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Building New Understanding Through Experiments: Students' Conceptual Shifts on Projectile Motion

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Abstract

Students' understanding of the concept of projectile motion is often hindered by misconceptions that are difficult to change through conventional teaching methods. This research explores how direct instruction, which remains relevant and effective in physics education, can be key to fostering conceptual change in students through a qualitative approach involving 39 elementary education teacher students as participants. Data was collected using two main instruments: in-depth interviews and student reflection journals, conducted during active and interactive learning processes. The research findings revealed that direct instruction not only helps students identify and correct misconceptions but also enriches their understanding by connecting the concept of projectile motion to real-life phenomena. Based on the reflection journals, students demonstrated increased awareness of conceptual errors and stated that direct involvement in experimental activities facilitated the internalization of concepts. In-depth interviews also indicated that group discussions, demonstrations, and direct observations of the motion trajectories of objects significantly reinforced their conceptual understanding. This transformation in understanding shows that direct teaching methods can bring abstract physics material to life, turning it into meaningful and applicable learning experiences. The conclusion of the research emphasizes that direct instruction is an effective strategy for improving the quality of students' conceptual understanding, particularly on the topic of projectile motion, and strengthening the foundation for sustainable physics education

Keywords: Conceptual Change; Projectile Motion; Students’ Understanding; Direct Instruction

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INTRODUCTION

Recent developments in the field of education over the past few decades have prompted significant changes in learning approaches, one of which is the shift from procedural teaching to concept-oriented teaching. Research shows that students often can solve scientific problems algorithmically but struggle to explain the conceptual meaning behind them (Saricayir et al., 2016; Ültay, 2017). This situation has led to increased attention on how scientific concepts should be taught effectively (Usta et al., 2020). In the context of physics, fundamental mechanics concepts such as displacement, velocity, acceleration, force, work, and energy are abstract and often sources of misconceptions. Students frequently understand these concepts through intuition or common sense, which may contradict scientific principles (Liu & Fang, 2016; Al-Rsa’I et al., 2020). This challenge is exacerbated by difficulties in reading graphs, analyzing problems, and relating physical phenomena to their mathematical representations. If not addressed early on, these misconceptions can persist and carry over into their future teaching practices as prospective teachers (Munfaridah et al., 2021; Lichtenberger et al., 2024). Some students equate learning physics with memorizing formulas and problem-solving algorithms, whereas others believe that learning involves connecting fundamental concepts with problem-solving techniques. Additionally, some students think that learning mainly consists of absorbing information, while others perceive learning as constructing their own understanding (Elby, 2001).

Students’ misconceptions in basic physics courses can cause difficulties in understanding physics in advanced courses. Moreover, misconceptions held by students who later become teachers can be transmitted to their own students in the future. Previous research on first-year students who have completed the General Physics course found that students’ conceptual understanding was low (≤ 50%) and that misconceptions occurred related to the following topics: (1) forces in vertical motion, (2) forces in circular motion, (3) resultant force and velocity vectors, (4) forces in projectile motion, and (5) forces in simple pendulum motion. The research also revealed that the majority of students (81%) experienced difficulties in solving physics problems despite understanding the concepts related to those problems. Additionally, many students (47%) felt that physics equations did not support their thinking in understanding the concepts, viewing the equations as merely tools needed for practice problems. It is suspected that the cause of students’ difficulties and misconceptions in understanding physics concepts is teaching that is not yet fully student-centered, particularly in actively involving students in constructing concepts, especially motion concepts (Mufit, 2018). Misconceptions are the number one factor causing students to fail in learning physics. To teach physics effectively, misconceptions must be identified and addressed. Texts on conceptual change are very useful in identifying and tackling these errors. Such texts can help physics teachers diagnose students’ misconceptions and the reasons behind them, as well as assist teachers in explaining the scientific truths that should replace these misconceptions (Özkan & Selçuk, 2013); Batlolona, 2024). Through conceptual change, naive views are reorganized into a scientific knowledge structure rather than being completely eliminated. Recently, there has been a growing consensus regarding the coexistence of alternative views and scientific conceptions in physics learning (Ding et al., 2024). The term "conceptual change" describes the process by which alternative conceptions are transformed, restructured, and revised into scientifically accepted ideas. Previous research has found that students’ alternative conceptions are difficult to completely eliminate and very often become integrated with new knowledge components (She et al., 2025).

A critical gap in the existing literature is the lack of empirical evidence regarding how direct experiences with physical phenomena, particularly in the realm of projectile motion, can facilitate profound conceptual change. While many studies have explored digital simulations such as the PhET Simulation (Chinaka, 2021; Villaruel, 2025) and abstract representations (Batuyong & Antonio, 2018; Banda & Nzabahimana, 2021), these studies often overlook the cognitive and emotional engagement that arises from concrete interactions with physical objects. For instance, research by Karpudewan et al., (2016) highlights the effectiveness of hands-on learning in enhancing students' conceptual understanding in physics, emphasizing the need for active engagement. This study aims to fill this gap by investigating how simple, hands-on experiments involving projectile motion can catalyze transformative learning experiences for students. By encouraging students to engage in physical activities, analyze their results, and reflect on their understanding, we seek to elucidate the complex cognitive processes underlying their learning. This approach not only aims to identify and correct misconceptions but also aspires to foster a deeper and more intuitive understanding of the underlying principles of physics. Furthermore, the integration of triangulated data through observations, interviews, and reflective journals will provide a comprehensive framework for understanding how students reconstruct their knowledge. This innovative methodology will make a significant contribution to the physics education literature by revealing the dynamic interplay between hands-on learning and conceptual understanding, particularly in the context of projectile motion. The findings may align with those of Vosniadou & Skopeliti (2014), which emphasize the importance of addressing misconceptions through experiential learning.

One of the topics considered still difficult and subject to many misconceptions is projectile motion. A study in South Africa shows that students perform poorly on the concept of projectile motion. Further analysis of student responses on this topic reveals serious deficiencies in mathematical skills such as interpreting and drawing graphs, solving equations, and working with trigonometric ratios. It is also evident that most students have little or no problem-solving skills. Most students struggle to tackle problems. Many stop midway through their answers involving calculations, possibly because they do not have a calculator or lack the necessary skills to use one (Mudau, 2014; Batlolona, 2025). In addition, students often face challenges due to variations in specific conditions (for example, initial speed or launch angle). They may try to follow different procedures for different specific conditions while overlooking the important common characteristics of projectile problems (Tang, 2017). Galileo Galilei, a pioneering figure in the realm of physics, was the first to unravel the intricacies of projectile motion, breaking it down into its horizontal and vertical components (Naylor, 1980). Through meticulous observations, he revealed that the dominant vertical force acting on any projectile is none other than gravity, with an acceleration of 9.8 m/s^2. Galileo's insights didn't stop there; he posited that the horizontal motion of a projectile remains constant, adhering to the principle of inertia. This principle asserts that "an object will maintain its state of rest or uniform motion unless acted upon by an external force." Moreover, he illuminated the fascinating interplay between horizontal and vertical motions, demonstrating that together they create a mathematical curve known as a parabola (Franco, 2003; Palmerino, 2004), His relentless pursuit of knowledge led him to discover that the collisions of falling objects reveal a striking pattern: as distance increases during free fall, so too does the instantaneous velocity, showcasing the profound implications of his groundbreaking work (Said et al., 2023). The trajectory is parabolic, and the maximum horizontal range is achieved at a launch angle of 45°. However, the launch angle for maximum horizontal range is less than 45°, as theoretically demonstrated by Groetsch (Benacka, 2011).

Over the past thirty years, constructivist learning theory has revolutionized the way we view the teaching and learning process worldwide. This theory emphasizes that each learner actively constructs their own knowledge by linking new information to existing knowledge frameworks, making learning more meaningful and personal (Uwamahoro et al., 2021). In this process, if new knowledge does not align with the learner's existing knowledge, they may choose to reject it (Sewell, 2002). Numerous studies have shown that learners possess some initial knowledge that is not scientifically accepted (Amin, 2015). Learners' conceptions that differ from those accepted by the scientific community are referred to as misconceptions in the science education literature (Sabo et al., 2016; Hudha et al., 2019). Although teachers sometimes overlook learners' misconceptions, these misconceptions significantly influence how learners construct new scientific knowledge and hinder subsequent learning. Consequently, identifying and correcting learners' misconceptions is crucial for improving conceptual understanding. This process is known as conceptual change. Conceptual change has become an important approach to addressing misconceptions in science education. One explanation of conceptual change is provided by Posner et al. (1982) proposed that for conceptual change to occur, there must be dissatisfaction with the old concept, understanding of the new concept, logical coherence, and the usefulness of the new concept. Recent studies have shown that traditional learning methods are not sufficiently effective in promoting this knowledge restructuring (Bigozzi et al., 2018). Therefore, constructivism-based teaching strategies such as hands-on activities, the use of analogies, and conceptual change-based learning have been developed (Özkan & Selçuk, 2013; Uwamahoro et al., 2021).

Since then, Western researchers have proposed the connotation of conceptual change from constructivist theory, namely the concept of conceptual change learning. The perspective of conceptual change learning argues that conceptual change is a process of modification, development, and reconstruction of original concepts in students' minds, that is, the transformation from pre-scientific concepts to scientific concepts (Wu et al., 2023). Conceptual change is a major research area in science education, and its domain extends to other fields such as mathematics and religious education. Research on conceptual change began in the 1970s with what can be described as the "misconception literature," particularly in mechanics. This literature found that, across cultures and age groups including physics students many learners hold intuitive beliefs about force and motion that contradict the concept of force in Newtonian mechanics (Rowlands & Graham, 2005; McLure et al., 2020). Experts tend to start by using general scientific principles to analyze problems conceptually, while beginners tend to begin by selecting equations and plugging in numbers. Therefore, giving students the opportunity to reason qualitatively about problems can help them think like experts (Park, 2020). Furthermore, physics education should emphasize the importance of connecting prior knowledge with new physical phenomena (Mills, 2016; Bao & Koenig, 2019). Deep conceptual understanding is essential to equip students to apply their knowledge to real-world scenarios and to foster innovation (Dessie et al., 2023). Physics learning fundamentally focuses on mastering a set of fundamental concepts that serve as the foundation for systematically understanding various natural phenomena. Alternative approaches often rely on humans' natural intuition about everyday physical aspects; however, these approaches do not build a clear structure of understanding nor explicitly or strategically investigate these concepts in depth, resulting in knowledge that tends to be general and poorly organized (Piloto et al., 2022).

One of the topics that frequently gives rise to misconceptions is projectile motion, particularly in relation to the separation of horizontal and vertical components, variations in launch angles, and the use of graphs and trigonometric ratios (Mudau, 2014; Tang, 2017).. Students generally struggle to understand the general characteristics of parabolic motion and tend to apply incorrect strategies. Other studies have also revealed that much of physics education remains procedural, failing to promote a comprehensive understanding of fundamental concepts and their applications in real-world contexts (Sabo et al., 2016; Bao & Koenig, 2019). Although various studies have examined conceptual change and misunderstandings in physics education, there are still shortcomings in methodological and contextual aspects, particularly in understanding how direct learning based on concrete experiences and active reflection can facilitate the restructuring of students' understanding. Previous research has focused more on the use of simulations such as PhET or digital media-based teaching strategies without delving deeper into the cognitive processes experienced by students personally while directly interacting with physical phenomena (Tang, 2017; Banda & Nzabahimana, 2021a). This study offers a different contribution by emphasizing direct interaction, simple physical experiments, and students' written reflections in understanding projectile motion. This approach highlights conceptual change as an internal process built from direct experiences, rather than solely from visual representations or animations. Furthermore, this research employs data triangulation from observations, interviews, and reflective journals, which is still rarely applied in similar studies. Thus, this study fills an important gap in the physics education literature by holistically exploring how direct learning can identify, reconstruct, and strengthen students' conceptual understanding. The aim of this research is to analyze the process of students' conceptual change regarding projectile motion through direct learning, particularly in identifying misconceptions, reconstructing knowledge structures, and reinforcing understanding through exploratory and reflective activities.

METHOD

Research Design

This study employs a descriptive qualitative approach to explore and describe how direct learning influences students' conceptual change regarding the topic of projectile motion. This design was chosen because it allows for an in-depth exploration of the cognitive processes of students, particularly the processes involved in identifying misconceptions and constructing new understanding through active, concrete, and reflective learning experiences. Developed by Sandelowski (2000), the qualitative descriptive (QD) approach is a method that provides a comprehensive overview of events or experiences. Unlike other qualitative methods such as phenomenology, grounded theory, and ethnography, QD focuses more on the 'who, what, and where' of experiences without delving into deep theorization or recontextualization (Neergaard et al., 2009). In contrast, QD remains closely tied to the data, offering a clear representation of experiences as expressed by participants (Sandelowski, 2010). The QD methodology is based on a naturalistic approach, committed to studying phenomena in their original context without pre-selection or manipulation of research variables (Bradshaw et al., 2017). QD has emerged as an important introductory method in qualitative research for researchers. Its main strength lies in its straightforward and adaptive approach, emphasizing direct descriptions of experiences and events while remaining close to the data (Hall & Liebenberg, 2024).

Research Population and Sample

The population in this study comprises second-semester students enrolled in the Elementary School Teacher Education Program (PGSD), which consists of five distinct classes. For the purpose of this research, the focus is narrowed down to one specific class that includes 39 students. These students are all actively engaged in the learning activities that form the core of the study's inquiry. The selection of this particular class was carried out using a purposive sampling technique, which involves intentionally selecting individuals who meet specific criteria relevant to the research objectives. In this case, the chosen class was selected because its members have experienced the same educational intervention, allowing for a more targeted examination of their learning processes and outcomes. Purposive sampling is especially suitable in qualitative research, where the goal is to gain in-depth insights and rich data from participants who can provide valuable information related to the study’s focus (Palinkas et al., 2015). By selecting this specific class, the study aims to capture a comprehensive understanding of the unique experiences and perspectives of these students, facilitating a nuanced analysis of their interactions and reflections within the educational context. This methodology aligns with the principles of qualitative research, which prioritize the exploration of individual experiences and the meanings that participants ascribe to them (Baxter & Jack, 2015). Thus, the findings from this research are expected to contribute valuable insights into the pedagogical practices within the PGSD program, enhancing the overall understanding of teacher education in elementary schools.

Sample Collection Techniques and Instrument Development

The data for this study were collected using three main instruments: direct observation, semi-structured interviews, and student reflection journals. Observations were conducted during learning sessions and projectile experiments. Two lecturers acted as observers using an observation checklist. To ensure inter-rater reliability, joint training and comparison of observation results were carried out. During the observation, several items from the checklist were utilized, including assessing students' active participation during the projectile experiment on a scale of 1 to 4, as well as their ability to explain the parabolic trajectory based on direct observation (Yes/No). Additionally, observers evaluated whether students corrected their prior understandings based on group discussions (Yes/No). Other checklist items included whether students asked questions related to the experiment (Yes/No) and the level of collaboration within groups (scale of 1 to 4).

Interviews were conducted with 10 students selected purposively based on their engagement and depth of reflection. These interviews were recorded and transcribed for thematic analysis. The interview guide included questions such as: "How do you understand projectile motion before and after the hands-on practice?" and "Which part of the lesson helped you realize your previous misconceptions?" Students were also asked about any changes in how they connect concepts to real-life situations, as well as specific moments during the lesson that changed their understanding. They were additionally prompted to describe how their peers influenced their learning during the experiments.

Reflections were collected in the form of manually written journals, which students filled out at the end of each learning session. These journals served as a means to explore conceptual awareness and changes in understanding. Guiding questions for the reflections included: "Write down one misconception that changed after today's activities," "What did you learn about the relationship between launch angle and projectile trajectory?" and "How did today's experience help you understand motion concepts in real life?" Students were also asked to describe any challenges they faced during the experiments and how they overcame them, as well as the strategies they would use in future experiments based on today's learning.

Data Analysis Techniques

The data analysis technique employed in this study is qualitative descriptive analysis. The qualitative data collected will be interpreted using the Miles and Huberman model, which includes data collection, data reduction, data presentation, and conclusion drawing (Dull & Reinhardt, 2014). In qualitative research, data collection occurs naturally in real-life conditions (Lim, 2025). The implementation stages involve: (1) gathering detailed information through interviews, direct and indirect observations, literature reviews, and documentation; (2) reducing data by summarizing and filtering relevant information related to the physics of projectile motion. This process entails selecting key elements and focusing on significant aspects that relate to the physics concepts, thereby allowing the reduced data to provide a clearer picture and facilitate further data collection (Wadsworth et al., 2025); (3) exploring physics concepts during field experiments involving projectile motion, such as throwing a ball, while considering local wisdom from South Sumatra. This exploration aims to elucidate the underlying physics concepts, which are then examined within their contextual framework. The analysis of these concepts involves formulating physical facts, principles, laws, and theories related to projectile motion (Kovačević et al., 2024); (4) summarizing the identified physics concepts related to projectile motion and presenting the findings. In qualitative research, the data will be expressed in descriptive or narrative text form; (5) drawing conclusions and offering recommendations based on the results obtained (Wiyono et al., 2024). The findings may include concrete evidence, causal relationships, or theoretical insights, ultimately leading to conclusions that identify the scientific concepts and principles within projectile motion.

RESULTS AND DISCUSSION

Comparative Study on Projectile Motion Learning

Projectile motion is a type of two-dimensional motion whose trajectory follows a parabolic path. This motion occurs when an object is launched into the air with an initial velocity of V_0 at a certain angle ϕ relative to the horizontal surface, and the only force acting on the object during its flight is the gravitational force (Fg), assuming air resistance is negligible. Projectile motion is a combination of two linear motions: uniform linear motion (constant velocity) along the *X-axis* (horizontal/abscissa) and uniformly accelerated linear motion along the *Y-axis (vertical/ordinate)*.

Projectile motion is an intriguing phenomenon commonly encountered in many everyday situations, such as when throwing a ball or launching a projectile. Understanding this concept is essential in physics and engineering applications. With proper illustrations, we can more easily grasp how objects move along a parabolic trajectory. The study of projectile motion includes: Definition of projectile motion, Separation of horizontal and vertical motion, Formulation of position, velocity, and acceleration Calculations of maximum height, total time of flight, and maximum range Graphical analysis and physical interpretation There are several characteristics of projectile motion that require in-depth kinematic study to explain both the physical and analytical phenomena, including: 1) An object moving along a parabolic path follows a symmetric curve. This trajectory can be described by a quadratic equation of the form $y = a \pm b\,x^2$. 2) The initial velocity (V_0) of the object greatly influences the maximum height (h_{max}) and the horizontal distance (range, R) achieved. The greater the initial velocity, the farther the object will travel; 3) The launch angle (α) plays a crucial role. A 45-degree angle provides the maximum range for projectile motion without air resistance; 4) The gravitational force (Fg) pulls the object downward, causing the parabolic trajectory to always descend after reaching the highest point (h_{max}).

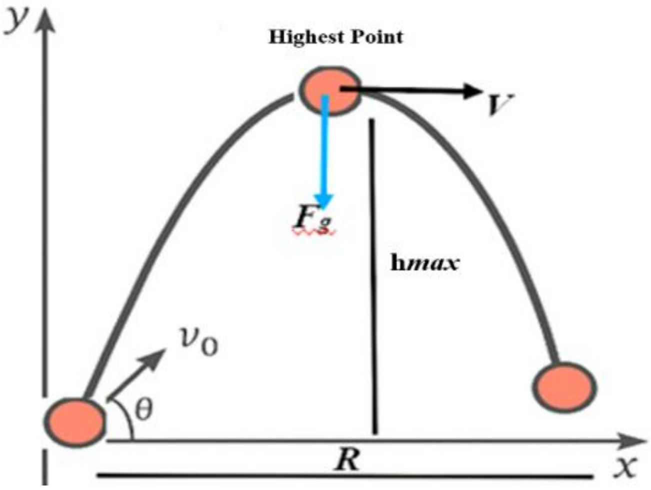

Figure 1. General pattern of parabolic motion

For example, when we observe a baseball and a tennis ball, as illustrated in Figure 1, while they are in the air during moments like a home run or a field goal kick, we can see that both balls follow a curved trajectory known as projectile motion. The concept of parabolic motion has been the subject of extensive research over the years (Siegel, 2017; Corvo, 2022); Warren, 2024). Although we believe that all characteristics of this motion are fully understood, we have encountered a surprising new phenomenon. The findings of Escobar et al., (2022) provide new insights into physics learning, where it appears that as a projectile is launched, the particle always moves away from the launch point, both from the perspective of the launcher and from a more distant position. However, in this study, we will demonstrate that this is not always true, even though it may sound strange. There are specific periods during which the projectile actually approaches the launch point. This discovery seems to contradict the common understanding of students and teachers. We often assume that projectiles always move away, but there are certain angles at which the distance between the projectile and the launch point decreases at specific moments in its trajectory. There is a critical launch angle above which certain predictable behaviors occur. Below this critical angle, the projectile will always move away from the launcher. We will also calculate the duration of the time interval during which this phenomenon occurs, which depends on the launch angle of the projectile.

Theoretical Direct Instruction (Lecture and Discussion)

Direct instruction is a traditional teaching approach in which the lecturer serves as the central source of information delivery, typically through structured and systematic lectures followed by discussion sessions. This method is widely used in physics education, including topics such as projectile motion, which require strong conceptual and mathematical understanding. Direct instruction is grounded in behaviorist theory and partly in cognitivism, emphasizing the lecturer’s role in guiding students to achieve specific learning objectives. Robert Gagné stated that effective learning requires sequential and focused presentation of information so that students can internalize the material well. In the context of physics education, such as projectile motion, mastery of theory, formulas, and calculation processes is well-suited to be delivered through structured lectures and discussions. This approach is based on the lecturer's explanation of projectile motion concepts, relevant formulas, and theoretical problem-solving. The advantages of this method include its systematic nature and ease of implementation, especially for foundational mathematical understanding. However, its drawbacks include limited concrete visualization of trajectories and real-time variable changes. Projectile motion knowledge is viewed as a set of objective and universal scientific laws, focusing on concepts such as trajectory, velocity, acceleration, and force. Students acquire knowledge through lecturer explanations, discussions, textbook reading, and memorization of formulas. This approach is oriented toward rationality and deductive logic, developing students' conceptual, logical, and analytical thinking skills, and preparing a theoretical foundation for advanced studies in physics or engineering. Instructors explain concepts, derive equations, and provide example problems, often using blackboards and diagrams. A strong mathematical and analytical understanding is essential. The general steps in direct instruction for projectile motion typically include: 1) Presentation of Initial Concepts: The lecturer explains the basic definition of projectile motion using illustrations, slides, or blackboard drawings. This includes elaborating on equations and their derivations based on fundamental physical phenomena of projectile motion; 2) Providing Example Problems: The lecturer presents example problems related to projectile motion; 3) Guided Problem Solving: The lecturer and students work together to solve problems such as calculating maximum height, time of flight, or range; 4) Guided Discussion: Students are given opportunities to ask questions and discuss equations and problems that are difficult to understand or solve; 5) Independent Practice: Students are assigned worksheets or relevant cases to assess their understanding.

The above perspective aligns with the findings of May et al. (2022) , which state that many undergraduate physics experimental programs have undergone changes to enhance student participation in scientific reasoning, critical thinking, and scientific practice. These reforms have emerged in response to the ongoing demand to transform experiment-based courses from a memorization and confirmation-oriented approach, which emphasizes reinforcing course material, to a more authentic laboratory experience that engages students in experimental activities and scientific reasoning. Students need opportunities to regularly engage with three aspects of scientific learning in the laboratory context, as all three collectively prepare them to "think like physicists" and develop true scientific skills (Cai et al., 2021). The laboratory classroom remains a distinctive educational setting where students can continuously interact and learn experimental practices, scientific concepts, and reasoning processes in ways that cannot be achieved in lecture halls or recitation sessions (Talanquer et al., 2024). To provide students with this opportunity and create significant changes in their learning and engagement, it is crucial to implement a clear pedagogical framework in the physics laboratory curriculum that builds relationships and consistency between experimental practices, conceptual material, and scientific reasoning (Dilber et al., 2009). The study results Mahmud et al. (2024) also explain that before conducting experiments, students were asked simple questions about whether projectile motion is one of the challenging topics in fundamental physics. They were then given time to solve projectile motion problems using a projectile launcher experiment kit. This experiment kit significantly enhanced students' understanding. About 60% of students agreed that projectile motion is one of the most challenging topics in fundamental physics. After implementing this kit, there was a significant increase in the percentage of students achieving a very good level of understanding (50%) and a good level of understanding (48.5%). Only a small fraction demonstrated poor understanding (1.5%), while the majority fell into the good category. This indicates that direct instruction with the projectile launcher experiment reinforces students' understanding of the concept of projectile motion. The projected parabolic motion pattern and its kinematic processes can be seen in Figure 2.

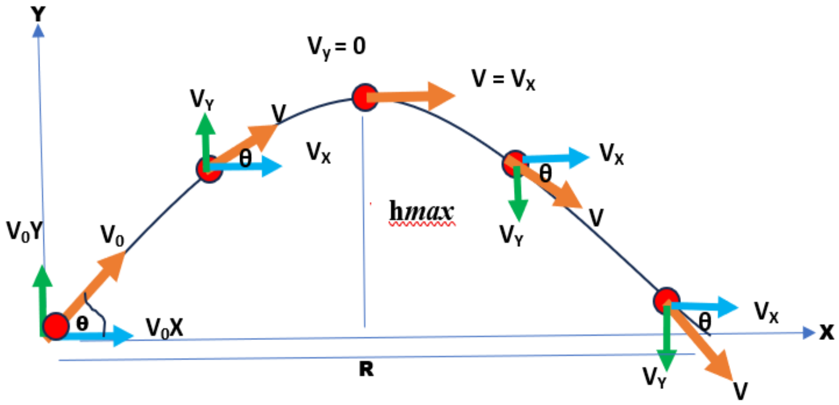

Figure 2. Parabolic motion pattern and its kinematic process

Projectile motion is a type of movement performed by a particle or object on a macro scale, whose motion can be analyzed in a two-dimensional plane, specifically along the X-axis and Y-axis. If the particle moves with an initial velocity V_0, this velocity can be decomposed into components along the X-axis and Y-axis:

Components of the initial velocity along the X-axis and Y-axis

$$V_0x = V_0 \cos \theta$$
$$V_0y = V_0 \sin \theta$$

Since the motion along the X-axis experiences no change in velocity or acceleration (i.e., ax=0), while the motion along the Y-axis involves a change in velocity with a constant acceleration $a_y = g$ (acceleration due to Earth's gravity), the following equations can be established:

Along the X-axis, it is known that $a_x = 0,\ V_0x = V_0 \cos \theta$

$$Vx = V_0x = V_0 \cos \theta$$
$$X = Vx\ t \text{ or } X = V_0x\ t$$
$$X = V_0 \cos \theta\ t$$

On the Y-axis it is known $a_y = -g,\ V_0y = V_0 \sin \theta$

$$V_y = V_0y + a_y\ t$$

as $V_0y = V_0 \sin \theta$ *and* $a_y = -g$ so

$$V_y = V_0 \sin \theta - g\ t$$
$$Y = Y_0 + V_0y\ t + 1/2\ a_y\ t^2$$
$$Y = Y_0 + V_0 \sin \theta\ t - 1/2\ g\ t^2$$

If Y_0, the initial position of the object, is equal to zero, then the above equation can be written as:

$$Y = V_0 \sin \theta\ t - 1/2\ g\ t^2$$

As it is known, an object moving along the Y-axis experiences motion with constant acceleration; therefore, it can be said that the object undergoes uniformly accelerated linear motion. Consequently, the equations of uniformly accelerated linear motion can be used to analyze the motion of an object, including the following:

$$V_y^2 = V_0^2 - 2a\ Y$$
$$V_y^2 = V_0 \sin \theta - 2.g\ Y$$

According to the diagram of the object's motion shown above, to determine the highest point the object can reach (the maximum height, hmax), we assume that at hmax, the vertical velocity V_y=0 (because the vertical velocity at the highest point is zero, and vectorially, the velocity vector changes direction significantly by 180°), from the equation

$V_y = V_0 \sin \theta - g\ t$ we obtain:

$0 = V_0 \sin \theta - g\ t$

$V_0 \sin\theta = g\,t$ so that $t = V_0 \sin\theta / g$, here, t represents the time to reach the maximum or highest point; therefore, to determine the highest point or hmax, we have:

$$Y = V_0 \sin\theta\, t - 1/2\, g\, t^2$$

If we substitute the value of t with $t = V_0 \sin\theta / g$ into the equation $Y = V_0 \sin\theta\, t - 1/2\, g\, t^2$ then $Y = h_{maks}$ so that :

$$Y = V_0 \sin\theta\, t - 1/2\, g\, t^2$$
$$h_{max} = V_0 \sin\theta\;\; V_0 \sin\theta / g - 1/2\, g\, (V_0 \sin\theta / g)^2$$
$$h_{max} = V_0^2 \sin^2\theta / g - 1/2\, V_0^2 \sin^2\theta / g$$
$$h_{max} = 1/2\, V_0^2 \sin^2\theta / g$$

To determine the maximum range of an object moving in projectile motion, as shown in the graph above, we assume that the time it takes for the object to reach the highest point is equal to the time it takes to descend from the highest point back to the ground level ($h=0$). Thus, it can be expressed as:

$$t_R = 2\, t_{max}$$
$$t_R = 2\, V_0 \sin\theta / g$$

$X = V_0 \cos\theta\, t$ by substituting $X = R$ dan $t = t_R$ we get

$$R = V_0 \cos\theta\; 2\, V_0 \sin\theta / g$$

$R = V_0^2\, 2 \cos\theta\, \sin\theta / g$ the equation becomes $2 \cos\theta\, \sin\theta = \sin 2\theta$

$$R = V_0^2 \sin 2\theta / g$$

Students attending lectures or discussions on the topic of projectile motion tend to exhibit a partial and superficial conceptual understanding. With a very limited mathematical background, most students struggle to comprehend the mathematical representation of two-dimensional motion, particularly in relating the physics formula $Y = V_0 \sin\theta\, t - 1/2\, g\, t^2$ to real-life situations or graphical illustrations. In lecture-based methods, students tend to be passive, merely receiving verbal information without much interaction or feedback regarding their understanding. This results in low cognitive engagement, where students can only recall some of the information presented but find it difficult to apply it, especially in numerical or contextual problems. In discussion-based methods, although there are opportunities to ask questions and engage in dialogue, students' limited mathematical language skills hinder their ability to express their understanding or respond clearly to questions. Discussions are often impeded by basic misconceptions, such as misunderstandings about the direction of motion, the influence of gravity, or the relationship between initial velocity and maximum height. Students also tend to avoid quantitative aspects and feel more comfortable discussing qualitative matters. Students exhibit a limited mastery of mathematical concepts. Based on interviews and observations, the following misconceptions were identified as shown in the Table 1.

Table 1. Types of misconceptions from interviews and observations

Thematic Code	Type of Misconception	Changes That Occurred	Source of Change (If Any)
MT1	Gravity is thought to accelerate upward motion	No change	No exploration or visualization
MT2	Trajectory is considered asymmetric	No change	Lectures did not include simulations or images
MT3	Time of ascent ≠ time of descent	No change	Lack of graphical representation of time

This limitation in understanding is caused by a verbal dominance without visual or empirical support. Students merely memorize formulas without comprehending their contextual meanings.

In general, students' ability to solve projectile motion problems remains relatively low. They require more time to understand the relationship between physical variables and their mathematical formulas. They also show a high dependence on example problems directly discussed by the instructor and struggle when faced with problem variations that demand further reasoning. This situation indicates that conventional teaching methods (lectures or discussions) are less effective if not complemented by visual, manipulative approaches or remedial strategies tailored to students' limited mathematical skills. The need for learning media that can bridge the gap between physics concepts and mathematical representations becomes crucial in this context. These findings align with the research conducted by Wakhata et al. (2023) which highlighted students' difficulties in applying mathematical models and equations in real-life contexts, indicating a gap between their conceptual understanding and practical application. Traditionally, the teaching of projectile motion has often been limited to memorizing formulas and mathematical derivations, resulting in superficial understanding and limited knowledge transfer (Grigore & Stefan, 2015). From this educational perspective, there is a strong emphasis on responsiveness. Research by Jeong & Gonzalez-gomez (2019) revealed that conventional teaching methods in physics are ineffective in conveying knowledge to students. Conversely, the learning process tends to be passive, with teachers acting as intermediaries in delivering information. Recognizing the shortcomings of traditional pedagogical methods, educators are increasingly turning to innovative approaches such as physics problem-solving and the integration of external representations into direct instruction (DI). The findings of Mansyur & Darsikin (2016) indicate that the experimental phase of DI can support students' mental modeling abilities. Enhanced direct instruction promotes student learning outcomes by actively engaging students in problem-solving and making them aware of each phase of the process. Another study by van der Graaf et al. (2019) shows that inquiry-based learning and direct instruction strengthen various components of scientific reasoning abilities, and that a combination of instructional methods is most effective for scientific reasoning skills, vocabulary, and specific knowledge.

Direct Practice (Throwing a Ball)

Physical experiments allow students to directly observe parabolic motion, such as through throwing a ball. This provides concrete experience and enhances observational skills. However, technical constraints like limited equipment, environmental conditions, or data inconsistencies can pose challenges. Ma et al. (2021) explain that experiments can help students develop conceptual understanding, application skills, and techniques. Experiments can enhance students' scientific processing skills, problem-solving abilities, capture their attention, and foster a positive attitude toward scientific approaches. Parabolic motion is understood as a real physical phenomenon experienced firsthand not merely as a concept but as a concrete event. The trajectory of the projectile will follow a parabolic path if only gravitational force influences its motion after release (La Rocca & Riggi, 2009). Knowledge is acquired through sensory (empirical) experience, namely by directly observing the thrown ball and measuring motion variables. Understanding grows from experience and reflection. Direct practice offers practical and applicable comprehension. It trains students' skills in observation, measurement, and reflection on real phenomena. This approach is relevant for developing students' fundamental scientific skills. Students throw the ball at specific angles and velocities, observe its path, and measure distance and time using a stopwatch and meter stick.

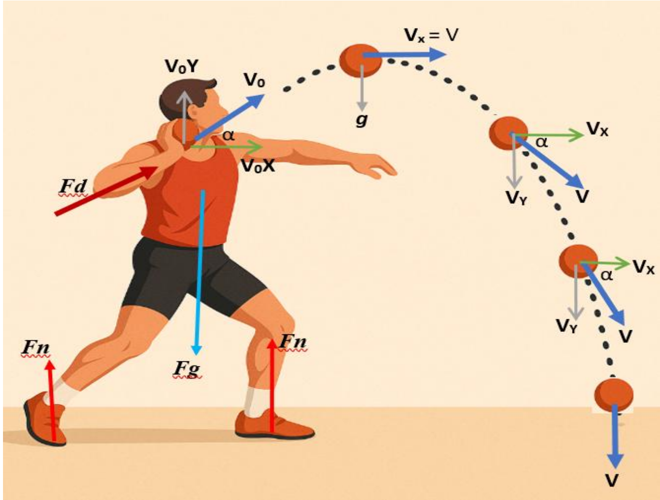

Figure 3. Parabolic motion pattern in shot put

The hand force *Fd* represents the push that manifests as the initial velocity V_0 of the projectile at a push angle α. The body's weight force *Fg* and the normal force *Fd* on the feet are two forces that influence stability and strength during the hand's push, as these forces interact with each other. To determine the kinematic equations applicable to this motion, the process follows the same steps as deriving equations in theoretical case studies. Therefore, in this shot put push, we only use the essential equations needed, including:

Time required for the bullet to reach the highest point:

$$t_h = V_0 \sin \alpha / g$$

Maximum Height of the Shot Put:

$$h_{max} = 1/2\, V_0^2 \sin^2\alpha / g$$

Maximum Range of the Shot Put:

$$R = V_0^2 \sin 2\alpha / g$$

The time required for the shot put to reach the farthest point :

$$t_R = 2\, t_h$$

$$t_R = 2\, V_0 \sin \alpha / g$$

Materials Used:

- ✓ Iron ball / small shot put as the object to be thrown
- ✓ Stopwatch to measure the flight time
- ✓ Measuring tape for measuring the throwing range
- ✓ Protractor / angled stand to determine the throwing angle
- ✓ Camera (optional) to record the trajectory of the throw
- ✓ Graph paper / spray paint (optional) to mark the landing point
- ✓ Calculator for data calculations

Procedure:

1. Prepare the Location
   Find a flat, open area such as a campus field or sports ground.
2. Set the Throwing Angle
   Install the auxiliary tools (angled stand or protractor) to maintain a consistent angle.
3. Perform the Throw
   Throw the ball at predetermined angles: 30°, 45°, and 60°.
4. Measure the Range
   Use the measuring tape to measure the horizontal distance from the starting point to where the ball lands.
5. Record the Flight Time (optional)

Use the stopwatch to record the time from the moment of the throw until the ball touches the ground.

6. Repeat the Throws
   Perform three throws for each angle to obtain valid data and calculate the average.
7. Record the Data
   Save all data in a table for further analysis.

Theoretically, an angle of 45° provides the maximum distance; however, this study shows an inverse relationship both in theory and in PhET simulations. In practical field conditions, when three male students with heights of 160 cm, 165 cm, and 175 cm threw a ball, the student with a height of 175 cm at an angle of 60 degrees achieved the farthest distance. This can be influenced by several factors, as shown in Table 2.

Table 2. Factors affecting throwing results based on height and throwing technique

Factor	**Student 175 cm (Angle 60°)**	**Students 160/165 cm (Angle 40° or 60°)**
Height of ball release	Higher, extending flight time	Lower, shorter flight time
Initial throwing speed	Higher due to arm span and technique	Lower due to shorter arm span
Throwing angle	60°, higher trajectory and longer flight time	40° or 60°, but with a lower release height
Throwing distance	Farther due to the combination of height and speed	Shorter

Students who participate in lectures on projectile motion through a hands-on field approach, particularly involving shot put activities, demonstrate more active physical and visual engagement, even though their theoretical understanding remains quite limited. Generally, these students do not have a deep grasp of physics concepts such as elevation angle, initial velocity, time of flight, or parabolic trajectory in the form of formulas or mathematical models. However, their involvement in real-world field activities allows them to develop a basic intuition about the relationship between motion and observable outcomes. Through direct observation of the object’s trajectory (the shot put), students begin to recognize that the throwing angle affects the range and that the force and direction of the throw influence the maximum height reached by the object. Although they are not yet able to explain these phenomena theoretically, they start to develop conceptual understanding inductively based on empirical experience. Hasil temuan Cross (2014) indicate that measurements were conducted to determine the speed of objects with different masses when thrown using an overhead throwing technique. Lighter objects can be thrown at higher speeds compared to heavier objects, although the difference in speed is not as significant as anticipated. When the mass of the thrown object increased by 60 times, its throwing speed only decreased by 2.4. This small change in throwing speed is attributed to the increase in force that can be applied to the object as its mass increases. Analysis of the muscle forces involved shows that the increase in force related to mass is more influenced by inertia (the tendency to maintain motion) than by physiological factors (related to body function). Furthermore, the total kinetic energy of the mass, hand, and forearm is hardly affected by the mass of the thrown object, and throwing speed is also not heavily dependent on the mass of the upper arm. In other words, although heavier objects are more difficult to throw, the increase in muscle force helps maintain a relatively stable throwing speed.

Linthorne (2001) explains that intuitively, it is clear that one can throw a baseball faster than a brick because the baseball is lighter. If the force applied to each object is the same and if both objects are accelerated over the same distance, then both objects will have the same kinetic energy. In practice, however, one can apply a greater force to the brick, resulting in the brick having greater kinetic energy. The additional force on the brick is not sufficient to propel it at the same speed as the baseball, but the percentage difference in their speeds is much smaller than the difference in their masses. This result will be of interest to those involved in teaching basic physics in life sciences or sports courses. One challenge in teaching physics to these students is the difficulty in obtaining relevant and reliable data about the forces and energies involved in human movement. An example of this issue relates to the optimal angle for jumping or throwing a shot put to achieve maximum distance. This angle not only depends on the physics of the trajectory but also on the fact that the biomechanical forces applied depend on the angle at which those forces are applied. The main physics question of interest in throwing is how the applied force varies with the mass of the thrown object, and why this force varies with the object's mass. Therefore, Cross (2014) findings in his paper provide answers to these questions, as they are not available in teaching or research literature. There is a conjecture in the physiology literature that heavy objects can only be thrown at low speeds because muscles generate large forces only at low contraction speeds. However, it is shown that the main effects involve elementary physics, not physiology. In the throwing experiment, the mass of the chosen objects varied by a factor of 60, from 57 g (tennis ball) to 3.4 kg (brick). Each object was thrown at least twice and up to four times by five male subjects at speeds approaching their maximum. As expected, all subjects threw the tennis ball faster than the brick. There has been much research on the biomechanics of throwing, but in almost all cases, the mass of the thrown object has not varied (Putnam, 1993). Students are more enthusiastic and active. However, their theoretical understanding remains weak. There has been a shift in some misconceptions due to direct experiences, as shown in the following Table 3.

Table 3. Types of changes in misconceptions due to direct experience

Thematic Code	Type of Misconception	Changes That Occurred	Source of Change
MP1	All angles produce the same distance	Changed; students realize that 45°–60° provides different ranges	Results of throws and group discussions
MP2	Gravity only acts when an object is rising	Changed; students realize the ball slows down and falls	Observation of the trajectory
MP3	Trajectory is only influenced by the force applied	Not changed; no discussion on the role of initial speed and angle	

Active engagement helps build intuitive understanding, but it still needs to be supported by reflection and reinforcement of theory. However, limitations in theoretical knowledge cause students to struggle to connect practical results with mathematical models or explain the scientific reasons behind their observations. They tend to use non-technical language such as "stronger," "higher," or "farther," without being able to quantitatively explain the effects of initial velocity or gravity. Moreover, when asked to relate their practical activities to trajectory graphs or parabolic motion formulas, most students exhibit confusion or provide incorrect answers. In general, learning through hands-on field practice facilitates an initial, contextual, and intuitive understanding of projectile motion concepts. Students are more easily engaged actively and show greater interest. However, without adequate theoretical guidance, their understanding remains limited, and unable to bridge the gap between physical experience and abstract scientific concepts. This situation indicates that field practice methods are effective for building concrete experiences but need to be complemented with pedagogical interventions that bridge practice and theory, such as reflective discussions based on observation results or the integration of visual media that illustrate the relationship between object motion and mathematical models.

Direct Instruction with Field Practice on Projectile Motion

Direct instruction is a systematic teaching approach where the teacher explicitly delivers the material, often through lectures and discussions, to convey and deepen students' understanding of fundamental physics concepts and formulas. In the context of projectile motion, this method covers both the mathematical and conceptual aspects, such as the horizontal and vertical components of motion, time of flight, range, and maximum height. The lecture format allows for a gradual presentation of these concepts, followed by interactive discussions with students. This approach offers several advantages: it provides a well-organized structure for content delivery, is effective for introducing new concepts, and works well in large classroom settings. However, it also has limitations, including minimal use of visual aids and real-world experiences, limited support for diverse learning styles, and low student interaction unless supplemented with active learning strategies.

Research by Romanvican et al. (2020) highlights that conventional lectures tend to be less effective when not combined with visual media or problem-solving activities, particularly for topics like projectile motion that require visualization of motion. Visualization techniques integrate empirical understanding with information processing tasks, providing intuitive illustrations of hidden patterns in student activities and fostering friendly interaction during data exploratio (Zhang et al., 2022). This approach actively involves students in physical experiments where they observe and measure the trajectories of thrown objects, such as iron balls or shot puts. By analyzing their observations alongside theoretical concepts, students gain direct experience of the parabolic nature of projectile motion. They also develop skills in measuring and calculating variables like range and flight time, linking practical results with physics theory. Advantages: Offers concrete, real-world experience, Enhances scientific skills and teamwork, Boosts student motivation and curiosity. Challenges: Dependent on weather conditions, equipment availability, and suitable locations, Requires additional time and coordination, Experimental data may be less accurate without proper tools

Several academic studies indicate that direct instruction (DI) effectively teaches challenging academic content to diverse learners. To achieve this, DI encompasses a complex system designed to organize and guide teacher-student interactions to maximize learning. This system includes: instructional formats that define interactions between teachers and students, flexible skill-based grouping, active student responses, responsive interactions between students and teachers, ongoing data-driven decision-making, and mastery teaching (Slocum & Rolf, 2021). Furthermore, research conducted in Ethiopia comparing the Direct Instructional Model (DIM), Experiential Learning Model (ELM), and their combination (DIM-ELM) shows that ELM is more effective than both DIM and DIM-ELM in improving post-test scores of conceptual understanding. ELM also outperforms the DIM-ELM method in enhancing post-test critical thinking scores, with DIM-ELM yielding better results than DIM. However, no significant differences were found in the impact of these learning approaches on metacognition. These findings suggest that ELM may be more effective than DIM and DIM-ELM in improving students' conceptual understanding and critical thinking skills in physics (Dessie et al., 2023). The field experiments show a variation in the throwing range results among students with different heights. Students who are 175 cm tall achieved a greater range at a 60° angle compared to students who are (160–165) cm tall at the same angle.

Effect of Body Height on Throwing Distance

Body height plays an important role in the ball-throwing experiment because it relates to the release height of the ball. Taller students usually release the ball from a higher position. This affects the throwing distance in the following ways: 1) The time the ball spends in the air becomes longer because it starts from a higher point, so it takes more time to fall to the ground; 2) With a longer flight time, the ball can cover a greater horizontal distance, even if the angle and initial velocity remain the same.

Role of Initial Velocity and Throwing Technique

Besides the release height, a student with a height of 175 cm may also have: 1) A longer arm span, allowing for a greater throwing force and a higher initial velocity of the ball; 2) Body biomechanics that support a 60° angle to produce an optimal throwing speed; 3) A more efficient body position and throwing technique at that angle, resulting in a favorable combination of angle and velocity. Since the throwing distance depends heavily on the square of the initial velocity (v^2), even a slight increase in initial velocity can lead to a significant increase in distance. Therefore, a student who is 175 cm tall has the advantage of a higher release point and potentially greater throwing speed, which makes the maximum range at a 60° angle greater compared to shorter students.

Comparison of Direct Instruction or Practical Work with Learning Using PhET Simulations on the Topic of Projectile Motion

PhET (Physics Education Technology) is an interactive web-based simulation developed by the University of Colorado. The Projectile Motion simulation allows students to adjust the angle, initial velocity, and gravity to observe parabolic trajectories. In relation to projectile motion material, the simulation enables direct manipulation of physical variables such as launch angle and initial speed, while visually demonstrating the relationships between these variables. It is highly suitable for understanding the connection between theory and the phenomena of projectile motion in an interactive manner. The advantages of using PhET simulations include providing in-depth interactive visualization that is safe, easily accessible, and free of charge, making it ideal for both independent and collaborative learning. However, the program has some limitations: it does not develop hands-on practical skills, requires digital literacy and appropriate devices, and its effectiveness depends on teacher guidance. Banda & Nzabahimana (2021) found that guided inquiry-based learning supported by PhET simulations significantly improves students' learning outcomes and critical thinking skills on the topic of projectile motion. The integration of direct instruction (lectures and discussions), field experiments, and PhET simulations offers a comprehensive, balanced, and effective approach to understanding projectile motion concepts, especially at higher education levels such as universities. Each method has complementary strengths: direct instruction provides a strong theoretical and mathematical foundation; field experiments allow students to connect theory with real physical phenomena, enhancing understanding through direct experience and observation; and PhET simulations offer interactive and exploratory visualization, accelerating conceptual comprehension and supporting independent and investigative learning.

All three methods have complementary strengths. Therefore, it is recommended to implement an integrative model, which includes systematic lectures for the introduction of concepts, field practices to build intuitive and applicable understanding, and PhET simulations for visualization and independent investigation, as shown in the following Table 4.

Table 4. Comparison of theoretical understanding, student engagement, misconception changes, and learning styles addressed based on the three direct learning methods.

Aspect	Lecture/Discussion	Direct Practice	PhET Simulation
Theoretical Understanding	Quite high (if mathematics is strong)	Low	High
Student Engagement	Low	High	High
Changes in Misconceptions	Slow	Moderate	Fast
Addressed Learning Styles	Auditory	Kinesthetic	Visual and Exploratory

By integrating these three approaches, students not only gain cognitive understanding of the concepts but also develop practical skills, critical thinking, and deeper scientific analytical abilities. This integrated application supports constructivist-based learning (learning through experience and exploration), accommodates various learning styles (auditory, kinesthetic, visual), and prepares students to tackle real-world problems with a holistic scientific approach. Therefore, the integration of teaching methods in the topic of projectile motion is highly recommended to comprehensively enhance the quality of both the learning process and student outcomes. Projectile motion is a common topic in physics courses. Projectile motion in a vacuum is studied first. Its trajectory forms a parabola, and the maximum horizontal range is achieved at a launch angle of 45°. In air, drag force acts, which depends on the square of the velocity (quadratic drag) (Benacka, 2011). Beberapa studi sebelumnya menyelidiki sudut lemparan atau lombatan. For example, Giavazzi et al. (2021) investigated the ballistic movement of small-legged insects and legless larvae after jumping. It was found that, although the general optimal angle for maximum distance is 45°, some animals have evolved to jump at a take-off angle of 60° in environments with obstacles. Furthermore, findings by (Liu et al., 2023) on how seam orientation affects cricket ball swings revealed that an optimal angle between 58° and 60° maximizes lateral force. Mehta (2022) also found that a projection angle of 45 degrees has a wider range compared to other projection angles using a Taylor series approach. A unique finding from Jaber (2014), indicates that when conducting a final investigation, simulations showed that an optimal launch angle of 33° is the best for maximizing horizontal range. This angle is significantly below the ideal 45°, thus validating that the actual optimal angle for achieving maximum range deviates from the ideal conditions. To obtain a more accurate angle, future investigations could attempt to incorporate more dynamic factors, such as speed-dependent drag changes or the effects of ball spin. For students wishing to replicate or expand on this study, we recommend considering the effects of variations in ball size, mass, or surface texture, all of which can influence drag.

CONCLUSION

This study confirms that direct learning is a highly effective instructional strategy for enhancing students' conceptual understanding of projectile motion, which has often been hindered by various misconceptions. Through a qualitative approach involving observations, in-depth interviews, and student reflections during an active and interactive learning process, this research successfully reveals how direct learning can be key to fostering significant conceptual change. One of the main findings is that direct learning not only helps students identify the misconceptions they hold but also provides them with opportunities to systematically correct these misunderstandings. Thus, this method can overcome cognitive barriers that are often difficult to address through more passive conventional teaching methods. Moreover, direct learning enriches students' understanding by linking the abstract concepts of projectile motion with real-life phenomena they encounter daily. This approach makes complex physics material more vivid, meaningful, and applicable, enabling students not merely to memorize concepts but to truly comprehend and apply them in relevant contexts. This approach reinforces the constructivist rationale, as students build new knowledge through active interaction with real and directed learning experiences. Physics material, which was initially abstract, becomes more applicable and relevant to everyday life, as evident in the phenomenon of projectile motion. Thus, students are not only able to remember concepts but also truly understand and apply them flexibly in new contexts. Furthermore, the conceptual transformation that occurs through direct learning demonstrates that this method can strengthen the foundation for sustainable physics education. By building a solid conceptual understanding, students are better prepared to tackle more complex physics topics in the future with greater confidence and effectiveness. Overall, the results of this study make an important contribution to the development of physics teaching strategies, particularly in addressing misconceptions that are major obstacles to understanding projectile motion concepts. However, this study has several limitations that need to be considered. As a qualitative study conducted in only one class, the findings cannot be broadly generalized to other learning contexts without further testing. Additionally, in the implementation of direct learning involving field practices, practical factors such as time constraints, weather conditions, and variability of equipment also affect the quality and reproducibility of the learning activities. These findings also open opportunities for further research to explore the application of direct learning in other physics topics, as well as to develop more innovative and responsive instructional models tailored to students' needs. Therefore, direct learning is not only relevant as a traditional method but also as an adaptive and effective approach within the context of modern physics education, which demands active student engagement and the connection of material to real-world experiences.

RECOMMENDATION

The findings of this study have significant implications for educators, policymakers, and curriculum developers in enhancing students' conceptual understanding of physics within the development of physics science learning, as outlined below. First, it is highly recommended that direct learning methods be more intensively integrated into the physics curriculum, particularly on the topic of projectile motion, as this approach has been proven effective in helping students recognize and correct misconceptions that have long been the main obstacles to conceptual understanding. Furthermore, the implementation of active and interactive learning techniques such as group discussions, simple experiments, and simulations of real phenomena should be strengthened to enable students to engage more directly in the learning process and connect abstract concepts with everyday experiences, thereby making learning more meaningful and applicable. Next, it is important for instructors to relate physics material to real-life examples relevant to students' lives, so that the concepts taught are not only understood theoretically but can also be applied in practical contexts. To support this, educational institutions should provide training and professional development for educators to effectively implement direct learning methods, including the accurate identification and remediation of student misconceptions. Moreover, further research employing mixed-method approaches is strongly encouraged to provide a more comprehensive picture of the impact of direct learning, both quantitatively and qualitatively. Longitudinal studies are also necessary to assess concept retention and the sustained effects of this method on students' ability to apply physics concepts. In addition, given the success of direct learning in the topic of projectile motion, there is great potential to explore the application of this method to other physics topics that also present high levels of difficulty and misconceptions, such as dynamic electricity, waves, or thermodynamics. Thus, direct learning is not only relevant as a traditional method but also as an adaptive and effective approach to improving the overall quality of physics education in a comprehensive and sustainable manner.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Jamaludin	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓	
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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

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