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Development of Innovative Teaching Materials with QR Code Assistance for Basic Science Concepts to Enhance Critical Thinking Skills

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Abstract: This study aims to develop innovative teaching materials for the Basic Concepts of Science using QR Codes to enhance the critical thinking skills of prospective elementary school teachers. The study employs the 4D development model, which includes the stages of define, design, develop, and disseminate. The developed teaching materials are integrated with QR Codes, allowing prospective teachers to easily access additional learning resources, rich information, instructional videos, interactive multimedia, and even virtual simulations. The teaching materials are also designed to include learning activities that facilitate the development of critical thinking skills related to the basic concepts of science. The validity testing phase was conducted by five experts, and the validation results were analyzed using Aiken's V to determine the validity index of the developed materials. Based on the data analysis, the teaching materials were found to be valid and suitable for use. The innovative QR Code-assisted teaching materials for Basic Concepts of Elementary Science can effectively train the critical thinking skills of prospective elementary school teachers.

Keywords: Basic Concepts Of Elementary School Science, Critical Thinking Skills, QR Code, Teaching Materials.

Introduction

The development of teaching materials that are innovative and relevant to the needs of higher education is crucial in preparing prospective teachers who are ready to face the challenges of the 21st century. One innovation that can be implemented is technology-based teaching materials, such as QR (Quick Response) codes. QR codes allow prospective elementary school teachers to access additional information quickly and interactively, which is expected to improve their understanding of concepts and critical thinking skills that are important in education (Barus et al., 2022). The implementation of QR code-based teaching materials in higher education, especially in basic concepts of Natural Sciences (IPA), has the potential to create a more effective and interesting learning experience (Awwalina & Indana, 2022; Indriani et al., 2023; Permana et al., 2023).

Learning science in higher education, especially for prospective elementary school teachers, requires a deep understanding of the basic concepts that they will teach in the future (Suryana & Muhtar, 2022). Basic science concepts are the foundation for prospective teachers to teach more complex material and instill scientific thinking skills in elementary school students (Adhani & Rupa, 2020; Waruwu et al., 2023). Therefore, it is important for prospective teachers to not only understand the material factually but also master critical thinking skills in analyzing and solving problems relevant to natural phenomena.

The ability to think critically is an essential skill prospective elementary school teachers must have (Manurung et al., 2023; Handayani et al., 2019; Rahayu et al., 2021). Teachers who can think critically are

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expected to encourage their students to receive information passively and explore and evaluate information actively (Megawati et al., 2023; Fahlevi, 2022). Therefore, teaching materials oriented towards developing critical thinking skills for prospective elementary school teacher students are necessary for the higher education process. Using technology such as QR codes in teaching materials provides opportunities to strengthen the development of these abilities through wider and dynamic access to learning resources.

QR code-based teaching materials have many advantages, including presenting richer and more interactive information (Firmansyah et al., 2019). Through the use of QR codes, prospective elementary school teacher students can access various additional learning resources such as videos, scientific articles, and animated simulations relevant to basic science concept material. This allows students to deepen their understanding of the material and enrich their scientific insight, which will be useful in teaching elementary school students in the future (Salma, 2020).

Using QR codes in teaching materials also encourages prospective elementary school teacher students to participate in the learning process actively (Yani et al., 2022). Students not only act as recipients of information but also as active actors who can explore, analyze, and assess various information presented through this technology. Critical thinking skills involved in this process include assessing the validity of information, relating material to empirical experience, and solving problems with a scientific approach (Harahap et al., 2023).

In the context of teacher education, the validity of teaching materials is a very important aspect. Valid teaching materials must be by the curriculum and effective in achieving the expected learning objectives (Amirudin & Widiati, 2017; Kharisma & Asman, 2018). In this case, QR code-based teaching materials designed for prospective elementary school teachers must be validated to ensure that the teaching materials can improve the critical thinking skills of prospective teachers. This validation process includes the evaluation of aspects of material clarity, suitability to expected competencies, and relevance of the material to broader learning objectives.

This research aims to test the validity of QR code-based basic science concept teaching materials oriented toward critical thinking skills for prospective elementary school teacher students. Through this research, it is hoped that the teaching materials developed can make a positive contribution to preparing prospective teachers who not only master basic science concepts but are also able to integrate critical thinking skills in the teaching process. Thus, it is hoped that this research can help prospective teachers develop skills that are essential for their profession.

The teaching materials that will be validated in this research cover various basic science concepts, such as objects' properties, changes in objects' shape, and the water cycle. These concepts were chosen because they are relevant to the material that will be taught in elementary schools and can be used to train the critical thinking skills of prospective elementary school teachers. These concepts also provide opportunities for students to understand how to teach scientific concepts to students more effectively and interactively.

Using QR code-based teaching materials, it is hoped that prospective elementary school teacher students can learn in a more interactive, collaborative, and fun way. Ultimately, this research can make a significant contribution to developing teaching materials that suit the needs of higher education and the skills demands of the 21st century, especially in the context of prospective elementary school teacher education.

Method

This research is part of development research that refers to Thiagarajan's 4-D model, which consists of four stages: Define, Design, Develop, And Disseminate. However, this research is only limited to stages Develop, namely the validation of QR code-based teaching materials that are oriented towards the critical thinking abilities of prospective elementary school teacher students. At stage Define, learning needs, curriculum, and competencies must be analyzed, especially in developing critical thinking skills. Stage Design focuses on designing teaching materials, which include material preparation and validation instruments, which include material clarity, suitability to the curriculum, and the relevance of QR codes in developing critical thinking skills.

At the development stage, validation was carried out by 5 experts in science education, educational technology, and teaching materials development. Validators assess teaching materials based on the instruments that have been prepared and provide suggestions for improvement if necessary. Data from validation results are analyzed descriptively and quantitatively, and teaching materials are considered valid if they obtain an average score of at least 3.5 on a scale of 1-4. If aspects are deemed less valid, revisions are made according to the validator's input. This validation is expected to ensure that the teaching materials developed are of sufficient quality to improve the understanding of basic science concepts

and critical thinking skills of prospective elementary school teacher students**.**

Result and Discussion

The results obtained consist of results at the define stage, results at the design stage, and results at the product development stage, as well as data from validation by expert lecturers. The define stage aims to determine and define the needs in the Basic Concepts of Elementary School Science lecture process. Literature and field studies are carried out on the developed products at this stage. Literature studies are carried out by collecting information and references, which will be used as reference theories in product development by collecting articles, research journals, and books related to the research topic, as well as determining the objectives and outline of the teaching materials being developed. Field studies are conducted by making observations at one of the universities that will be used as the research object. This aims to obtain information about student character, the learning model applied, and the available infrastructure. At this stage, the researcher carried out detailed activities in the form of problem analysis, learner analysis, task analysis, concept analysis, and learning objective analysis.

The results of the problem analysis show that higher education learning has not fully implemented information technology and facilitated students' critical thinking abilities. In fact, education at universities is required to develop student competencies to compete in the era of the Industrial Revolution 4.0. As is known, the current learning bill is integrated with digital systems and must emphasize the process of active student participation.

Learner analysis analyses student characteristics, including abilities and cognitive development level. In this research, the characteristics of students in the second semester of the Elementary School Teacher Education Study Program are reviewed. The student analysis results show that students tend to be interested in learning by using information technology in learning. Students are also more interested in learning directly related to real-life examples. Apart from that, learning motivation tends to be low, so efforts are needed to improve this.

The results of the assignment analysis showed that the student assignments given by the lecturer were completed on time; however, the quality of the assignments submitted by the students was not optimal, as expected. Some of the tasks given have not facilitated the use of information technology. Therefore, efforts are needed to motivate students to learn so as to improve the quality of learning and learning outcomes.

Based on the results of the concept analysis, information was obtained that the Elementary Science Basic Concepts lecture was related to several important concepts related to everyday life. The next analysis carried out by researchers was an analysis of learning objectives. This analysis includes the formulation of learning objectives based on the learning outcomes of the Elementary Science Basic Concepts course. What is studied at this stage is the formulation of learning objectives obtained after reviewing the task and concept analysis results. Based on the results of this analysis, learning objectives were formulated in the Lesson Plan and outlined in teaching materials. Learning objectives also facilitate students' critical thinking skills. Based on the results of the preliminary study that has been reported, there is a great need for innovation in teaching Elementary Science Basic Concepts in universities. The learning process needs to develop learning experiences through approaches and innovation. Learning also requires more detailed and extensive understanding and explanation.

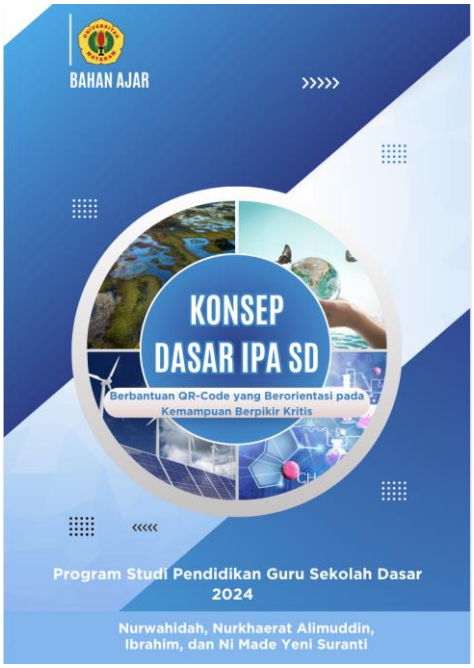
The next stage is the design stage. At this stage, the design of teaching materials is carried out with the help of QR-Code. The initial design is prepared by determining material, theme/subtheme, type of project, and lesson plan, as well as preparing material and measurement instruments adapted to the basic science concepts course.

The innovative teaching material on Basic Science Concepts for Elementary School with QR Code assistance is designed to enhance students' critical thinking skills by utilizing technology to provide easy access to supplementary materials such as videos, images, articles, and simulations. In this teaching material, students can access various additional learning resources that stimulate their analytical and reflective thinking. Furthermore, the material includes a mind mapping section at the beginning, which helps students organize information and understand the relationships between concepts more clearly. Through the integration of QR Codes, students can also obtain other information, such as videos and images, that enrich their learning experience. In addition, the teaching material includes formative assessments to monitor students' understanding during the learning process and self-assessment to allow students to evaluate their progress and mastery of the material. Learning activities such as quizzes, discussions, and educational games are also designed to challenge students to think more critically, analyze situations, and provide solutions based on evidence.

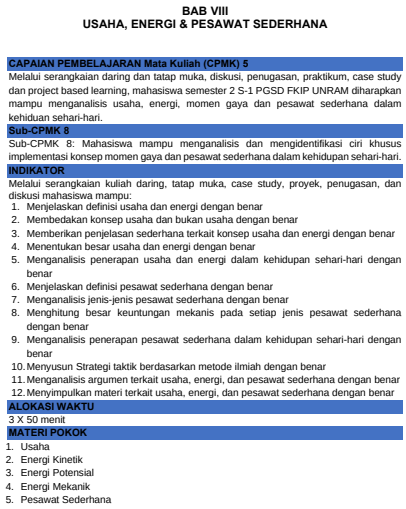
This teaching material developed aims to enhance students' critical thinking skills by using QR Codes to provide access to in-depth and varied

supplementary materials. This teaching material also aims to help students organize and understand basic science concepts more clearly through the use of mind mapping. Additionally, the material seeks to facilitate formative assessments that track students' understanding and self-assessment, increasing students' awareness of their progress and mastery of the material. Overall, this teaching material aims to encourage students to be more active in independent learning and expand their knowledge through technology, thus improving their understanding of basic science concepts.

The design of the developed teaching material can be seen in the following Figure 1.



(a) Cover



BAB VIII
USAHA, ENERGI & PESAWAT SEDERHANA

CAPAIAN PEMBELAJARAN Mata Kuliah (CPMK) 5

Melalui serangkaian daring dan tatap muka, diskusi, penugasan, praktikum, case study dan project based learning, mahasiswa semester 2 S-1 PGSD FKIP UNRAM diharapkan mampu menganalisis usaha, energi, momen gaya dan pesawat sederhana dalam kehiduan sehari-hari.

Sub-CPMK 8

Sub-CPMK 8: Mahasiswa mampu menganalisis dan mengidentifikasi ciri khusus implementasi konsep momen gaya dan pesawat sederhana dalam kehidupan sehari-hari.

INDIKATOR

Melalui serangkaian kuliah daring, tatap muka, case study, proyek, penugasan, dan diskusi mahasiswa mampu:

1. Menjelaskan definisi usaha dan energi dengan benar
2. Membedakan konsep usaha dan bukan usaha dengan benar
3. Memberikan penjelasan sederhana terkait konsep usaha dan energi dengan benar
4. Menentukan besar usaha dan energi dengan benar
5. Menganalisis penerapan usaha dan energi dalam kehidupan sehari-hari dengan benar
6. Menjelaskan definisi pesawat sederhana dengan benar
7. Menganalisis jenis-jenis pesawat sederhana dengan benar
8. Menghitung besar keuntungan mekanis pada setiap jenis pesawat sederhana dengan benar
9. Menganalisis penerapan pesawat sederhana dalam kehidupan sehari-hari dengan benar
10. Menyusun Strategi taktik berdasarkan metode ilmiah dengan benar
11. Menganalisis argumen terkait usaha, energi, dan pesawat sederhana dengan benar
12. Menyimpulkan materi terkait usaha, energi, dan pesawat sederhana dengan benar

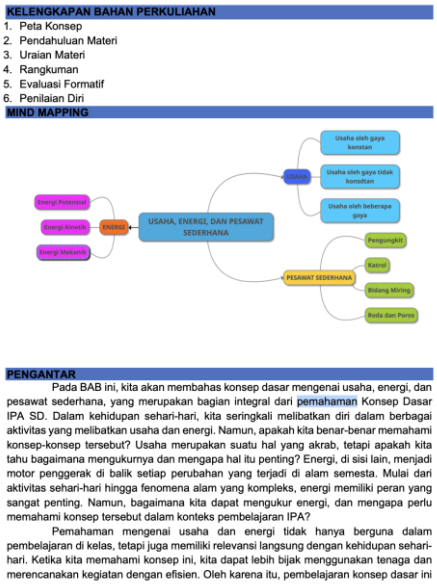
ALOKASI WAKTU

3 X 50 menit

MATERI POKOK

1. Usaha
2. Energi Kinetik
3. Energi Potensial
4. Energi Mekanik
5. Pesawat Sederhana

(b) Learning Outcomes and Indicators



KELENGKAPAN BAHAN PERKULIAHAN

1. Peta Konsep
2. Pendahuluan Materi
3. Uraian Materi
4. Rangkuman
5. Evaluasi Formatif
6. Penilaian Diri

MIND MAPPING

PENGANTAR

Pada BAB ini, kita akan membahas konsep dasar mengenai usaha, energi, dan pesawat sederhana, yang merupakan bagian integral dari pemahaman Konsep Dasar IPA SD. Dalam kehidupan sehari-hari, kita seringkali melibatkan diri dalam berbagai aktivitas yang melibatkan usaha dan energi. Namun, apakah kita benar-benar memahami konsep-konsep tersebut? Usaha merupakan suatu hal yang akrab, tetapi apakah kita tahu bagaimana mengukurnya dan mengapa hal itu penting? Energi, di sisi lain, menjadi motor penggerak di balik setiap perubahan yang terjadi di alam semesta. Mulai dari aktivitas sehari-hari hingga fenomena alam yang kompleks, energi memiliki peran yang sangat penting. Namun, bagaimana kita dapat mengukur energi, dan mengapa perlu memahami konsep tersebut dalam konteks pembelajaran IPA?

Pemahaman mengenai usaha dan energi tidak hanya berguna dalam pembelajaran di kelas, tetapi juga memiliki relevansi langsung dengan kehidupan sehari-hari. Ketika kita memahami konsep ini, kita dapat lebih bijak menggunakan tenaga dan merencanakan kegiatan dengan efisien. Oleh karena itu, pembelajaran konsep dasar ini

(c) Mind Mapping

Kotak Informasi

Amati dan pelajari berbagai cara perpindahan panas. Pindai QR-code berikut untuk sebagai sumber belajar perpindahan panas yang dapat digunakan di kelas maupun di rumah.

Mari kita lihat contoh perpindahan panas yang terjadi ketika sebuah benda panas bersentuhan dengan benda dingin ataupun sebaliknya.

1. Konduksi

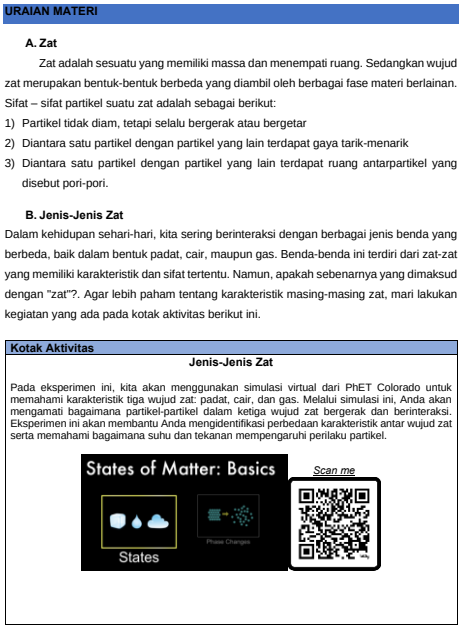
Konduksi merupakan proses perpindahan kalor tanpa disertai dengan perpindahan partikelnya. Proses konduksi ini secara umum terjadi pada logam atau yang bersifat konduktor (menghantarkan panas). Seperti tampak pada gambar di bawah ini.

Kotak Aktivitas

Di mana konduksi terjadi di rumah Anda? Cobalah berjalan di seluruh rumah Anda. Di setiap ruangan, amati apakah ada benda-benda yang mengalami perpindahan panas secara konduksi? Berdasarkan pengamatan Anda, buatlah daftar sebanyak mungkin contoh perpindahan panas melalui konduksi yang Anda temukan. Ingat, perpindahan panas melalui konduksi terjadi pada benda padat.

Gambar 7. Perpindahan Panas Secara Konduksi

(d) Information Box With QR-Code



URAIAN MATERI

A. Zat

Zat adalah sesuatu yang memiliki massa dan menempati ruang. Sedangkan wujud zat merupakan bentuk-bentuk berbeda yang diambil oleh berbagai fase materi berlainan. Sifat – sifat partikel suatu zat adalah sebagai berikut:

1) Partikel tidak diam, tetapi selalu bergerak atau bergetar
2) Diantara satu partikel dengan partikel yang lain terdapat gaya tarik-menarik
3) Diantara satu partikel dengan partikel yang lain terdapat ruang antarpartikel yang disebut pori-pori.

B. Jenis-Jenis Zat

Dalam kehidupan sehari-hari, kita sering berinteraksi dengan berbagai jenis benda yang berbeda, baik dalam bentuk padat, cair, maupun gas. Benda-benda ini terdiri dari zat-zat yang memiliki karakteristik dan sifat tertentu. Namun, apakah sebenarnya yang dimaksud dengan "zat"?. Agar lebih paham tentang karakteristik masing-masing zat, mari lakukan kegiatan yang ada pada kotak aktivitas berikut ini.

Kotak Aktivitas

Jenis-Jenis Zat

Pada eksperimen ini, kita akan menggunakan simulasi virtual dari PhET Colorado untuk memahami karakteristik tiga wujud zat: padat, cair, dan gas. Melalui simulasi ini, Anda akan mengamati bagaimana partikel-partikel dalam ketiga wujud zat bergerak dan berinteraksi. Eksperimen ini akan membantu Anda mengidentifikasi perbedaan karakteristik antar wujud zat serta memahami bagaimana suhu dan tekanan mempengaruhi perilaku partikel.

States of Matter: Basics

States

Scan me

(e) Activity Box With QR-Code: Simulation Acivity

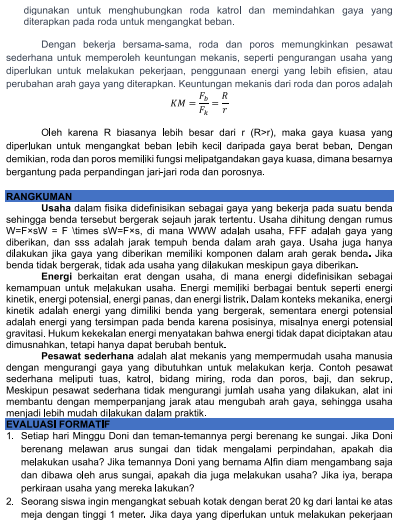
Kotak Aktivitas

Pindai QR-code diatas dan berikan alasan yang mendukung jawaban Anda!

c. Daun, adalah bagian tumbuhan yang tumbuh pada batang. Daun pada umumnya berwarna hijau. Pada daun berwarna hijau, terdapat kandungan zat klorofil yang merupakan salah satu bahan yang dibutuhkan pada proses fotosintesis. Bentuk daun yang bermacam-macam dan variasi ini dapat terlihat dalam berbagai spesies tumbuhan. Beberapa tumbuhan dapat memiliki daun dengan karakteristik campuran.

Jenis Daun	Bentuk	Fungsi Utama
Daun Menyirip	Panjang dengan ujung bergerigi atau runcing	Menangkap sinar matahari untuk fotosintesis
Daun Menjari	Berbentuk jari atau menjari	Memaksimalkan area permukaan untuk fotosintesis
Daun Jarum	Tipis, panjang, dan berbentuk jarum	Adaptasi untuk mengurangi penguapan air di lingkungan yang kering

(f) Activity Box With QR-Code: Observing by Video



digunakan untuk menghubungkan roda katrol dan memindahkan gaya yang diterapkan pada roda untuk mengangkat beban.

Dengan bekerja bersama-sama, roda dan poros memungkinkan pesawat sederhana untuk memperoleh keuntungan mekanis, seperti pengurangan usaha yang diperlukan untuk melakukan pekerjaan, penggunaan energi yang lebih efisien, atau perubahan arah gaya yang diterapkan. Keuntungan mekanis dari roda dan poros adalah

$$KM = \frac{F_b}{F_k} = \frac{R}{r}$$

Oleh karena R biasanya lebih besar dari r (R>r), maka gaya kuasa yang diperlukan untuk mengangkat beban lebih kecil daripada gaya berat beban. Dengan demikian, roda dan poros memiliki fungsi melipatgandakan gaya kuasa, dimana besarnya bergantung pada perpandingan jari-jari roda dan porosnya.

RANGKUMAN

Usaha dalam fisika didefinisikan sebagai gaya yang bekerja pada suatu benda sehingga benda tersebut bergerak sejauh jarak tertentu. Usaha dihitung dengan rumus W=F×sW = F \times sW=F×s, di mana WWW adalah usaha, FFF adalah gaya yang diberikan, dan sss adalah jarak tempuh benda dalam arah gaya. Usaha juga hanya dilakukan jika gaya yang diberikan memiliki komponen dalam arah gerak benda**.** Jika benda tidak bergerak, tidak ada usaha yang dilakukan meskipun gaya diberikan**.**

Energi berkaitan erat dengan usaha, di mana energi didefinisikan sebagai kemampuan untuk melakukan usaha. Energi memiliki berbagai bentuk seperti energi kinetik, energi potensial, energi panas, dan energi listrik. Dalam konteks mekanika, energi kinetik adalah energi yang dimiliki benda yang bergerak, sementara energi potensial adalah energi yang tersimpan pada benda karena posisinya, misalnya energi potensial gravitasi. Hukum kekekalan energi menyatakan bahwa energi tidak dapat diciptakan atau dimusnahkan, tetapi hanya dapat berubah bentuk**.**

Pesawat sederhana adalah alat mekanis yang mempermudah usaha manusia dengan mengurangi gaya yang dibutuhkan untuk melakukan kerja. Contoh pesawat sederhana meliputi tuas, katrol, bidang miring, roda dan poros, baji, dan sekrup. Meskipun pesawat sederhana tidak mengurangi jumlah usaha yang dilakukan, alat ini membantu dengan memperpanjang jarak atau mengubah arah gaya, sehingga usaha menjadi lebih mudah dilakukan dalam praktik.

EVALUASI FORMATIF

1. Setiap hari Minggu Doni dan teman-temannya pergi berenang ke sungai. Jika Doni berenang melawan arus sungai dan tidak mengalami perpindahan, apakah dia melakukan usaha? Jika temannya Doni yang bernama Alfin diam mengambang saja dan dibawa oleh arus sungai, apakah dia juga melakukan usaha? Jika iya, berapa perkiraan usaha yang mereka lakukan?
2. Seorang siswa ingin mengangkat sebuah kotak dengan berat 20 kg dari lantai ke atas meja dengan tinggi 1 meter**.** Jika daya yang diperlukan untuk melakukan pekerjaan tersebut adalah 200 joule, hitunglah efisiensi penggunaan energi dalam mengangkat kotak tersebut.
3. Setiap hari Sabtu Raihan selalu dijemput oleh Afif untuk pergi ke tempat futsal mengendarai sepeda motor yang bermassa 85 kg dengan kecepatan 50 m/s. Karena melihat lampu merah, Alfin mengerem motornya sehingga kecepatan motor berkurang secara teratur menjadi 20 m/s. Selesaikan permalasahan tersebut dengan cara menentukan hubungan usaha karena adanya perubahan kecepatan motor tersebut.
4. Seorang siswa mendesain sebuah mainan menggunakan pesawat sederhana. Namun, mainan tersebut tidak bekerja seperti yang diharapkan. Bantulah siswa tersebut untuk menganalisis dan mengidentifikasi kemungkinan penyebabnya, serta memberikan solusi untuk memperbaikinya.
5. Berdasarkan prinsip-prinsip usaha, energi, dan pesawat sederhana, rancanglah sebuah percobaan sederhana yang dapat mengilustrasikan konsep-konsep tersebut kepada anak-anak kelas 4 SD. Jelaskan langkah-langkah yang diperlukan dan tujuan dari percobaan tersebut.
6. Berikan contoh dari kehidupan sehari-hari di mana konsep usaha, energi, dan pesawat sederhana diterapkan. Bagaimana penggunaan konsep ini dapat mempermudah atau mempersulit pekerjaan sehari-hari?
7. Bandingkan antara penggunaan energi dalam mengangkat benda dengan memanfaatkan pesawat sederhana seperti bidang miring dan mengangkat benda secara langsung. Manakah yang lebih efisien dalam hal penggunaan energi? Jelaskan.

PENILAIAN DIRI

Petunjuk: Baca setiap pernyataan di bawah ini dengan cermat, lalu beri tanda centang (✓) pada kolom yang sesuai dengan tingkat pemahaman Anda.

NO	PERNYATAAN	YA	TIDAK
1	Saya memahami konsep dasar usaha dan dapat menghitung usaha yang dilakukan pada suatu benda.		
2	Saya dapat menjelaskan hubungan antara energi kinetik, energi potensial, dan usaha dalam kehidupan sehari-hari.		
3	Saya memahami berbagai bentuk energi dan dapat memberikan contoh dari perubahan energi dalam kehidupan sehari-hari.		
4	Saya dapat menjelaskan cara kerja pesawat sederhana seperti tuas, katrol, dan bidang miring untuk mempermudah usaha.		
5	Saya dapat menghitung gaya, usaha, dan keuntungan mekanis yang diperoleh dari penggunaan pesawat sederhana.		
6	Saya mampu menerapkan konsep usaha dan energi untuk menyelesaikan soal-soal yang melibatkan pesawat sederhana.		
7	Saya memahami hukum kekekalan energi dan dapat menjelaskan bagaimana energi tidak diciptakan atau dimusnahkan, melainkan berubah bentuk.		

(g) Summary and Evaluation

(h) Self Assessment

Figure 1. The Design of Innovative Teaching Materials with QR Code Assistance for Basic Science Concepts

At this design stage, teaching materials are designed using QR-Code. The material in the QR code is in the form of teaching material from YouTube links, Instagram links, and/or website links in accordance with teaching material in basic science concepts. QR code is expected to increase effectiveness in the learning process. The teaching materials prepared are also equipped with activity boxes, which are expected to increase knowledge and critical thinking skills.

The third stage in this research is the development stage. The initial product is teaching materials adapted to the curriculum and Lesson Plan for the Basic Science Concepts course. At this stage, product validation is carried out, which has been

developed by expert validators. The validation results were analyzed based on Aiken's V, as in Table 1 below.

Table 1. Expert Validation Results

Validator	Aspect 1	Aspect 2	Aspect 3	Aspect 4
Validator 1	4	3	5	4
Validator 2	3	4	5	4
Validator 3	5	4	4	3
Validator 4	4	4	5	5
Validator 5	3	5	4	4
Average Score	3.5	4.0	4.6	4.0
Aiken V	0.78	0.85	0.90	0.85
Percentage of Agreement	80%	85%	90%	85%

The validation results indicate that the QR Code-based teaching materials for basic science concepts in elementary education demonstrate strong validity across all evaluated aspects. The relatively high Aiken's V values (ranging from 0.78 to 0.90) and agreement percentages (80% to 90%) signify that the materials meet the quality standards expected by the validators. However, several areas for potential refinement were suggested. For Aspect 1 (Content Quality), which received an Aiken's V value of 0.78, the validators recommended further elaboration on the depth of critical thinking components in the materials, such as incorporating more case-based or inquiry-driven tasks to better support critical thinking development. For Aspect 2 (Design and Usability), with an Aiken's V value of 0.85, validators emphasized the importance of ensuring seamless QR Code integration across various devices and usability for students with varying technological proficiency levels. The highest-scoring Aspect 3 (Interactivity and Engagement), with an Aiken's V value of 0.90, reflected excellent interactivity. However, validators suggested enhancing student engagement by integrating additional multimedia resources, such as real-world examples or localized cultural elements, to make the materials more contextually relevant. Lastly, Aspect 4 (Alignment with Learning Objectives), which also had an Aiken's V value of 0.85, highlighted the need for continuous alignment between QR Code content and measurable learning outcomes. Validators recommended regularly updating the QR Code-linked resources to ensure their relevance to current educational standards and critical thinking benchmarks.

These results indicate that the teaching materials are considered appropriate and suitable to support the development of prospective teachers' critical thinking skills, while also offering room for improvement. By addressing these recommendations, the teaching materials can be further optimized to maximize their educational impact. These teaching materials are designed also to meet learning needs in accordance with students' local context and characteristics by utilizing digital technology, which is currently very relevant in the 21st-century learning era.

Previous studies have shown that using digital technology in learning can improve student engagement and learning outcomes. For example, e-learning modules are an innovative learning strategy that has proven effective in increasing success and learning outcomes. By utilizing digital technology, e-learning modules allow students to learn according to their own pace and learning style. This allows for a more personalized and adaptive learning process, which ultimately can increase learning motivation and student engagement in learning (Logan et al., 2021). The use of digital modules designed with integrated videos and images facilitates students in independently learning concepts (Syahfitri, 2024). Additionally, interactive teaching materials offer the advantages of presenting engaging content for easy comprehension, providing convenient access, and boosting users' learning motivation (Nurlita, 2023).

The presentation of videos, images, and various learning activities can be incorporated into modules with the help of QR codes, such as the teaching materials developed in this study. Using QR codes provides quick and easy access to additional material, stimulating student engagement and increasing understanding (Ahmed & Zaneldin, 2020). QR codes in teaching materials allow the integration of rich multimedia content, such as videos, images, and interactive simulations, which help students understand complex concepts and encourage independent learning and further exploration. This finding aligns with research that shows that technology-based learning, such as that done by Miftakhurrohmah et al. (2023), can improve students' critical thinking skills by providing a more interactive and immersive learning environment.

The integration of QR Code technology in education offers significant benefits, such as improved access to information, fostering digital literacy skills, and increased student engagement in the learning process. Consequently, to improve the quality of literacy education, there is an urgent need to research and develop instructional methods that utilize QR-code technology within the framework of literacy learning (Paramita & Lestari, 2024). Students benefit greatly from the use of QR codes in student-centred learning, as these tools enhance motivation, engagement, and access to educational resources. QR codes promote autonomy and collaboration, fostering active participation and self-directed learning. Despite

challenges such as varying motivation in group activities and time constraints, their integration into learning environments is widely supported. To maximize their potential, educators should focus on creativity and effective time management, ensuring QR codes continue to enrich student-centered approaches (Sriyulianti, 2024). In addition, QR codes enhance learning by integrating pictures, videos, colors, and texts that capture students' attention and excitement. This approach helps students retain and apply skills while forming a clear mental and motor perception. The engaging environment accelerates skill mastery and improves comprehension, while also saving time and effort (Al-Sababha, 2024).

To develop critical thinking skills, this teaching material is focused on activities that stimulate analysis, evaluation, and synthesis of information outlined in the information box (Ramdani, et al., 2021). This is in line with findings by Rahmawati et al. (2021), who state that well-designed teaching materials can develop students' critical thinking skills by emphasizing problem-solving and decision-making in relevant contexts. In addition Anggraeni (2023) stated that one effective strategy to foster critical thinking skills in education is to implement a learning model specifically designed to cultivate these abilities.

Integrating technology such as AR tools with effective pedagogical approaches can offer students unique and memorable experiences that enhance their enthusiasm and understanding of STEAM subjects and actively promote the development of critical thinking and other essential 21st-century skills (Alkhabra et al., 2023). Aligned with the findings of this study, the QR code-assisted teaching materials developed enable students to access supplementary content such as videos, articles, or simulations that stimulate analytical and reflective thinking. For example, students can explore case studies or experiments that encourage them to question the provided information and evaluate various solutions. The QR code-integrated modules can incorporate activities like quizzes, discussions, or educational games that challenge students to connect concepts, analyze situations, and propose evidence-based solutions. This approach supports the development of critical thinking.

Conclusion

This study successfully developed innovative teaching materials for the Basic Concepts of Science using QR Codes, which are valid and suitable for enhancing the critical thinking skills of prospective elementary school teachers. The teaching materials integrate QR Code technology to provide easy access to various supplementary learning resources, such as instructional videos, interactive multimedia, and virtual simulations. The validation process demonstrated that the teaching materials have a high level of validity based on Aiken's V analysis. The integration of specifically designed learning activities can also effectively facilitate prospective teachers' critical thinking skills in understanding the basic concepts of science. Further research is recommended to evaluate the effectiveness of these teaching materials in improving critical thinking skills through broader implementation on a larger scale

References

Adhani, A., & Rupa, D. (2020). Analisis Pemahaman Konsep Mahasiswa Pendidikan Biologi pada Matakuliah Fisiologi Tumbuhan. *Quantum: Jurnal Inovasi Pendidikan Sains*, *11*(1), 18-26.

Ahmed, W., & Zaneldin, E. (2020). Blending QR code with video learning in the pedagogical process for the college foundation level. *Interactive Technology and Smart Education*, *17*(1), 67-85.

Alkhabra, Y. A., Ibrahem, U. M., & Alkhabra, S. A. (2023). Augmented reality technology in enhancing learning retention and critical thinking according to STEAM program. *Humanities and Social Sciences Communications*, *10*(1), 1-10.

Al-Sababha, K. M. H. (2024). The effect of using a QR code-enhanced brochure on students' knowledge and skill learning outcomes. *Edelweiss Applied Science and Technology*, *8*(2), 84-99.

Amirudin, A., & Widiati, U. (2017, June). Pentingnya Pengembangan Bahan Ajar Tematik untuk Mencapai Pembelajaran Bermakna bagi Siswa Sekolah Dasar. In *Prosiding Seminar Nasional Mahasiswa Kerjasama Direktorat Jenderal Guru dan Tenaga Kependidikan Kemendikbud 2016*.

Anggraeni, D. M., Prahani, B. K., Suprapto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, *49*, 101334.

Awwalina, N. M., & Indana, S. (2022). Pengembangan E-Modul Interaktif Berbasis QR Code untuk Melatihkan Literasi Sains Siswa Kelas X SMA pada Materi Ekosistem. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, *11*(3), 712-721.

Barus, A. M., Sari, W. W., Stephanie, L., & Rahayu, I. P. (2022). *Panduan dan Praktik Baik Project-Based Learning: Menginspirasi, Mencipta, dan Mendedikasikan Karya*. PT Kanisius.

Fahlevi, M. R. (2022). Upaya pengembangan number sense siswa melalui kurikulum merdeka (2022). *Sustainable Jurnal Kajian Mutu Pendidikan*, *5*(1), 11-27.

Firmansyah, G., Hariyanto, D., & Kurniawan, R. (2019, October). Pengaruh Bahan Ajar Berbasis Qr Code Terhadap Motivasi Belajar Dan Keterampilan Dasar Bermain Tenis Meja. In *Prosiding Seminar Nasional IPTEK Olahraga (SENALOG)* (Vol. 2, No. 1).

Handayani, H., Sopandi, W., Syaodih, E., Setiawan, D., & Suhendra, I. (2019). Dampak perlakuan model pembelajaran radec bagi calon guru terhadap kemampuan merencanakan pembelajaran di sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *4*(1), 79-93.

Harahap, M. S., Harahap, S. D., Nasution, S. W. R., Siregar, D. A., & Karolina, E. (2023). Pengembangan Bahan Ajar Matematika Diskrit Berbasis Digital QR-Code untuk Meningkatkan Efektivitas Belajar Mahasiswa Pendidikan Matematika Institut Pendidikan Tapanuli Selatan. *JURNAL MathEdu (Mathematic Education Journal)*, *6*(1), 29-39.

Indriani, H., Rosyida, F., Soelistijo, D., & Suharto, Y. (2023). Pengembangan booklet digital berbantuan HTML 5 pada materi keragaman budaya Indonesia siswa kelas XI SMA. *Jurnal Integrasi dan Harmoni Inovatif Ilmu-Ilmu Sosial*, *3*(3), 203-224.

Kharisma, J. Y., & Asman, A. (2018). Pengembangan bahan ajar matematika berbasis masalah berorientasi pada kemampuan pemecahan masalah matematis dan prestasi belajar matematika. *Indonesian Journal of Mathematics Education*, *1*(1), 34-46.

Logan, R. M., Johnson, C. E., & Worsham, J. W. (2021). Development of an e-learning module to facilitate student learning and outcomes. *Teaching and Learning in Nursing*, *16*(2), 139-142.

Manurung, A. S., Fahrurrozi, E. U., & Gumelar, G. (2023). Implementasi berpikir kritis dalam upaya mengembangkan kemampuan berpikir kreatif mahasiswa. *Jurnal Papeda; Vol*, *5*(2), 50-62.

Megawati, A. Y. I., Lukito, A., & Rachmasari, D. H. (2023). Integrasi project based learning dengan stem pada pembelajaran fisika sebagai pendekatan efektif untuk meningkatkan keterampilan abad 21. *Humantech: Jurnal Ilmiah Multidisiplin Indonesia*, *2*(5), 894-904.

Miftakhurrohmah, N. L., Masykuri, M., Ariyani, S. R. D. A., & Noris, M. N. (2023). The effect of guided inquiry-based excretion system e-module to improve critical thinking and ICT literacy skills for students. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 681-689.

Nurlita, A. A. (2023). Development of digital-based interactive teaching materials in draping courses. *Indonesian Journal of Teaching in Science*, *3*(1), 97-104.

Paramita, P. E., Aziz, F., & Lestari, N. C. (2024). Animal learning media in nurturing literacy of elementary school children using QR-Code technology. *Jurnal Scientia*, *13*(01), 410-415.

Permana, N. D., Ramadan, C. P., Syarif, M. I., Mahartika, I., Setyaningsih, R., & Wibowo, F. C. (2023). The Development of Science E-modules in Junior High Schools Integrated with Al-Qur'an Verses and Assisted by Virtual Simulations on the Subject of Vibration, Waves and Sound. *Jurnal Inovasi Pendidikan IPA*, *9*(2), 164-176.

Rahayu, A. H., Sopandi, W., Anggraeni, P., Tursinawati, T., & Septinaningrum, S. (2021). Keterampilan berpikir kritis mahasiswa PGSD melalui model read-answer-discuss-explain-and create (RADEC) berorientasi masalah. *Jurnal Educatio FKIP UNMA*, *7*(3), 680-686.

Rahmawati, S., Masykuri, M., & Sarwanto, S. (2021). The effectiveness of discovery learning module classification of materials and its changes to enhance critical thinking skills. *Jurnal Inovasi Pendidikan IPA*, *7*(1), 74-84.

Ramdani, A., Jufri, A. W., Gunawan, G., Fahrurrozi, M., & Yustiqvar, M. (2021). Analysis of students' critical thinking skills in terms of gender using science teaching materials based on the 5E learning cycle integrated with local wisdom. *Jurnal Pendidikan IPA Indonesia*, *10*(2), 187-199.

Salma, D. K. (2020). Pengembangan Bahan Ajar Berbasis Kontekstual Berbantu Qr Code Pada Mata Pelajaran Praktikum Akuntansi Lembaga/Instansi Pemerintah Kelas Xii Smk. *Jurnal Pendidikan Ekonomi: Jurnal Ilmiah Ilmu Pendidikan, Ilmu Ekonomi Dan Ilmu Sosial*, *15*(1), 1-8.

Sriyuliyanti, S. (2024). Quick Response Codes in Promoting Student-Centred Learning. *JEPAL (Journal of English Pedagogy and Applied Linguistics)*, *4*(2), 73-86.

Suryana, C., & Muhtar, T. (2022). Implementasi Konsep Pendidikan Karakter Ki Hadjar Dewantara di Sekolah Dasar pada Era Digital. *Jurnal Basicedu*, *6*(4), 6117-6131.

Syahfitri, J. (2024). The utilization of local wisdom-based interactive digital module to improve

students' critical thinking skills. *International Journal of STEM Education for Sustainability*, *4*(1), 110-119.

Waruwu, A. N., Rahmadhanty, A., Hutagalung, A., Sari, I. P., & Almsy, Z. (2023). Keterampilan Bertanya dalam Proses Pembelajaran di Kelas. *Paedagogi: Jurnal Kajian Ilmu Pendidikan (e-journal)*, *9*(1), 65-71.

Yani, R., Anwar, R. B., & Vahlia, I. (2022). Pengembangan Modul Matematika Berbasis Pendekatan Kontesktual Disertai Qr Code Pada Materi Logaritma. *Jurnal Pendidikan Matematika (EMTEKA)*, *11*(1), 224-234.