities correlation associated with the treatment easy to be detected.

The T-TRACESS model support system is consists of learning resources or materials related experiment which is selected and formed carefully by the teachers, the materials well organized and rich of data, the teacher could show that the material conceptually arranged. The physical system model that would be explored first should allow students to be able to share data units and can generalize samples using smartphone sensors. At the learning using the T-TRACESS model in the experiment group, the experimental system with traditional technology themes as a model of the physical system was reorganized to focus on the concept to be explored and the capabilities of the following smartphone sensors. There is a direct and indirect measurement in the measurement of a physical phenomenon so that teachers should endeavor to use traditional technology, sensors and applications with visualization as fluent as possible to be easiest and clearest so that phenomena and concepts can be easily detected and understood by students [22,23].

Instructional effects or impacts refer to a combination of concept attainment and advance organizer models that appear in the T-TRACESS learning model, namely: the nature or characteristics of the concept, conceptual structure, and its application, and analysis of information and ideas. Furthermore, the nurturant effects of T-TRACESS learning models, namely: inductive reasoning, conceptual flexibility, and tolerance of ambiguity, but still seeking the right thinking habits, creativity, and research interest. Figure 2 shows results consistent with this. From the gain score of conceptual understanding between the experiment group and the control group, it could be seen in the medium category with the higher in the experimental group. Nevertheless, reviewing the gain score in both aspects seems clear that learning in experiment groups is more structurally or cognitively leading to germane load, despite in the learning was occurred greater information density or cognitive load [24].

Reviewing the results of implementation in the experiment group using the T-TRACESS model turned out that smartphone usage can help students learn and in what way they learn. The meaning for this is the model supports or in line with the effort to help students be responsible for learning. Conceptual understanding is still an important focus of physics education research [8]. The application of the T-TRACESS model in the study proved to show better results than the discovery learning model in this conceptual understanding aspect. Students can train themselves and with the model, it would be introduced to new ways of learning. The T-TRACESS model also helps students gain new knowledge, skills, and self-understanding through the acceptance of new cognitions, abilities, and values that are useful to overcome the difficulties of learning, especially when associated with the acceptance of local wisdom values. The T-TRACESS model is universally oriented, as it allows the formation of awareness that past (traditional) societies have been technologically knowledgeable as part of a culture closely linked to the concept of science (physics) today. This is very natural and scientific because technology refers to the truth of the regularity of the universe or the truth of the biophysical order of the universe is tested and proved by experimental empirical testing [25]. Each universal element of
culture in all nations will be forms cultural systems, social systems, and elements of physical culture (artifacts) [26]. These elements of physical culture (artifacts) are closely related to the study of traditional technology and science (physics). Traditional technology is the implementation of indigenous knowledge related to science in the simple form. If teachers consider particular characteristic similarities with physics apparatus in introductory physics laboratories. The negative of ethnocentrism should be extended to a broader positive dimension to the preservation of local wisdom so that it is not lost and can be shared for the benefit of globally. The paradigm raised is a harmonious collaboration between positive things in the past and the present in the technological context, and this is represented in the T-TRACESS model clearly by traditional technology and smartphone technology. Advance organizers combined in smartphones can link information learned with what will be learned so as to support constructive orientation, help to affirm learning scaffolding and to be a good tool to review the mastery of the concepts. Research relevant to this study shows that online advance organizer concept teaching materials (ONACOM) combined with information processing learning model can improve learning outcomes because concepts can be constructed, adapted and linked to other knowledge or concepts more effectively [27]. Nevertheless, ONACOM only takes the form of a concept map base that leads to four link forms, i.e. links leading to experimental activities, simulations, and photos and videos related to concepts, and this is different from the advance organizer that refers to the T-TRACESS model that is not just taking the basic form of concept map that leads to the four forms of links. Teachers and students will be able to recognize their progress and needs regarding 21st-century skills, where everyone needs the skills to use hardware and software on a smartphone in a positive and constructively oriented manner. The experimentation system using smartphones demands interaction with the development of research, information, ideas, multiple perspectives in cyberspace that include global activity [22]. The learning of this model using traditional technology reorganized as a physical system model and using an advance organizer that is aligned with the exploration of concepts using smartphone sensors encourages an experimental environment containing analogies that further engage students into divergent states which is related to scientific creativity.

4. Conclusion
The communal characteristics of traditional societies and the ability to maintain close relationships with nature by preserving them can be reflected in various artifacts or specifically traditional technologies. The characteristics of traditional society are very different from modern society, so many local wisdom values are actually useful and can be optimized to form a better global society to welcome the era of the 21st-century. Traditional-technology reystemmed and aligned on concept exploration with smartphone sensor model could improve the students' conceptual understanding and cultural knowledge. This model promises to be further studied because it allows students to process and understand information more structured through more active participation. The principle of reaction and support system of this model allows being developed on the other relevant aspects in line with technological advances, not limited on conceptual understanding and cultural knowledge as the study. Although this model is still oriented to the learning achievement, this model in line with efforts to reveal and re-introduce indigenous knowledge, especially traditional technology by empowering more positively advances in technology, especially smartphone technology, and its applications.

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