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The Implementation of a Deep Learning Approach Using QR Code–Based Learning Media to Enhance High School Students' Academic Performance in Kinematics

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Abstract: Educators and schools might seek the availability of adequate learning resources. The learning resources for kinematics at SMAN 1 Bawang are limited in quantity and diversity. Previous observations indicated that most students relied on rote memorization of formulas, which led to difficulties when applying them to problems. Consequently, the author is motivated to investigate the application of the Deep Learning Approach utilizing QR Code learning media, aiming to assess the enhancement of high school students' learning outcomes in kinematics who engaged with this method, as well as to compare the improvement in learning outcomes between the experimental and control classes. The research employed a quasi-experimental design with a pretest–posttest control group. The research population comprised students at SMA Negeri 1 Bawang, with the sample consisting of students from grades XI VI and XI VII. The sampling technique employed was cluster random sampling. The instruments utilised were assessments and surveys to evaluate learning outcomes and student feedback. The statistical test yielded a significant value. The two-tailed p-value of <0.05, specifically 0.00, indicates the rejection of H_0. Consequently, it is concluded that a difference exists in the learning outcomes of kinematics material between pretest and posttest scores in the experimental class, which utilised a deep learning approach with QR code media. The data reveal an improvement from a pretest score of 47.37 to a posttest score of 77.73, reflecting a 30.36% increase. The implementation of a deep learning strategy utilising QR code media demonstrates a significant enhancement in learning outcomes relative to traditional classroom instruction. The research suggests creating an interactive digital module that combines printed materials with actual experimental videos or virtual simulations, accessible via QR codes in each sub-chapter of the kinematics content.

Keywords: Deep learning; Learning media; Learning outcomes; QR-Code

Introduction

Attaining learning objectives is essential for effective teaching and learning endeavours. Elements contributing to the efficacy of teaching and learning activities may originate from both internal and external sources. The learning media employed are an external component that influences this. Learning media should be organised to facilitate students' access to learning, unhindered by spatial and temporal limitations. This aligns with the adoption of technology. Moreover, to ensure that learning transcends mere knowledge acquisition and has significance, it is essential to employ a deep learning approach, which emphasises the exploration of examples or issues framed as enquiries.

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The application of a deep learning approach integrates various disciplines utilised in daily life.

Access to learning resources is crucial in the instructional process. Sufficient learning resources are essential to fulfil students' learning requirements. The primary hurdles encountered include difficulties in comprehending concepts, processing information, developing comprehension, and applying content in daily life. This challenge is most notable in kinematics, where students must conceptualise abstract notions such as position, velocity, and acceleration that vary over time. Strategies to navigate this complexity necessitate the utilization of novel learning media as a conduit between theory and tangible comprehension. Kinematics necessitates dynamic visual representations to enhance students' responses to mathematical and pictorial data. By effectively integrating learning media, barriers to understanding the concept of motion can be reduced, enabling students not only to resolve technical issues but also to apply kinematic principles to elucidate diverse motion phenomena in the real world. Kinematics is a subject that high school students must study. Kinematics is a discipline that examines motion and its underlying causes. Kinematics can be better understood through media than through traditional lecture-based explanations. Diverse methodologies may be employed; however, specific techniques must be implemented, including a deep learning approach. This aims to furnish students with a profound comprehension, transcending mere memorization of theories or formulas, thereby fostering a more meaningful grasp of the material.

The majority of students at SMA Negeri 1 Bawang enrolled in kinematics courses mostly memorise formulas, hindering their ability to apply them to problem-solving. The material includes theoretical explanations and formulas, but lacks case examples or contextual problems. This is one rationale for the author's application of the deep learning approach in the study. To fulfil the learning objectives using this method, the author identified the fundamental and relevant competencies or applications to be utilised via QR codes integrated into student worksheets as learning media.

The authors' investigation of media utilisation stems from the restricted availability of learning tools for students. The QR code was selected as the medium due to its superior ease of use and practicality. The incorporation of QR codes into student worksheets, utilising the deep learning approach, introduces a novel integration of learning strategies and media. QR codes are perceived as more user-friendly than barcodes due to their alignment with contemporary technological advancements. Utilising a mobile phone or smartphone, a single scan can present learning media in the form of videos curated by the author to facilitate authentic learning experiences through audio-visual means and to analyse challenges encountered in daily life. This combination enables students to review information continuously and study anywhere, not just at school.

The deep learning approach and Problem-Based Learning (PBL) frameworks are contemporary strategies demonstrated to enhance educational quality. The deep learning approach can markedly improve students' mathematical performance and practical intelligence by fostering comprehension, connecting new information to prior knowledge, and refining critical thinking skills (Hammadi et al., 2023). Moreover, the efficacy of learning can be enhanced by a systematic Problem-Based Learning (PBL) paradigm that emphasises problem orientation in assessing the problem-solving process (A'yun & Murtini, 2025). The integration of technology, specifically QR code cards, into Project-Based Learning has been empirically demonstrated to enhance students' cognitive learning outcomes and problem-solving skills compared with traditional direct instruction techniques (Haryanto et al., 2024; Santoso et al., 2019).

An aspect of learning intimately associated with technology is learning media (Fatonah & Isdaryanti, 2024). Learning is not exclusively dependent on instructional resources from a singular source, such as textbooks. The utilisation of learning media can facilitate student learning. Learning media are tangible instruments employed to transmit learning content (Alika & Radia, 2021). Consequently, improving learning media is essential for developing a more holistic and adaptable learning experience.

The application of a deep learning approach in higher education has demonstrated improvements in student engagement, critical thinking abilities, and learning efficiency across various disciplines, including geography and physical education (Syafril & Junaidin, 2025; Huang & Yu, 2022). Studies indicate that methodologies like deep learning-based Project-Based Learning (PjBL) markedly enhance critical scientific thinking abilities among students in low- and middle-income nations (Taufik et al., 2025). This technology facilitates a more thorough academic assessment via data-driven performance forecasting and enhances students' physical fitness more efficiently than conventional approaches (Kadam & Oza, 2025; Wang, 2024). Consequently, investing in faculty development and examining the long-term effects of practical implementations is a strategic measure to maximise the potential of this technology in learning practice.

Physics is a fundamental discipline that examines natural phenomena across distinct areas, including kinematics, which focuses on the geometric analysis of particles, including position, distance, and displacement

(Lusiani et al., 2021; Rismaningsih et al., 2021). In mastering these intricate topics, abstraction abilities are essential for students to identify patterns and construct meaningful learning beyond mere mathematical formalism (Handayani et al., 2022). Nonetheless, empirical evidence indicates that in computational thinking-based problem-solving methodologies, students predominantly excel in the decomposition and abstract phases. At the same time, they encounter challenges in the visualisation and design phases at elevated cognitive levels, including analysis, evaluation, and creation (Rabiudin et al., 2023). The challenges are primarily attributable to students' inadequate capacity to analyse case narratives and discern significant variables. Consequently, the incorporation of more structured computational thinking is crucial for reducing conceptual and analytical errors in physics education.

Current inadequate student learning outcomes are attributed to the ineffective utilisation of technology-based learning media and the insufficient application of problem-solving learning paradigms by educators (Tsaniyyati & Andriani, 2024). This scenario underscores the need for educators to create adaptive learning resources that align with students' circumstances and needs while integrating current technological advancements (Koehtae et al., 2025). Teachers are expected to enhance the learning environment by incorporating technological innovation into problem-solving processes, thereby addressing contemporary educational issues.

The integration of QR Code technology in education has demonstrated its efficacy as an innovative tool for enhancing learning quality across diverse disciplines and educational levels. QR Codes, as a two-dimensional encoding system that efficiently stores digital information, provide students with convenient, autonomous access to learning resources, instructional videos, and media usage guidelines (Az-zahra et al., 2025; Putri & Prasetyaningtyas, 2025; Sondhi & Kumar, 2022). Numerous studies indicate that the incorporation of QR Codes in modules, case study teaching materials, and digital book applications can markedly enhance learning outcomes, critical thinking skills, scientific literacy, and students' numeracy competencies (Arifah et al., 2023; Defianti et al., 2025; Kartika Sari & Nabilla Qonita, 2024; Harjo et al., 2025). Besides cognitive factors, the implementation of QR Code-based media, including the U-Learning system and POE-based modules, has demonstrated an enhancement in students' motivation, engagement, and psychomotor skills, particularly in physical education and for students with special needs (Chin et al., 2015; Fernandez et al., 2024; Haris et al., 2023; Sidik et al., 2021). QR code-based instructional materials have demonstrated considerable efficacy in enhancing learning outcomes and technical skills relative to traditional approaches (Al-sababha, 2024; Mahendra & Agustiana, 2024; Nesami et al., 2025; Widanti & Fathurrahman, 2024).

QR Code-based modules in education have demonstrated efficacy as an innovative solution that markedly enhances student motivation and learning outcomes across diverse disciplines. This technology integration facilitates the creation of interactive and accessible materials, thereby promoting engagement and student-centered learning (Kandiri et al., 2025; Sriyuliyanti, 2024). QR Codes offer advantages over traditional barcodes because they can store 10 times more data in the same space, making them highly efficient for conveying dense information (Widyasari et al., 2019). Moreover, the application of this media in particular disciplines such as Physics, History, and Mathematics has been empirically demonstrated to enhance digital literacy, rectify student misconceptions, and elevate learning outcomes to 87.47% (Anggraeni et al., 2022; Ar Hanan et al., 2022; Sejati & Sayekti, 2023; Harjo et al., 2025). Consequently, the use of QR Code-based modules not only enhances information dissemination but also endows students with 21st-century competencies through the purposeful application of digital media.

The application of Realistic Mathematics Education (RME) with PANTAR learning media supplemented by QR codes can enhance student engagement and elevate mathematics learning outcomes (Agustina et al., 2025). The integration of QR code-based digital media in science education significantly enhances its feasibility and effectiveness in fourth-grade science classes (Kartika Sari & Nabilla Qonita, 2024). The Google Sites-based physics learning media, using QR codes for particle dynamics content, meet the required standards and criteria, proving highly beneficial and appropriate as a physics educational resource for tenth-grade high school students (Prihatiningtyas et al., 2022).

EGAMERASI media significantly enhances students' cognitive skills and motivation in studying kinematics, yielding effective outcomes in knowledge, comprehension, application, and analysis (Saputro et al., 2025). Empirical research in the field supports the utilisation of digital technology-based learning media to address inadequate physics learning results. A pertinent study by Zannah et al. (2022) involving 11th-grade students at Arjasa State Senior High School demonstrated that QR Code-based Student Worksheets on Light Waves significantly enhanced academic performance and stimulated student interest in learning (Zannah et al., 2022).

The achievement at Arjasa State Senior High School demonstrates that incorporating quick response codes into educational tools can transform students' engagement with challenging content, making it more engaging and practical. Increased access to materials encourages students to freely explore physics concepts, leading to substantial improvements in learning outcomes. These findings establish a robust basis for the creation of analogous learning media that prioritise not only the dissemination of knowledge but also the enhancement of student motivation and active engagement in the science learning process at the secondary school level. The authors aspire to pursue studies at the secondary school level, specifically at State Senior High School 1 Bawang, located in Batang Regency, Central Java.

The prevailing issue among students is their tendency to memorise formulas, which hinders their ability to apply them to problems. Consequently, educators who embrace technological advancements integrate media into their teaching to enhance student learning outcomes, thereby rendering the learning experience more meaningful. The objective of the deep learning approach is to strengthen the significance of learning by addressing quotidian challenges. Students need a comprehensive understanding of the subject being offered.

Another factor motivating researchers to pursue further study is the limited learning resources at State Senior High School 1 Bawang, which consist solely of an incomplete library collection. To address this deficiency, implementing QR Codes can facilitate access to educational materials, allowing students to scan and access comprehensive content without constraints on time or space. Furthermore, it can render the utilisation of student worksheets more pragmatic and environmentally sustainable, thus contributing to ecological awareness. This study employs a deep learning approach, which facilitates the integration of one subject with another and utilises real-life issues, thereby enhancing relevance for students through direct analysis of applications in particular cases or inquiries.

This work introduces a fresh approach by employing deep learning-based QR Codes as a learning medium for kinematics content to enhance student learning outcomes, drawing on this and numerous related studies. Considering restricted access to educational resources, the author proposes utilising QR codes, which serve both as a conduct for delivery and as a mechanism for facilitating deep learning, with the objective of fostering a profound understanding of the subject matter.

The integration of a deep learning approach with QR Code technology represents a novel contribution that distinguishes it from prior research. However, other studies have documented the use of QR codes in alternative media, such as EGAMERASI. Recent research by Saputro et al. (2025) demonstrates that EGAMERASI media effectively enhances students' cognitive abilities and motivation in kinematics; however, the study primarily focuses on advancing knowledge, understanding, and application through an educational game platform. Conversely, research on deep learning approaches and the application of QR-code media demonstrates significant potential to enhance meaningful learning and promote long-term information retention (Hammadi et al., 2023; Kandiri et al., 2025).

A notable research gap exists regarding the integration of a deep learning approach with QR-code media in the realm of kinematics materials. If EGAMERASI prioritises game-based interactions for motivation, then integrating QR codes with a deep learning approach provides a more adaptable and comprehensive way to link abstract kinematic principles with students' existing knowledge. This gap presents an opportunity to analyse how QR-Code media operates not only as a digital accessibility tool but also as a pedagogical instrument that fosters independent deep understanding and digital literacy, aspects that have not been adequately addressed in traditional educational game media. The authors formulate the problem as follows: (1) Does the application of deep learning utilising QR-Code media enhance the learning results of high school students in kinematics? Is there a disparity in the enhancement of learning results regarding kinematics content between the experimental class and the control class of high school students?

This study seeks to evaluate the enhancement of learning outcomes in high school students in kinematics material through deep learning facilitated by QR code media, and to compare learning outcomes between experimental and control classes. Owing to restricted access to instructional resources, the author proposes using QR codes, which serve both as a conduit for delivery and as a mechanism for deep learning, to facilitate a profound understanding of the subject matter.

Method

This study employs a quantitative, experimental design to evaluate the efficacy of a treatment on a designated variable. This approach utilises a trial design in which the experimental group receives a specific treatment, while the control group serves as a comparison and receives either standard care or no treatment at all.

This study utilised an experimental methodology to objectively and quantitatively assess the significance and efficacy of the tested approach in enhancing research outcomes (Darmawan et al., 2024). The methodology employed was a quasi-experimental research design, incorporating several variations including Time Series Design, Single Subject Design, Control Time Series Design, Separate Sample Pretest-Posttest, Intact Group Comparison, and Non-Equivalent Control Group Design (Abraham & Supriyati, 2022). This design choice enabled researchers to conduct a comprehensive assessment of treatments used in controlled field conditions.

Table 1. Classical Experimental Design (Darmawan et al., 2024)

Design Pre-experimental	True-Experimental	Quasi Experimental
The One-Shot Case Study Design: R O	The Pretest-postest Control Group Design: R O X O R O O	The Time Series Experimental Design: O O O O X O O O O
The One Group Pretest-Posttest Design: O X O	The Solomon Four Group Design: R O X O R O O R X O R O	Non-Equivalent Control Group Design: O X O O O
The Static Group Comparison Design: O O O	The Posttest Only Control Group Design: R O X O R O O	Counterbalanced Design O / Time I / Time II / Time III / Time IV A: X O X O X O X O B: X O X O X O X O C: X O X O X O X O D: X O X O X O X O The Separate Sample Pretest-Posttest Design: R O (X) R X O The Multi Time Series Design O O O O X O O O O O O O O O O O O

Information: X: Treatment; O: Observation; R: Randomisation

This research is a quasi-experimental study. The research flow is shown in Figure 1.

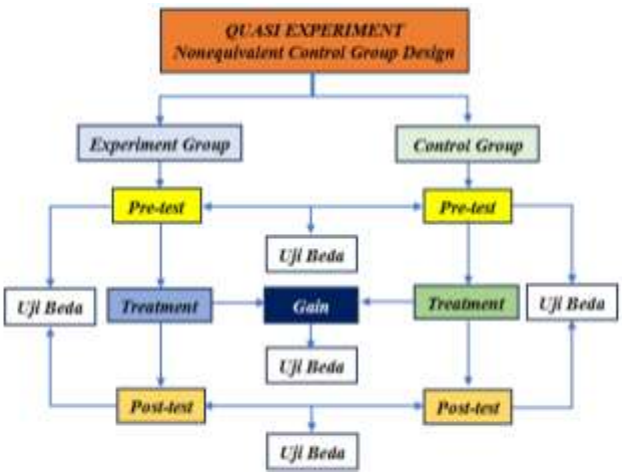


Figure 1. Research flowchart

The research design used was a pretest-posttest control group design. The research design is displayed in Figure 2.

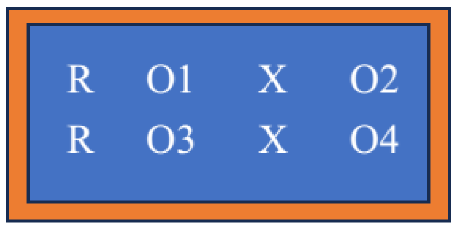


Figure 2. Research design

Information:
R= Random
O1 = pretest of experimental class
X = Deep Learning approach utilising QR-Code-based media
O2 = posttest of experimental class
O3 = pretest of control class
O4 = posttest of control class

The sample population consisted of students from State Senior High School 1 Bawang. The research sample comprised students in grades XI-VI and XI-VII. The employed sampling method was cluster random sampling.

Tests are a commonly employed evaluative instrument in educational assessments, in conjunction with other methodologies (Muhammad et al., 2022). The employed data collection approach was a test. The tool employed was a deep learning kinematics assessment comprising three questions, each covering one of the three stages of deep learning.

The study instrument employed was a Student Worksheet featuring inquiries regarding the implementation of the deep learning approach utilising QR codes. The instructional media employed were created in full colour to enhance student participation. The worksheet was organised in alignment with the learning outcomes of the physics sub-chapter on kinematics, which is founded on deep learning. The research tool is available in two formats:

By Llink
https://bit.ly/MediaQRCodeberbasisDeepLearning

By QR-Code

Figure 3. QR Code media based on deep learning (Source: researchers document)

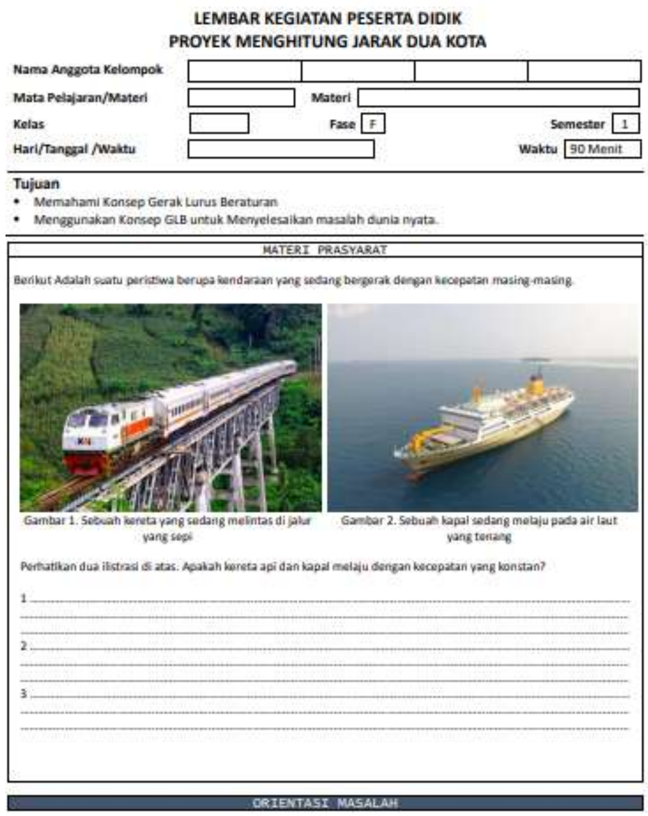
Implemented learning activities must have objectives that must be attained to enhance the quality of teaching and learning, thereby impacting the overall quality of education. The effectiveness of the learning process can be assessed through the evaluation of learning outcomes. The review of learning outcomes must include all assessment domains: cognitive, affective, and psychomotor (Vitantri et al., 2025). This research assessed students' cognitive and affective dimensions.

The research instrument employed was a cognitive assessment utilising pretest and posttest questions to evaluate the learning outcomes achieved. Students received pretest questions prior to the treatment, which involved applying a deep learning approach utilising QR-code media. Posttest questions were administered after the treatment in the experimental class, while the control class underwent pretest and posttest assessments through conventional learning methods. Additionally, students were administered a questionnaire to assess the extent of their response achievement regarding the application of the deep learning strategy utilising QR-code media. The questionnaire was disseminated in two variants, specifically:

By Link
https://bit.ly/KuesionerDeepLearningQRCodeKinematika

By QR-Code

Figure 4. QR-Code questionnaire for deep learning implementation using QR-Code (Source: researchers document)


LEMBAR KEGIATAN PESERTA DIDIK
PROYEK MENGHITUNG JARAK DUA KOTA

Nama Anggota Kelompok
Mata Pelajaran/Materi
Materi
Kelas
Fase F
Semester 1
Hari/Tanggal /Waktu
Waktu 90 Menit

Tujuan
- Memahami Konsep Gerak Lurus Beraturan
- Menggunakan Konsep GLB untuk Menyelesaikan masalah dunia nyata.

MATERI PRASYARAT

Berikut Adalah suatu peristiwa berupa kendaraan yang sedang bergerak dengan kecepatan masing-masing.

Gambar 1. Sebuah kereta yang sedang melintas di jalur yang sepi
Gambar 2. Sebuah kapal sedang melaju pada air laut yang tenang

Perhatikan dua ilistrasi di atas. Apakah kereta api dan kapal melaju dengan kecepatan yang konstan?

1
2
3

ORIENTASI MASALAH

Figure 5. Front cover of student worksheet (Source: researchers document)

This student worksheet includes a QR code for instant access to learning materials.

Bumi adalah sebuah planet yang berbentuk menyerupai bola dan kita terkadang tidak menyadarinya. Misalkan kita naik sebuah kapal dari Pelabuhan Teluk Dalam di Nias (Indonesia) menuju Pelabuhan Tamatave (Madagaskar). Dalam perjalanan itu kita merasa lintasan yang berupa lautan adalah lintasan yang lurus. Jika kita menyadari bahwa kita sebenarnya sedang berlayar di atas bola raksasa maka kita akan menyadari bahwa lintasan yang kita lalui membentuk garis melengkung seperti busur panah.

Apakah gerak kapal tersebut merupakan gerak lurus beraturan?

MATERI PEMBELAJARAN

GERAK LURUS BERATURAN | GLB

Suatu benda dikatakan bergerak jika benda itu mengalami perubahan kedudukan terhadap titik tertentu sebagai acuan pada selang waktu tertentu.

Saat seorang pelajar berangkat sekolah dan melewati sebuah pohon maka dia sedang bergerak. Posisi awalnya berada di sebelah kiri pohon kemudian berubah posisi menjadi tepat di depan pohon dan berubah posisi lagi berada di kanan pohon. Pohon tersebut merupakan titik acuannya Karena titik acuan bisa berbeda-beda, maka gerak benda bersifat relatif. Artinya, benda yang bergerak menurut acuan A belum tentu bergerak untuk acuan B. Salah satu jenis gerak yang umum adalah gerak lurus. Sesuai dengan sebutannya, gerak lurus adalah gerak benda yang lintasannya berupa garis lurus atau lintasan yang relatif lurus pada selang waktu tertentu.

Sebuah kapal yang mengelilingi bumi setelah sekian waktu kemudian kembali ke Pelabuhan tempat dimana kapal tersebut berangkat, apakah kapal sudah dikatakan bergerak?

Kapal tetap dikatakan bergerak karena selama perjalanan kapal mengalami berbagai tempat misalnya Pelabuhan, pulau, gunung dan lainnya yang berbeda, artinya kapal mengalami perubahan posisi walaupun pada akhirnya kembali ke titik semula. Tapi dari peristiwa ini kemudian muncul dua istilah dalam fisika yaitu perpindahan dan jarak. Pada peristiwa tersebut dapat dikatakan perpindahan kapal sama dengan nol karena titik awal dan akhir sama, namun jarak yang di tempuh kapal tidak sama dengan nol. Jawak yang di tempuh kapal Adalah panjang lintasan yang dilalui oleh kapal.

Jarak dan perpindahan kemudian memunculkan dua istilah yaitu kecepatan dan kelajuan. Berikut Adalah rumusnya:

$$Kecepatan = \frac{Perpindahan\ (meter)}{Selang\ Waktu (detik)} \qquad Kelajuan = \frac{Jarak\ (meter)}{Selang\ Waktu (detik)}$$

Dari rumus tersebut dapat dikatakan bahwa Kecepatan Adalah besaran vector karena dipengaruhi oleh arah sedangkan kelajuan Adalah besaran scalar karena tak dipengaruhi oleh arah.

SISTEM KOORDINAT GEOGRAFIS

Titik Koordinat sebuah Lokasi di permukaan Bumi

Figure 6. QR code display in the student worksheet (Source: researchers document)

The goals to be attained using the student worksheet instrument for the Project Calculating the Distance between Two Cities are as follows: Students comprehend the principle of Uniform Straight Motion (*Gerak Lurus Beraturan*). Students apply the principle of Uniform Straight Motion to address real-world challenges. The QR-Code student worksheet will assess attainment of learning outcomes in kinematics by completing three learning activities aligned with the stages of deep learning. The cognitive level assessed through the student worksheet comprises multiple stages: Activity 1 (understanding), representing stage 1 in Problem Based Learning (PBL) as problem orientation; Activity 2 (applying), which includes three stages: stage 2 PBL as organising students for learning, stage 3 PBL as investigation, and stage 4 PBL as presenting discussion outcomes; Activity 3 (reflecting), encompassing stage 5 in PBL as analysis and evaluation.

Validity and reliability assessments are conducted on instruments to ensure the quality and precision of data collected in a study. Validity tests assess the accuracy or legitimacy of an instrument, confirming that each question effectively measures the variable under investigation. Reliability tests evaluate the consistency and stability of an instrument, ensuring that measurement findings remain consistent and dependable throughout various time frames and situations.

The evaluation of the assessment tools was analysed from both logical and empirical viewpoints. The rational analysis included the material, construction, and language domains. The empirical analysis encompassed validity, reliability, difficulty level, and test discrimination (Hasan et al., 2021). Quantitative data analysis employed descriptive and inferential statistics. Data were processed using MS Excel and SPSS 26 for Windows.

Data analysis employing descriptive statistics included calculating the mean, standard deviation, minimum, and maximum values for pretest and posttest data. Prerequisite Analysis Test: Normality assessment of data via the Shapiro–Wilk test. Given that the sample size is less than 100, the test was used to verify the normality of the data. Hypothesis Test: Paired Sample T-Test to evaluate significant changes between pretest and posttest results. Data analysis was conducted on the pretest and posttest findings to ascertain the enhancement in student learning outcomes.

Results and Discussion

Deep Learning

Research documentation was carried out in three activities (5 stages) according to the student worksheet, namely:

Figure 7. Activity 1 (stage 1) problem orientation

Figure 8. Activity 2 (stage 2) as organising students for learning

Figure 9. Activity 2 (stage 3) investigation

Figure 10. Activity 2 (stage 4) presenting discussion outcomes

Figure 11. Activity 3 (stage 5) analysis and evaluation

Observations regarding the execution of learning were conducted over two meetings. Learning was deemed effective if 85% of all stages were completed. In 15% of cases where the learning implementation phases were not completed, the closing activity stage, which included instructor feedback and the conclusion of learning activities, was not carried out due to time constraints. Generally, the execution of the deep learning approach utilising QR-Code media on kinematics material commenced with the actions of comprehension, application, and reflection. Additionally, at the second meeting, all educational phases were comprehensively executed. The outcomes of the learning implementation are presented in Table 2.

Table 2. Learning Implementation Results

Meeting	Number of stages	Implemented	Not implemented	%
1st Meeting	17	15	2	88.24%
2nd Meeting	17	17	0	100%

According to Table 2, the learning observations indicate that learning implementation in the first and second meetings exceeded 85%. This indicates that deep learning with QR-Code-based student worksheets can be characterised as effective. Three actions in deep learning were executed proficiently.

QR-Code Based Learning Media

Validity Test Result of Research Instruments

Validity was assessed at a significant level of 0.05. Degrees of freedom (df) = N − 2 = (60 − 2) = 58. The r-table value for df = 58 was 0.21. If the r-count exceeds the r-table value, it is deemed valid. All Pearson correlations exceeding the r-table indicate that all items are valid. A statement item is deemed valid if the r-count value exceeds the r-table value, according to the decision-making criteria. The study results indicate that all items show a correlation coefficient greater than 0.21, confirming that all instruments are valid and appropriate for research data collection.

Table 3. Validity Test Results of the Instrument Used in the Experimental Class

		Item 1	Item 2	Item 3
	Pearson Correlation	1	0.459	0.340
Item 1	Sig.(2-tailed)		0.000	0.008
	N	60	60	60
	Pearson Correlation	0.459	1	0.391
Item 2	Sig.(2-tailed)	0.000		0.002
	N	60	60	60
	Pearson Correlation	0.340	0.391	1
Item 3	Sig.(2-tailed)	0.008	0.002	
	N	60	60	60

Reliability Test Results

Reliability testing was performed to assess the consistency of the research instrument, utilising Cronbach's Alpha. An instrument is deemed dependable if its Cronbach's Alpha value exceeds 0.60, according to the testing standards. The analysis yielded a Cronbach's Alpha score of 0.65, indicating that all items in this instrument meet reliability standards and possess adequate stability for use as a data-gathering tool.

Table 4. Reliability Test Results of the Instrument Used in the Experimental Class

Case Processing Summary			
		N	%
Case	Valid	60	100
	Excluded	0	0
	Total	60	100

Reliability Statistics	
Cronbach's Alpha	N of Item
0.659	3

Item Total Statistics	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected item-Total Correlation	Cronbach's Alpha If Item Deleted
Question 1	30.60	85.76	0.47	0.56
Question 2	30.77	79.26	0.51	0.50
Question 3	33.27	77.18	0.42	0.62

The findings from the examination of the student response questionnaire regarding the QR Code media utilised are presented in Tables 5-7. According to Table 5, the mean percentage score of the media usage questionnaire was 72.06%. The value of 72.06% is classified under the Good criterion for media usage. Consequently, it can be inferred that the use of deep learning utilising QR Code media in kinematics content meets the requirements for effective learning media. Student feedback on the comparative ease of use between barcode media and QR Codes indicated a value of 76%, categorising it under the Good category. Thus, it is determined that QR Code media is superior for usage as a learning medium compared to barcode media. This aligns with Widyasari's study, which indicates that QR Codes are easier to use than barcodes, as detailed in Table 8.

Table 5. Result of the Questionnaire Analysis on Students' Responses to the Use of QR Code Media

Question number	Total score	Maximum score	Average percentage
1-20	1081	1500	72.06%

Table 6. Likert Scale Score

Score	Code	Description
5	SS	Strongly agree
4	S	Agree
3	N	Netral
2	TS	Disagree
1	STS	Strongly Disagree

Table 7. Criteria for Media Usage

Interval	Criteria
0%-19.99%	Very Bad
20%-39.99%	Not Good
40-59.99%	Enough
60-79.99%	Good
80-100%	Very Good

Table 8. Advantages QR Code Over Traditional Barcode (Widyasari et al., 2019)

	QR code	Barcode
Connect to the web page	Yes	No
Acces information	Unlimited	Limited
Using Purpose	Many	Product information
Access to multimedia object	Yes	No
Get product information	Yes	Yes
Device to scan	Mobile phone	Bar code reader
The distance where it is scanned	At a distance	Near

Learning Outcomes

The analysis findings are delineated in multiple phases as follows:

Hypothesis Testing

The research hypothesis can be articulated as two distinct statistical hypotheses: an examination of disparities in learning outcomes within the experimental cohort.

H_0 = There is no disparity in learning outcomes for kinematics content between the pretest and posttest scores in the experimental group.

H_1 = A disparity exists in the learning outcomes for kinematics content between the pretest and posttest scores in the experimental class.

Table 9. Normality Test of the Experimental Class

	Class	Shapiro-Wilk Statistic	df	Sig.
Pretest	1st Experiment Class	0.98	30	0.84
	2nd Experiment Class	0.95	30	0.25
Posttest	1st Experiment Class	0.95	30	0.24
	2nd Experiment Class	0.97	30	0.73

Table 10. Homogeneity Test of the Experimental Class

		Lavene Statistic	Df1	Df2	Sig.
Pretest	Based on mean	0.60	1	58	0.44
	Based on median	0.60	1	58	0.43
	Based on median and with adjusted df	0.60	1	57.74	0.43
	Based on timmed mean	0.59	1	58	0.443
Posttest	Based on mean	0.26	1	58	0.87
	Based on median	0.60	1	58	0.80
	Based on median and with adjusted df	0.60	1	55.83	0.808
	Based on timmed mean	0.26	1	58	0.873

The prerequisite for the paired sample t-test for the experimental class is satisfied, as evidenced by normally distributed data, indicated by a significance value of 0.84 for the pretest in experimental class 1, a significance value of 0.25 for the pretest in experimental class 2, a significance value of 0.24 for the posttest in experimental class 1, and a significance value of 0.73 for the posttest in experimental class 2. The data indicate a significant value greater than 0.05, thereby confirming that the distribution is normal. The results show that the sample accurately represents the population and is suitable for proceeding to the hypothesis testing step.

The homogeneity precondition test revealed that the data were homogeneous, as evidenced by a significance value of 0.44 for both the pretest and posttest. The comprehensive data indicated a significance value above 0.05, thereby confirming the homogeneity of the data. Satisfying this homogeneity assumption indicates that the groups being compared have identical variance characteristics, warranting further investigation with parametric statistics.

The data have been evaluated and demonstrate normality and homogeneity; hence, the subsequent paired-samples test will proceed.

Table 11. Paired Samples Test

Paired Samples Statistic

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	47.37	60	11.02	1.42
	Posttest	77.73	60	10.04	1.29

Paired Samples Correlation

		N	Correlation	Sig.
Pair 1	Pretest & Posttest	60	0.52	0.00

Paired Sample Test

			Pair 1 Pretest-posttest
Paired Differences		Mean	-30.36
		Standard Deviation	10.27
		Standard Error Mean	1.32
	95% Confidence interval of the Difference	Lower	-33.02
		Upper	-27.71
		t	-22.88
		df	59
		Sig. (2-tailed)	0.00

According to Table 11, the 2-tailed p-value is less than 0.05 (specifically 0.00), indicating the rejection of H_0. Therefore, it is determined that there is a difference in learning outcomes for kinematics content between pretest and posttest scores in the experimental class. Additionally, the improvement data were evaluated using the mean, revealing a pretest score of 47.37 and a posttest score of 77.73, resulting in an increase of 30.36, corresponding to a 30.36% enhancement in learning outcomes.

An examination of disparities in learning outcomes between experimental and control groups was conducted.

H_0 = There is no disparity in learning outcomes for kinematics between students in the experimental and control groups.

H_1 = A disparity exists in learning outcomes for kinematics between students in the experimental and control groups.

All results of the normality test exceeded 0.05. The data exhibited a normal distribution. Consequently, it can be inferred that the research data follow a normal distribution, thus satisfying the prerequisites for subsequent analysis with parametric statistical methods.

Table 12. Normality Test of the Experimental Class and the Control Class

Class		Shapiro-Wilk		
		Statistic	df	Sig.
Pretest	1st Experiment Class	0.98	30	0.84
	2nd Experiment Class	0.95	30	0.25
	1st Control Class	0.96	36	0.26
	2nd Control Class	0.94	36	0.07
Posttest	1st Experiment Class	0.95	30	0.24
	2nd Experiment Class	0.97	30	0.73
	1st Control Class	0.96	36	0.25
	2nd Control Class	0.95	36	0.18

Table 13. Homogeneity Test of the Experimental Class and the Control Class

		Lavene Statistic	Df1	Df2	Sig.
Pretest	Based on mean	1.41	3	128	0.24
	Based on median	1.39	3	128	0.24
	Based on median and with adjusted df	1.39	3	115.80	0.24
	Based on timmed mean	1.41	3	128	0.24
Posttest	Based on mean	2.41	3	128	0.06
	Based on median	2.27	3	128	0.08
	Based on median and with adjusted df	2.27	3	124.20	0.08
	Based on timmed mean	2.38	3	128	0.07

Test of Homogeneity Predicated on a mean value exceeding 0.05. The data are homogeneous, indicating that the groups have the same variance. Satisfying this homogeneity assumption justifies the application of parametric statistics in subsequent hypothesis testing.

Table 14. Independent Sample Test Experiment Class and Control Class

Group Statistic					
	Class	N	Mean	Std. Deviation	Std. Error Mean
Pretest	Experiment Class	60	47.37	11.02	1.42
	Control Class	72	42.49	9.36	1.10

Independent Sample Test			Pretest	
			Equal Variances assumed	Equal Variances not assumed
Lavene's Test for Equality of Variances		F	1.97	
		Sig.	0.16	
T-test for Equality of Means		T	2.75	2.71
		df	130	116.31
		Sig.(2-tailed)	0.00	0.00
		Mean Difference	4.88	4.88
		Std.Error Difference	1.77	1.80
	95% Confidence interval of the Difference	Lower	1.37	1.31
		Upper	8.39	8.44

Levene's test for equality of variances yielded a significant value of 0.16, indicating homogeneity. Concurrently, the t-test produced significance (two-tailed) values of 0.00 and 0.00 (<0.05), indicating the acceptance of H1, which confirms the existence of a difference. This indicates a pre-existing disparity in pretest scores between the experimental and control groups, thereby rendering the posttest comparison invalid for direct interpretation. Consequently, the examination proceeded with the analysis of improvement data. Before proceeding, a normality test was conducted, as shown in Table 15.

Table 15. Result of Normality Test of Improvement Data

	Class	Shapiro-Wilk Statistic	df	Sig.
Improvement data	Experiment Class	0.99	60	0.89
	Control Class	0.95	72	0.00

The data for the normality test enhancement were not normally distributed (<0.05). Consequently, because one dataset was non-normal, the analysis proceeded with a non-parametric test. The Independent Samples Mann-Whitney U Test, a non-parametric test, was employed as detailed in Table 16.

Table 16. Result of independent samples Mann-Whitney U test

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of improvement is the same across categories of class	Independent Samples Mann-Whitney U Test	0.00	Reject the null hypothesis

Hypothesis Test Summary

Asymptotic significances are displayed. The significance level is 0.05

The outcomes of the non-parametric analysis utilising enhancement data. The SPSS results indicate a significance level of 0.00 (<0.05), leading to the rejection of the null hypothesis (H_0). Consequently, it is concluded that there is a difference in the improvement of learning outcomes in kinematics material between students in the experimental class and those in the control class. The diagrammatic representation is illustrated in Figure 12.

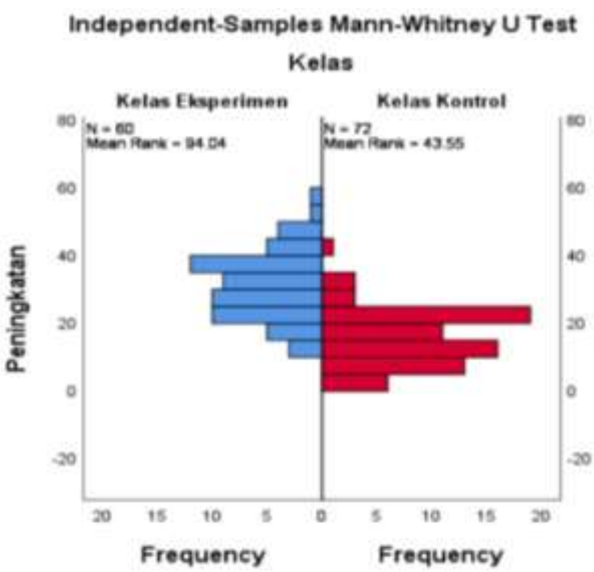


Figure 12. Independent samples Mann Whitney U test diagram of the increase in the experimental class and the control class

The diagram illustrates the disparity in learning outcomes enhancement in kinematics material between students in the experimental class and those in the control class.

The results indicate that the deep learning approach has been effectively implemented through the reflection stage, leading to the conclusion that this approach is suitable for high school students in the kinematics subject. The kinematics material, which was once perceived as abstract and primarily memorised by students for problem-solving, was transformed after the introduction of a deep learning approach utilising QR code media. This method enabled students to attain the learning objectives associated with deep learning, reaching the reflection stage, thereby modifying their cognitive processes towards a more profound interpretation of the material.

The validity and reliability assessment of the QR code media yielded valid and reliable results, indicating that the instrument is appropriate for use in the teaching of kinematics. An analysis of questionnaire responses indicated that the media met the criteria for effectiveness, supporting the conclusion that the implementation of the deep learning approach utilising QR code media is suitable for kinematics material. This indicates that access to educational media is improving, and the variety and quantity of learning resources in kinematics are expanding.

The examination of learning outcomes revealed disparities in the kinematics material scores between pretest and posttest in the experimental class. The analysis of the improvement data revealed an average pretest score of 47.37 and a posttest score of 77.73, resulting in an increase of 30.36, corresponding to a 30.36% improvement in learning outcomes. This indicates that administering treatment using a deep learning technique that utilises QR-code media can enhance high school students' learning outcomes in kinematics. Additional data corroborate the study's findings, revealing a significance value of 0.00 < 0.05 upon further analysis of the experimental and control groups. Consequently, it was concluded that there is a disparity in the enhancement of learning outcomes in kinematics material between students in the experimental and control groups.

The analysis of multiple phases concluded that employing a deep learning strategy utilising QR-Code as a learning medium can enhance high school students' academic performance in kinematics. Research by Hammadi in 2023 indicates that deep learning tactics markedly enhance mathematics proficiency and practical intelligence in high school students relative to standard methods (Hammadi et al., 2023). Hammadi's research distinguishes itself by comparing the employed method with traditional approaches, while sharing the similarity of enhancing student learning outcomes or achievement.

Consistent with Saputro's 2025 research, EGAMERASI media significantly enhances students' cognitive skills and motivation in learning kinematics, yielding effective outcomes in knowledge, comprehension, application, and analysis (Saputro et al., 2025). Saputro likewise examined kinematics material; however, the distinction from the authors' research lies in the introduction of novel media, specifically the EGAMERASI media.

A subsequent study by Sriyuliyanti in 2024 found that QR codes effectively promote student-centred learning by enhancing motivation, engagement, and access to educational resources, with strong consensus on their continued use in future learning (Sriyuliyanti, 2024). The resemblance pertains to the accessibility of educational resources, which aligns with the author's research purpose of facilitating access to learning materials through QR code-based media.

Zannah's 2022 study revealed improvements in student learning outcomes and interest among eleventh-grade students at Arjasa State Senior High School when utilising the QR Code-Based Student Worksheet model for the topic of Light Waves (Zannah et al., 2022). The distinction is that, alongside learning outcomes, student motivation for learning also increased with the implementation of QR Code–Based Student Worksheets.

A significant problem in this research is the media's reliance on an internet connection. Media accessed via QR codes are not optimally usable in contexts with limited network connectivity or in places without stable internet access. Consequently, while this media have demonstrated a substantial improvement in student learning outcomes in kinematics, further advancement is advisable to mitigate this constraint, including the provision of an offline version.

Conclusion

The descriptive analysis results indicate that the statistical tests yielded a significance (2-tailed) of less than 0.05, specifically 0.00, leading to the rejection of H0. Consequently, it is concluded that there is a significant difference in the learning outcomes of kinematics material between the pretest and posttest scores in the experimental class, which utilised a deep learning approach with QR-Code media for kinematics instruction. The analysis of the improvement data revealed a mean pretest score of 47.37 and a posttest score of 77.73, resulting in an increase of 30.36, equating to a 30.36% enhancement in learning outcomes. The implementation of a deep learning strategy utilising QR code media demonstrated improvements in learning outcomes compared to traditional classroom instruction. Implementing a deep learning approach that uses QR codes as a learning medium can enhance high school students' academic performance in kinematics. The utilisation of QR Code–based learning media informed by deep learning has demonstrably enhanced student learning outcomes in kinematics at the high school level. This study advocates several strategic measures to enhance physics education, including converting laboratory operations into project-based learning, supported by digital documentation via QR codes, to sustain student engagement and comprehension of intricate concepts. Additionally, schools are encouraged to install permanent QR codes in laboratory spaces or reading corners as visual aids for subjects that are challenging to comprehend from text alone. An interactive digital module is being developed, combining printed materials with videos of actual experiments or virtual simulations, accessible via QR codes in each sub-chapter of the kinematics content.

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Conceptualisation, L,L and S,S; methodology, L,L and S,S; formal analysis, L,L and S,S; investigation, S,S; resources, L,L and S,S; writing—preparation of original draft, L,L and S,S; writing—reviewing and editing, L,L , S,S, and DMV; visualisation, DMV; supervision, DMV; project administration, DMV; obtaining funding, L,L. All authors have read and approved the published version of the manuscript.

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