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Development of the Science Knowledge Application on Temperature, Heat, and Expansion to Improve Student Learning Outcomes

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Abstract: Sains Knowledge is an application developed to support student learning. This study aims to examine the validity, practicality, and effectiveness of the Sains Knowledge application in improving student learning outcomes on the topics of temperature, heat, and expansion. The research employed a One-Group pretest–posttest design, with data analyzed using the N-gain test. The study was conducted with seventh-grade students (Class VII-A) at SMP Negeri 11, Gorontalo City, and employed a Research and Development (R&D) approach based on the 4D model, comprising the stages of define, design, development, and dissemination. The findings show that Sains Knowledge met the eligibility criteria as a learning medium, with an average validation score of 94%. The practicality instruments indicated a 92% implementation rate, while student responses fell into the "very good" category at 80% and the "good" category at 20%. In terms of effectiveness, student activity reached 86%, and learning outcomes improved from an average score of 48 (pretest) to 90 (posttest), with an average N-gain of 0.81 in the "high" category. These results demonstrate that the Sains Knowledge application is valid, practical, and effective in enhancing student learning outcomes, with broader implications for improving digital learning media in secondary education.

Keywords: Learning Media; Learning Outcomes; Smart Apps Creator; Sains Knowledge; 4D Model.

Introduction

Learning is shaped by several interrelated components, including instructional objectives, learning materials, teaching methods, media, instructional models, and supporting facilities. High-quality instruction facilitates students' mastery of specific competencies, whereas ineffective instruction can impede the development of essential knowledge and skills. Hence, education must be systematically and effectively implemented to ensure the achievement of meaningful learning outcomes and to enhance overall educational quality.

With the advancement of science and technology, it is expected that the level of thinking and creativity of both teachers and students will develop significantly. In the current educational context, teachers are required to integrate technology into the learning process, one of which is through the use of instructional media.

Instructional media encompass the physical tools used to deliver learning content, which may include books, tape recorders, films, slides, transparencies, photographs, graphics, television, and computers. These tools, ranging from visual to electronic and audio media, serve to facilitate the delivery of learning materials to students in a more accessible and effective manner [1].

One form of instructional media development is the digitalization of learning resources, which can be adapted to the rapid advancements in technology, information, and communication, for example, electronic-based learning media [2]. The integration of instructional media in teaching and learning activities not only fosters students' interest and engagement but also enhances their motivation throughout the learning process [3].

Research and Development (R&D) is an approach designed not only to produce a specific product but also to evaluate its effectiveness. In the field of education, this method is applied to design, develop, and assess various products that support the learning process. Thus, it can be concluded that educational research and development is a method used to create and validate products intended for use in educational contexts [4].

Based on the explanation above, it can be concluded that research and development are efforts to produce a product that is more valid, practical, and effective than the existing ones. The essence of research and development lies in generating new products or improving existing ones that require refinement.

One of the most widely used models is the 4D model developed by Silvasailam Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel (1974), which consists of four stages: define, design, develop, and disseminate [5]. This model was selected because it is systematic and relevant for developing instructional media that meet the identified needs [6].

Smart Apps Creator (SAC) is a desktop application that can be used to design interactive media in the form of APK files, which can be executed on both Android and iOS smartphones [7]. SAC provides students with the opportunity to utilize smartphones not only as a medium for social interaction but also as a tool for learning [8]. The novelty of this study lies in the use of SAC to develop an instructional media application, named Sains Knowledge, which is specifically designed based on the junior high

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school curriculum.

The Sains Knowledge application was developed to support students in understanding the concepts of temperature, heat, and expansion through interactive content, such as videos, animations, and quizzes, which can be accessed at any time, even without an internet connection [9]. This application is expected to enhance learning motivation, facilitate material review outside the classroom, and support self-directed learning in a more engaging and efficient manner.

The quality of the Sains Knowledge application development was evaluated through tests of validity, practicality, and effectiveness [10]. Validity encompasses content and construct aspects, practicality is assessed through the implementation of learning and student responses, while effectiveness is measured based on student activities and learning outcomes [11]. Accordingly, this study aims to develop the Sains Knowledge application using Smart Apps Creator and to examine its validity, practicality, and effectiveness in improving students' learning outcomes on the topics of temperature, heat, and expansion.

Research Method

This study employs a Research and Development (R&D) approach, a process used to develop and validate existing products or create new ones. The 4D development model consists of four stages: (1) Define, (2) Design, (3) Development, and (4) Disseminate. The Define stage involves conducting a needs analysis through classroom observations to design appropriate learning media. The Design stage focuses on creating the initial design of the Sains Knowledge application. The Development stage aims to produce the Sains Knowledge application through two activities, namely expert validation for design improvement and a limited trial with Grade VII students to evaluate validity, practicality, and effectiveness. The Disseminate stage refers to the broader distribution of the product. However, in this study, dissemination was carried out only on a limited scale due to time and financial constraints; therefore, the development process primarily focused on limited classroom trials.

The Define stage was carried out by analyzing learning needs through classroom observations and content review to design appropriate instructional media. The Design stage aimed to develop the blueprint of the Sains Knowledge application. The Develop stage involved the product development process, including expert validation for design refinement and limited trials with Grade VII students. The Disseminate stage, which ideally entails broader implementation, was conducted in this study on a limited scale within the scope of the trial.

The research sample was determined using a purposive sampling technique, consisting of 25 Grade VII-A students at SMP Negeri 11 Kota Gorontalo. The research instruments included: (1) validation sheets assessed by two validators using a Likert scale, (2) observation sheets on the implementation of learning and student response questionnaires to measure practicality, and (3) observation sheets of student activities and learning achievement tests to evaluate effectiveness.

The data were analyzed using descriptive quantitative methods by calculating mean scores, percentages, and assessment categories. To measure students' learning outcomes, the N-Gain test was employed to determine the improvement in understanding after the use of the Sains Knowledge application.

Results and Discussion

Define

The Define stage aimed to identify learning needs through observations in Grade VII-A. The observations revealed that students had a low understanding of the concepts of temperature, heat, and expansion due to the limited learning media available. This condition led to low student engagement in the learning process. To address this issue, the Sains Knowledge application was developed as a visual, interactive, and contextual learning medium designed to enhance conceptual understanding, learning motivation, and active student participation.

Design

At this stage, the researcher selected Smart Apps Creator as the desktop application for designing the Sains Knowledge learning media. Subsequently, the content on temperature, heat, and expansion was compiled, supporting images were collected, and the menus and icons were designed. The initial interface design was created using Canva, resulting in the first draft of the product.

Development

The development of the Sains Knowledge application began with a needs analysis that included identifying learning problems related to the topics of temperature, heat, and expansion in Grade VII-A. This was followed by a validation test assessed by two expert validators. The Development stage in the 4D research and development model involved the realization of the previously designed product [12]. The following is the display of the Sains Knowledge application based on the suggestions provided by the two expert validators.

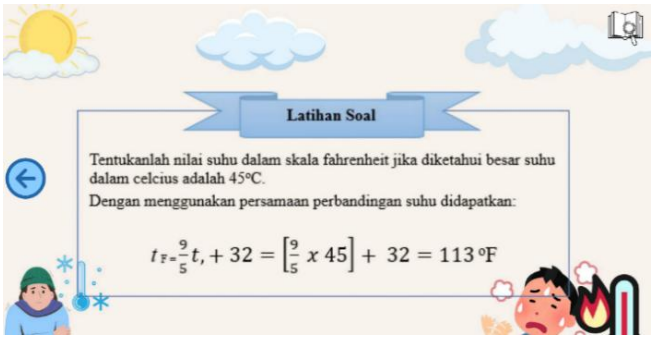

Figure 1. Practice questions on the topic of temperature

Figure 2. Practice Questions on the topic of heat

Table 1. Validation of the learning devices

No.	Learning Tools	Average	Criteria
1.	Sains Knowledge Application	93.8	Very valid
2.	Learning Modules	95.9	Very Valid
3.	Learning Materials	93.8	Very Valid
4.	Students Worksheets	94.0	Very Valid
5.	THB	92.5	Very Valid

The average validation scores for each instrument indicate that the media is feasible for use after minor revisions. The high validation scores are consistent with previous studies [13] The high validation scores are consistent with previous studies, which emphasize that application-based learning media tend to demonstrate strong validity because they present learning materials through concrete and interactive visualizations, thereby helping students better understand abstract concepts.

Desseminate

At this stage, the validated product was packaged, and the Sains Knowledge application, along with its user guide, was distributed to users, particularly science teachers, during a limited trial in Grade VII at SMP Negeri 11 Gorontalo City. This limitation is important to note, that development research requires trials across multiple classes or schools to ensure the generalizability of the product [14].

Practicality of learning

Practicality was assessed through a lesson implementation questionnaire and student responses. Observation results indicated an increase in implementation, from 85% in the first meeting, 92% in the second, to 100% in the third. This improvement suggests that the application can be consistently integrated into classroom learning. A learning product is considered practical if it can be implemented with a high level of fidelity by practitioners [15-16]. The average percentage scores of lesson implementation are presented below [11].

Next, students' responses to the use of the Sains Knowledge application after three learning sessions were collected using a questionnaire consisting of 18 items related to the development of the application. Each item was rated on a Likert scale to assess user perceptions and satisfaction with the learning media.

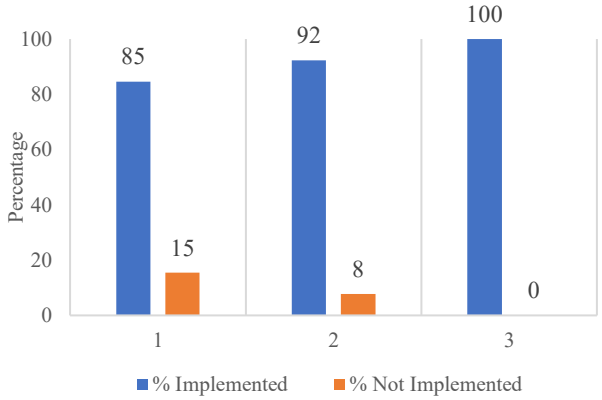

Figure 3. Percentage of learning implementation

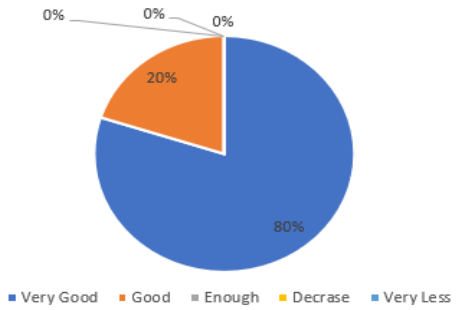

Figure 4. Percentage of Student Response Questionnaires

Student responses indicated that 80% fell into the "very good" category and 20% into the "good" category. These results suggest that the application is user-friendly and engaging for students. Mobile learning media are considered practical if at least 70% of students provide positive feedback [17]. The Sains Knowledge application meets the criteria for practicality.

Results Effectiveness

The instruments used in this study were a student activity questionnaire and a learning achievement test. The study was conducted over three sessions with 25 participating students, monitored by two observers. Student activity showed an average increase of 2% per session, reaching the "very good" category. This increase in engagement indicates that interactive media can motivate students to participate actively, and application-based media enhance both students' cognitive and affective involvement [18-19].

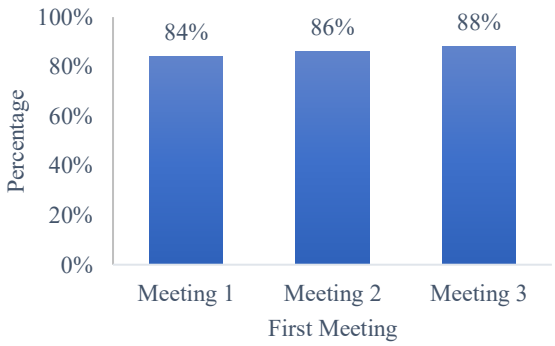

Figure 5. Percentage of Student Activity

Next, the learning achievement test consisted of 10 essay questions. The results of the students' tests are presented in the diagram (Figure 6). The learning achievement test showed an average pretest score of 48% and a posttest score of 90%, with an N-Gain of 0.81, categorized as high.

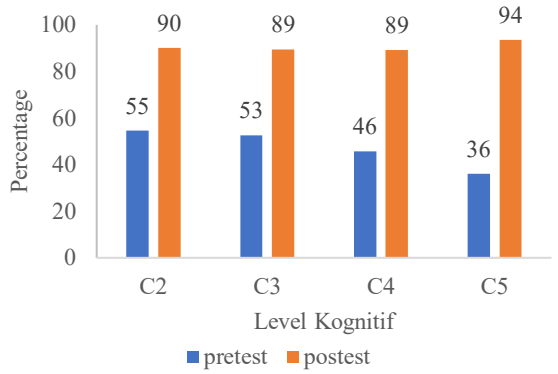

Figure 6. Cognitive Representation of Pretest and Posttest

Uji N-Gain

Table 2. N-Gain Learning Results in Limited Trials

Responden	Pretest	Posttest	N-Gain	Categories
25	48	90	0.81	high

These results indicate a significant improvement in students' understanding of the concepts of temperature, heat, and expansion. This improvement is consistent with previous studies reporting that interactive application-based learning enhances science learning outcomes, with high N-Gain categories [20].

Overall, the Sains Knowledge application has been proven to be valid, practical, and effective in enhancing student engagement and learning outcomes. High validity was influenced by the alignment of the content with the curriculum and the use of interactive visual presentations. Practicality was supported by a simple and easily accessible interface design. Effectiveness was reflected in increased student activity and learning outcomes, consistent with the principles of student-centered learning, which emphasize the importance of active student engagement.

However, this study has several limitations. First, the trial was conducted in only one class with a limited number of students, so the results cannot be generalized widely. Second, the implementation period was relatively short (three sessions), and therefore, the long-term impact remains unknown. Third, the study did not involve a control class, so the observed improvement in learning outcomes cannot be fully compared to conventional teaching methods. These limitations present opportunities for future research with a larger sample size, longer implementation duration, and an experimental design involving a control group.

Conclusion

The Sains Knowledge application developed using Smart Apps Creator has been proven to be valid, practical, and effective in enhancing students' understanding of temperature, heat, and expansion. Its implications suggest that teachers can integrate this application into other science topics to make learning more interactive and contextual. In the future, the application should be disseminated more widely through training and inter-school collaboration, and tested in various contexts and over longer periods to assess students' knowledge retention.

Author Contributions

Chindy Dahlia Mokoginta: Conceptualization, Original Draft Preparation, Methodology; Mursalin: Curation, Original draft writing; Citron S. Payu: Methodology; Tirtawaty Abdjul: Writing review and editing; Nova Elysia Ntobuo: Formal analysis, Methodology; Ritin Uloli: Validation.

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