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Enriching Physics Education with Islamic Heritage: Al-Khazini's Gravitational Theory

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ABSTRACT
This research examines the contributions of Al-Khazini, a 12th-century Muslim scientist, who proposed the theory of gravity in his book "Mizan Al-Hikmah," predating Isaac Newton by several centuries. Despite Al-Khazini's pioneering work, his contributions are often overlooked in the history of Physics, with Newton predominantly recognized in educational contexts. This study aims to underscore Al-Khazini's significant role in the development of gravitational theory and enhance students' understanding of the history of Physics. Employing a qualitative descriptive approach and literature review, the research analyzes relevant references to highlight this oversight. This study found that Physicsteachers frequently omit the discoveries of Muslim scientists, leading to a Western-centric view of Physicshistory among students. The study concludes that while Al-Khazini first conceptualized the theory of gravity, Newton later formulated it mathematically. Integrating Al-Khazini's contributions into Physicseducation can enrich students' comprehension of scientific history, deepen their grasp of gravitational concepts, and foster appreciation for the contributions of Muslim scientists. This integration promotes a more diverse and inclusive teaching approach, encouraging curriculum revisions to better acknowledge Islamic intellectual heritage and provide a more comprehensive education.

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ABSTRAK

Penelitian ini mengkaji kontribusi Al-Khazini, seorang ilmuwan Muslim abad ke-12, yang merumuskan teori gravitasi dalam bukunya "Mizan Al-Hikmah," jauh sebelum Isaac Newton. Meskipun merupakan karya pionir, kontribusi Al-Khazini sering diabaikan dalam sejarah Fisika, sementara Newton lebih dikenal. Studi ini bertujuan untuk mengungkap peran signifikan Al-Khazini dalam pengembangan teori gravitasi dan meningkatkan pemahaman siswa tentang sejarah Fisika. Dengan menggunakan pendekatan deskriptif kualitatif dan tinjauan literatur, penelitian ini menganalisis referensi yang relevan untuk membahas adanya kesenjangan ini. Studi ini menemukan bahwa guru Fisika sering mengabaikan penemuan ilmuwan Muslim, sehingga sejarah Fisika yang diajarkan ke siswa seringkali berpusat pada Barat. Studi ini menyimpulkan bahwa benar Al-Khazini pertama kali mengkonseptualisasikan teori gravitasi, namun Newton yang kemudian merumuskannya secara matematis. Mengintegrasikan kontribusi Al-Khazini ke dalam pendidikan Fisika dapat memperkaya pemahaman siswa tentang sejarah Fisika, memperdalam pemahaman mereka tentang konsep gravitasi, dan mendorong apresiasi

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terhadap kontribusi ilmuwan Muslim. Integrasi ini menyarakankan pendekatan pengajaran yang lebih beragam dan inklusif, mendorong revisi kurikulum untuk lebih mengakui warisan intelektual Islam dan menyediakan pendidikan yang lebih komprehensif.

Introduction

Physics as a science that studies natural phenomena and the basic principles that govern the universe, provides a strong basis for every individual's understanding of the world and modern technology (Aleksi & Leevi, 2022). Thus, Physics has become an important aspect for the world of education (Fidan & Tuncel, 2019). One of the Muslim figures who made an important contribution to the field of Physics was Al-Khazini.

Al-Khazini, as a scientist from the 12th century produced work that is significant for the study of Physics in the modern era. He introduced an early theory of gravity that contributed to the theoretical basis of Physics. His most famous work is "Kitab Mizan al-Hikmah" which discusses balance and gravity. Al-Khazini developed the theory of gravity which states that objects fall to the earth due to the earth's gravitational force. This theory became the basis for further understanding of gravity before Isaac Newton developed his theory in the 17th century. Isaac Newton in the 17th century succeeded in proving that apples fell from the tree to the ground because of an interaction. Apart from that, Newton also proved that there is an interaction that holds the position of planets in their orbits around the sun as the center of the solar system (Santi & Darajat, 2017). In 1687 Newton published the law of gravity, also known as *law of gravitation* which explains the moon and planetary motion and discovers the basic character of gravity between two objects along with the three laws of motion.

Despite its significance, Al-Khazini's theory of gravity is rarely taught in modern physics curricula (Santi & Darajat, 2017). Students from elementary to high school are more familiar with Newton as the originator of the theory of gravity, which explains the attractive force between the earth and other celestial bodies (Rust, 2020). This reflects a lack of integration between scientific knowledge and religious values in education, which could enrich students' learning experiences by providing a broader historical and cultural context (Rusdi, 2020). From an Islamic science learning perspective, it is important to acknowledge and integrate the contributions of Muslim scientists into the curriculum to create a more holistic understanding of science (Rusdi, 2020).

The primary focus on well-known Western discoveries, such as Newton's theory of gravity, often results in the contributions of Muslim scientists like Al-Khazini being overlooked in physics education. A preliminary study of teachers at MAS Nurul Islam Cianjur, who are UIN alumni, revealed that their lesson plans only cover Newton's version of the theory of gravity, without mentioning earlier contributions by Muslim scientists. This omission leads students to believe that Newton was the first to develop the theory of gravity, ignoring the significant contributions of Muslim physicists (Santi & Darajat, 2017).

The discoveries of Muslim scientists are often underrepresented in educational materials, with physics textbooks typically focusing on Western figures without detailing the processes behind their discoveries (Santi & Darajat, 2017). Physics teachers play a crucial role in designing and implementing lessons that integrate science and Islamic values (Suprapto, 2020). Teachers need to understand Al-Khazini's theory of gravity and how to teach it within the context of Islamic history and culture (Jamaluddin, 2019). Additionally, they must develop strategies that facilitate conceptual understanding and reflection of religious values in physics learning (Lee, 2021).

Research indicates that integrating religious values into science education can be achieved through various methods, such as contextual approaches, project-based learning, and historical stories (Ningsih et al., 2022). Teaching Al-Khazini's theory of gravity can involve historical narratives about the development of science in the Islamic world, relevant experiments, and discussions on ethical values in science (Chowdhury, 2016). Information and communication technology (ICT) can also be an effective tool for integrating science learning with Islamic values (Ari Nugroho, 2017). Digital media, such as videos, simulations, and applications, can provide interactive and engaging learning resources that explain Al-Khazini's theory of gravity in a broader context, helping students understand concepts more deeply and relate them to their daily lives (Dewi et al., 2021).

Teaching that integrates religious values can increase student motivation and make learning more meaningful (Danumiharja et al., 2023). This approach helps students develop critical and reflective thinking skills and appreciate the contributions of scientists from various cultures and religions (Dewi et al., 2021). Therefore, it is important to develop a physics learning model that incorporates the Islamic science learning perspective, particularly Al-Khazini's theory of gravity.

Integrating Islamic science learning is not just about adding religious content to the curriculum but also about creating an inclusive learning environment that respects diversity (Purwanto et al., 2019). Teachers must accommodate students' diverse backgrounds and beliefs and encourage open dialogue about the relationship between science and religion (Purwanto et al., 2019). This approach can foster mutual respect and tolerance among students. Managing physics learning, especially the theory of gravity from Al-Khazini's perspective, is a crucial step in creating holistic and meaningful education. This integration can enrich the curriculum and positively contribute to the development of education in Indonesia (Suprapto, 2019).

This article is novel in emphasizing the teaching of Al-Khazini's theory of gravity within the context of Islamic science learning, an approach rarely discussed in depth in previous literature. While most research has focused on the general integration of Islamic values in science education, this article specifically explores Al-Khazini's theory of gravity and how its integration can enrich physics learning. It highlights the contributions of Muslim scientists in the history of physics and proposes teaching strategies that combine historical, ethical, and spiritual aspects in the physics curriculum.

The aim of this research is to examine and highlight Al-Khazini's significant contributions to the theory of gravity. By doing so, it seeks to inform students about the achievements of Muslim scholars who discovered the theory of gravity before Isaac Newton, thereby offering a more comprehensive and accurate understanding of the history of Islamic science. Additionally, this research aims to provide innovative insights for teachers on integrating Islamic values into physics education.

Methods

This research employs a descriptive qualitative design with a case study approach to deeply understand the implementation of physics education from an Islamic science perspective, focusing on Al-Khazini's theory of gravity. The case study approach is ideal for exploring the integration of Al-Khazini's theory, allowing for an in-depth analysis of its incorporation into the physics curriculum and teaching methods. This approach also identifies best practices and barriers to applying the theory in various educational settings.

The research method involves a literature review, collecting references from national and international journals and relevant e-books. After gathering and reviewing these references, a synthesis was conducted to identify key findings for this research. The study was conducted at MAS Nurul Islam Cianjur in 2023. This research site was selected because the physics teacher, an alumnus of an Islamic University, has integrated Islamic teachings into the school curriculum, prompting further investigation into this integration, particularly concerning gravity.

The study population includes physics teachers and students at Madrasah Aliyah (MA) schools with curricula integrating science learning with Islamic values. The sample was purposively selected from one or two schools meeting these criteria. In each school, several physics teachers who teach gravity theory and students enrolled in these classes were chosen as respondents. The sample size was determined to achieve data saturation.

Data collection techniques included in-depth interviews, classroom observations and document analysis. The researcher directly engaged with the physics teacher during data collection. In-depth interviews with physics teachers explored their teaching strategies and views on integrating Islamic values into physics education. Classroom observations allowed the researcher to witness the implementation of Al-Khazini's theory of gravity. Document analysis involved reviewing teaching materials, lesson plans (RPP), and evaluations.

Surveys (classroom observations) and interviews were chosen to provide a comprehensive approach to collecting complementary data. Surveys efficiently gathered quantitative data from many respondents, offering a general view of knowledge and attitudes towards Al-Khazini's theory. In-depth interviews provided detailed qualitative insights, exploring teachers' and students' views, experiences, and challenges in integrating the theory. Combining these methods gave researchers a holistic understanding of the acceptance and application of Al-Khazini's theory in physics education. Students and teachers participated in surveys and interviews with explicit consent. Student results were kept confidential using code numbers or aliases to protect individual identities. Data was collected and analyzed anonymously to maintain privacy and security.

The research instruments, including interview guides, observation sheets, and document analysis formats, were developed based on the research conceptual framework and validated by educational experts. Data analysis was conducted using Excel, which, although not typically used for qualitative data analysis, proved useful for organizing data, creating frequency tables, and producing visualizations to aid in understanding research findings. The data analysis technique involved two main steps: first, grouping and analyzing interview data based on emerging themes and patterns to understand participants' views and experiences. Second, statistically analyzing survey data to identify general trends and patterns in responses. Combining these methods provided a complete picture of how Al-Khazini's theory is accepted and applied in physics education.

This article begins with an in-depth literature review on the history of physics, particularly Al-Khazini's contributions, and relevant previous research. After formulating the research problem, the researcher developed an interview questionnaire integrating Al-Khazini's theory of gravity. Data was collected through interviews with teachers and students, classroom observations, and analysis of teaching tools. The data was qualitatively analyzed to understand the implementation of the learning design and its impact on student understanding. Finally, the analysis results were compiled into a comprehensive research report, presenting key findings and implications for developing physics education with an Islamic perspective.

Results

The following data is the results of online survey with a 1 to 4 Likert scale filled by 57 students, which is then measured based on six aspects and six indicators related to Muslim scientists, especially Al-Khazini, on the topic of Gravity.

Table 1. Result of Questionnaire on Students' Knowledge about Al-Khazini and Its Findings

No.	Aspect	Indicator	Grade Average	Category
1	General knowledge about science	Get to know important figures in the history of science	81,14	Good
2	Understanding the Concept of Gravity	Understand the basic concepts of gravity and the contributions of scientists	76,46	Enough
3	Understanding of Al-Khazini's Character	Knowing Al-Khazini's contribution to the development of the theory of gravity.	76,43	Enough
4	Perceptions of Science	Assess the importance of knowing the contributions of scientists from various cultures.	73,98	Enough
5	Attitudes towards the History of Science	Understand the importance of the history of science in education.	80,99	Good
6	Interest and Motivation	Knowing students' interest in studying scientific figures.	74,56	Enough

From the table above, Aspect 1, General Knowledge about Science, had an average score of 81.14, categorized as “Good.” This aspect assessed students’ knowledge of important figures in the history of science. While most students could recall several Islamic figures, interviews revealed a lack of understanding regarding each figure’s contributions to science. The contributions of Muslim scientists have significantly influenced the development of modern scientific knowledge (Jailani, 2018).

Aspect 2, Understanding the Concept of Gravity, had an average score of 76.46, categorized as “Sufficient.” This aspect measured students’ understanding of the basic concepts of gravity and the contributions of scientists. A solid grasp of gravity’s basic concepts is essential for further learning in physics (Subhan et al., 2022). Enhancing students’ understanding of gravity can be achieved through simulations and visualizations in the learning process (Lindner et al., 2019). Using technology, such as computer simulations and augmented reality applications, to visualize gravity and adopting an inquiry-based learning approach are effective solutions (Lindner et al., 2019).

One example of a useful simulation is the PhET Simulation, an accessible and interactive computer-based tool for supporting science learning, including physics (Prima et al., 2018). PhET simulations of gravity provide a visual and interactive understanding of how gravity works. Key concepts often explained by these simulations include: (1) Newton's Law of Gravity, demonstrating that the gravitational force between two objects is proportional to their masses and inversely proportional to the square of the distance between them; (2) Mass and Distance, showing how changes in mass or distance affect the strength of the gravitational force; and (3) Gravity of Planets and Satellites, illustrating how planetary gravity keeps satellites in orbit and explaining the concept of centripetal force required to maintain orbit (Prima et al., 2018). PhET simulations offer an interactive learning experience, allowing users to experiment with variables and observe the results directly (Prima et al., 2018). See figure 1 and 2.

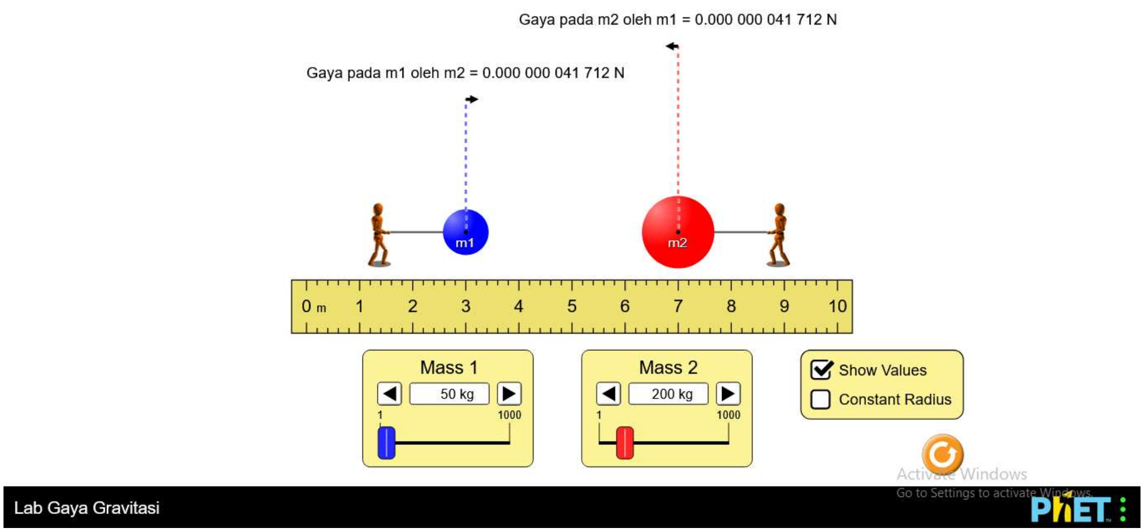


Figure 1. PhET simulation display of gravity between two objects

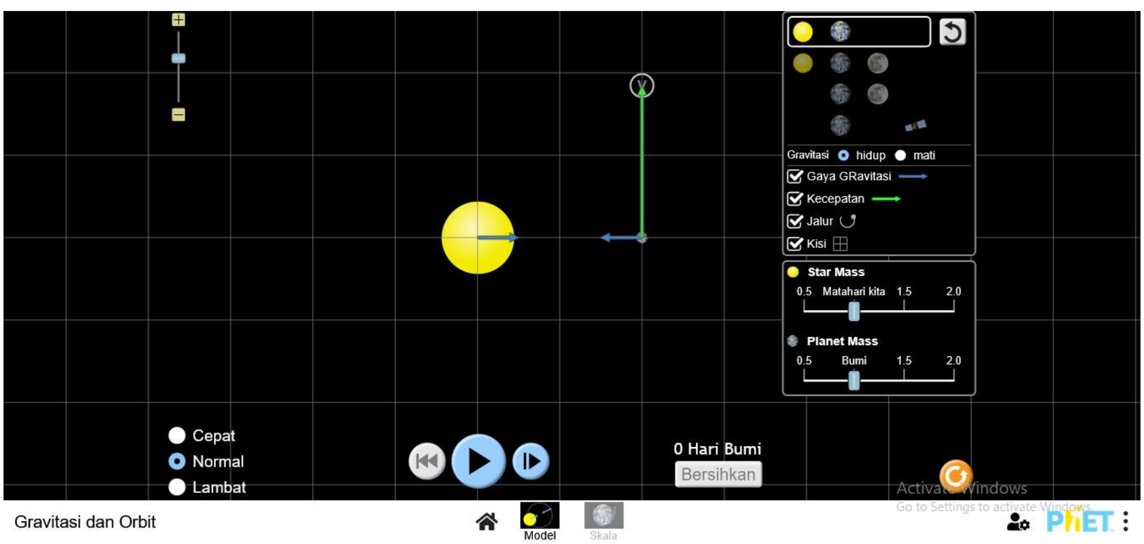


Figure 2. PhET display of gravity between planets and satellites

Aspect 3, Understanding the Character Al-Khazini, had an average score of 76.43, categorized as "Sufficient." This aspect assessed students' knowledge of Al-Khazini's contributions to the development of the theory of gravity. Integrating the history of Muslim scientists into the curriculum can enhance students' understanding of contributions from various cultures (R. Dewi, 2016). Knowledge about Muslim scientists like Al-Khazini can boost cultural pride and identity among Muslim students (Santi & Darajat, 2017). Developing learning materials that specifically discuss these contributions and involving students in analyzing them is an effective solution.

Aspect 4, Perception of Science, had an average score of 73.98, also categorized as "Sufficient." This aspect measured students' assessment of the importance of knowing contributions from scientists of various cultures (Bakker & Telli, 2023). Positive perceptions of science correlate with higher interest in studying the subject. Appreciating contributions from diverse cultures can increase diversity and inclusiveness in science education (Beaulieu, 2022). Positive perceptions can motivate students to pursue STEM careers (Sellami et al., 2023), and abilities in STEM can be enhanced with competent facilitators (Rahim, 2015). Raising awareness about contributions from various cultures through extracurricular activities and seminars can effectively improve this aspect.

Aspect 5, Attitudes towards the History of Science, had an average score of 80.99, categorized as "Good." This aspect assessed students' understanding of the importance of the history of science in education. Understanding the history of science is crucial for appreciating the holistic development of scientific knowledge (Riley et al., 2024). A positive attitude towards the history of science can increase students' interest in learning (Robinson-Jones et al., 2024). Integrating the history of science into the curriculum can strengthen students' understanding of scientific concepts (Ndomondo et al., 2022). An interdisciplinary approach that connects history and science, along with visits to science and history museums, can effectively enhance understanding of the history of science.

Aspect 6, Interest and Motivation, had an average score of 74.56, categorized as "Sufficient." This aspect measured students' interest in studying scientific figures. High interest in scientific figures can increase learning motivation (Getz et al., 2024). Learning that aligns with students' interests can improve outcomes (Herianto & Wilujeng, 2021). Intrinsic motivation can be strengthened through knowledge of inspirational figures in science (Turan et al., 2022). Identifying students' interests and adapting teaching methods accordingly, as well as inviting renowned scientists to provide inspiration, can be effective solutions.

Data shows that most teachers rarely or never discuss the contributions of Muslim scientists, including Al-Khazini, in their physics lessons. One teacher stated, "We focus on Newton's theory of gravity because that is what is generally accepted in the curriculum, and we don't discuss figures from other scientific traditions much." Student surveys revealed that 77.26% of respondents felt they lacked an adequate understanding of the history of gravity theory and considered it important to learn about contributions from various cultural backgrounds. One student remarked, "I think it is important to know that the theory of gravity does not only come from Newton, but also from other scientists such as Al-Khazini." This highlights the need to integrate Al-Khazini's contributions into physics education and introduce more diverse historical perspectives in the curriculum.

The research results confirm the hypothesis that "there is a lack of integration in the modern physics curriculum regarding the contributions of Muslim scientists, especially Al-Khazini," and that "integrating Al-Khazini's theory can enrich students' understanding." Analysis of survey and interview data reveals that Al-Khazini's contributions are often inadequately introduced in physics teaching, leaving students more familiar with Isaac Newton's theory of gravity. The findings suggest that integrating Al-Khazini's theory can improve students' understanding of the history of science and provide a broader perspective on contributions from various cultures. Thus, the research supports the hypothesis that adding material about Al-Khazini to the curriculum can enrich physics education.

Discussion

Gravity Theory in the Physics Textbook for Class X

Gravity Theory is contained in the Physics textbook for class X Curriculum 2013 written by Marthen Kanginan, Erlangga publisher. There is one chapter containing Newton's Law of Gravity, of which explains the theory of gravity as follows:

Before 1686, many previous researchers had collected a lot of data about the orbits of planets and moons which were shaped like circles and the planets moved around their respective orbits, but at that time there were no research results that explained the reasons why planets and the earth could move around their orbits (Halliday, 2018, p. 345). So, to answer this question, a western scientist named Issac Newton conducted an experiment which succeeded in explaining the law of gravity which consists of three types and the result of circular motion or what is called centripetal force (Levitin, 2021, p. 3). Apart from that, Newton researched the movements of celestial bodies such as the moon and planets (Kanginan, 2016, p. 305). Newton assumed that based on Newton's first law, it explains that there is a force that causes the moon to keep moving in its orbit around the sun, if that force were not there then the moon would move in a straight path (Halliday, 2018, p. 345).

At that time Newton thought about a problem about forces that seemed to have nothing to do with the forces on the moon. Newton observed objects that fell downwards or towards the ground (Henry, 2021, p. 330). The reason objects always fall downwards is because there is a gravitational force or also called the earth's gravitational force (Halliday, 2018, p. 345). If there is a force on an object then that force is generated from the force on another object, this is explained in Newton's third law, which essentially states that all objects that fall at a certain height will always fall freely downwards towards the center of the earth so Newton made the conclusion that the center of the earth exerts a force on falling objects so that falling objects always point downwards (Halliday, 2018, p. 345).

According to history, at that time Newton was relaxing in his garden while watching apples fall from the tree, suddenly Newton thought that there was a gravitational force on the tree that was dropping the fruit. Of course, the moon also has a gravitational force (Tipler, 2014, p. 364) (Kanginan, 2016, p. 305). Based on the help and motivation of Robert Hooke, namely Newton's friend, the idea of gravity that emerged made Newton able to compose the law of gravity in detail which is famous to this day (Tipler, 2014, p. 364).

Newton also made a comparison between the amount of earth's gravity that attracts the moon and the value of other objects on the earth's surface (Tipler, 2014, p. 364). Objects on the surface of the earth have an acceleration due to gravity of 9.8 m/s^2. Newton assumed that there were other factors that influenced the gravitational force apart from distance, namely the value of the mass of the object (Tipler, 2014, p. 364). Based on Newton's third law, it explains that if the moon exerts a gravitational force on the earth, then the earth will also exert a gravitational force on the moon but in the opposite direction. This symmetrical characteristic is what made Newton suggest that the value of the gravitational force on an object is proportional to the value of the mass of the object (Tipler, 2014, p. 364).

$$\boldsymbol{F} \infty \frac{\boldsymbol{m_{bm} m_{be}}}{\boldsymbol{r^2}}$$

With information namely:

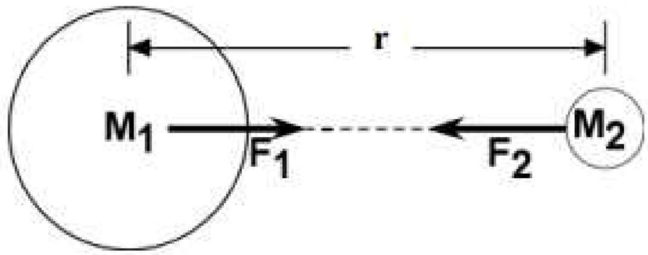
$\boldsymbol{m_{bm}}$ = is the mass of the earth

$\boldsymbol{m_{be}}$ = is the mass of another object

$\boldsymbol{r}$ = is the distance of the object from the center of the earth

Newton then researched to carry out an analysis of the planet's gravitational value by collecting previous data about the planet's orbit around the sun (Giancoli, 2021, p. 148). It turns out that the fact that planets always orbit the sun decreases in the inverse square value of the planet's distance from the sun (Giancoli, 2021, p. 148). Thus, Newton concluded that the sun's gravity made the planets able to orbit the sun (Giancoli, 2021, p. 148).

Next, Newton stated Newton's general law of gravitation, which states "The gravitational force between objects is an attractive force whose magnitude is directly proportional to the mass of each object and inversely proportional to the square of the distance between the two" (Giancoli, 2021, p. 148). See figure 3.



Picture 3. Force of Attraction between Two Objects

Formulated through the following equation:

$$\boldsymbol{F_{12} = F_{21} = F = G\frac{m_1 m_2}{r^2}}$$

With the statement that:

$\boldsymbol{F_{12} = F_{21} = F}$ = Magnitude of the force of attraction between the two objects (N)
$\boldsymbol{G}$ = General constant of gravity (6.67 x 10^{-11} Nm^2/kg^2)
$\boldsymbol{m_1}$= Mass of the first object (kg)
$\boldsymbol{m_2}$ = Mass of the second object (kg)
$\boldsymbol{r}$ = Distance between the center points of the two objects (m)

Gravitational force, also called weight force, is the force of the earth's attraction to objects (Erwin, 2017, p. 37). Conversely, there is an equally large force of attraction between objects and the earth. The distance between objects on the surface of the earth to the center of the earth is around 4,670 km (Erwin, 2017, p. 37).

Henry Cavendish in 1798 AD was an English scientist who conducted experiments using the Cavendish balance as a tool for measuring gravity and succeeded in finding the value of the universal gravitational constant (G) which has a fixed value, until now this tool is still used (Santi & Siti Zakiah Annasir Darajat, 2017). The following is an illustration of the Cavendish balance sheet measuring instrument, see figure 4.

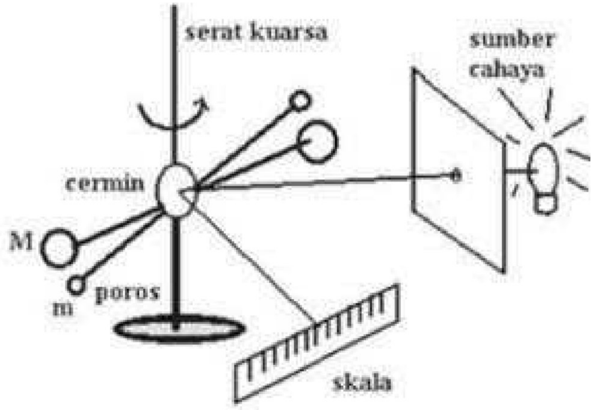


Figure 4. Cavendish's balance sheet

History of the theory of gravity briefly according to the article written by Salvatore that gravity is perhaps the fundamental interaction that still remains the most confusing, it is related to phenomena experienced in everyday life and is the easiest to understand without sophisticated knowledge. In fact, gravitational interactions were the first to be observed under a microscope in experimental investigations, obviously due to the simplicity of constructing appropriate experimental equipment. Galileo Galilei was the first to introduce the pendula and inclined plane to study terrestrial gravity at the end of time. 16th century (Henry, 2021, p. 330). Gravity played an important role in the development of Galileo's ideas about the need for experimentation in the study of Science, which had a major impact on modern scientific thinking. However, it was not until 1665, when *Isaac Newton* introduced the now famous "law of inverse square gravity", that terrestrial gravity is actually related to celestial gravity in one theory (Kanginan, 2016, p. 307). Newton's theory made correct predictions for a variety of phenomena on different time scales, including terrestrial experiments and planetary motion. Clearly, Newton's contribution to gravity, despite its enormous contribution to Physics as a whole, was not limited to the expression of the inverse square law. Much attention should be paid to the conceptual basis of the theory of gravity, which combines two key ideas: (1) The idea of absolute space, i.e. the view of space as a fixed and unaffected structure; a rigid arena in which physical phenomena occur; (2) The idea of what was later called the Weak Equivalence Principle, expressed in the language of Newtonian theory, states that inertia and gravitational mass coincide (Kanginan, 2016, p. 307).

Al-Khazini's Version of Gravity Theory

Isaac Newton was not a Muslim scientist, but it is not impossible that Newton obtained his source of knowledge from Muslim scientists such as Al-Khazini (Handayani et al., 2023). When you hear the word "gravity" or *gravity*, of course we are immediately connected to the theory of falling apples proposed by Isaac Newton. Until now, the scientist who discovered the theory of gravity is better known as Newton, because Newton was the first to formulate and establish mathematical equations to describe the theory of gravity Khazini (Handayani et al., 2023). In fact, in the 12th century a Muslim scientist named Al-Khazini appeared who first put forward the theory of gravity, long before Newton created the theory of gravity. The scientist Al-khazini is not as well-known as Ibnu Sina or others, but his research results are relatively specific relating to the theory of gravity and hydrostatics theory which is worth studying Khazini (Handayani et al., 2023).

Al-Khazini has the full name of Abdurrahman Al-Khazini or Abu Fal Abdu ar-Rahman who lived from 1115 AD to 1130 AD, who was born in Byzantium or Greece. He was one of the Muslim physicists and astronomers in the middle of the golden age of Islam. Al-Khazini lived in Turkey during the Seljuk Dynasty Khazini (Handayani et al., 2023). Al-Khazini became a slave when the Seljuk Dynasty managed to control the kingdom of Constantinople, then in the 12th century he was invited by his employer to the city of Mervi to become an official in the Muslim government because Al-Khazini had the potential of good intellectual ability so he was educated by his employer by Umar Khayam who is a great scientist and poet. Al-Khazini was taught various sciences about philosophy, astronomy, mathematics and literature by his teacher, so that his thinking was partially influenced by his teachers such as Omar Khayyam, Al-Biruni, Aristotle, Ibnu Khaitam and Archimedes (Handayani et al., 2023).

Starting from a slave to becoming an influential Muslim scientist, when the development of Western science was influenced by Al-Khazini's thoughts, because he was able to formulate many scientific theories such as mechanics, especially experimental scientific methods, gravity, potential energy, mass, distance, weight, and differences in force (Handayani et al., 2023).

In 1121 AD or 515 H Al-Khazini made one of the works written in a book called Mizan Al-Hikmah or in English called *Balance of Wisdom*, the book explains Physicsconcepts such as lever theory, hydrostatic equilibrium, density, the effect of temperature on density, and the center of gravity. The book also explains the development of knowledge from previous researchers and contemporary scientists, as well as explaining tools *aerometer* made by Pappus, *pycnometer flask* which was created by al-Biruni (Subagiya, 2022).

The formulation of gravitational force created by Al-Khazini resulted from several experiments called At-Thiqli, which explains that gravity is found in every object that has weight at a certain position towards the center of the earth. So it can be concluded that gravity depends on the distance from the center of the earth (Handayani et al., 2023). Then in the 17th century, after Al-Khazini succeeded in discovering the theory of gravity, a western scientist named Isaac Newton emerged who succeeded in making mathematical formulations and equations between each variable in the phenomenon of gravity. Based on this history, it can be concluded that Al-Khazini was the first discoverer of the theory of gravity, while Isaac Newton was the writer who mathematically formulated the theory of gravity. So it is clear that Al-Khazini was the one who succeeded in discovering and creating the theory of gravity for the first time, then it was deepened by Isaac Newton who created the formula and proved the relationship of the formula to the theory of gravity (Handayani et al., 2023).

Al-Khazini is a figure who has succeeded in discovering certain gravity in solid and liquid objects. Apart from that, the results of his research succeeded in creating measurement standards, balances, and proposed theories about capillary systems and simple lever systems (Salsabila, 2021, p. 128). The results of his findings were written in a book entitled *Book of Mizân al-Hikmah* became a guide in Europe in the Middle Ages (Salsabila, 2021). See figure 5.

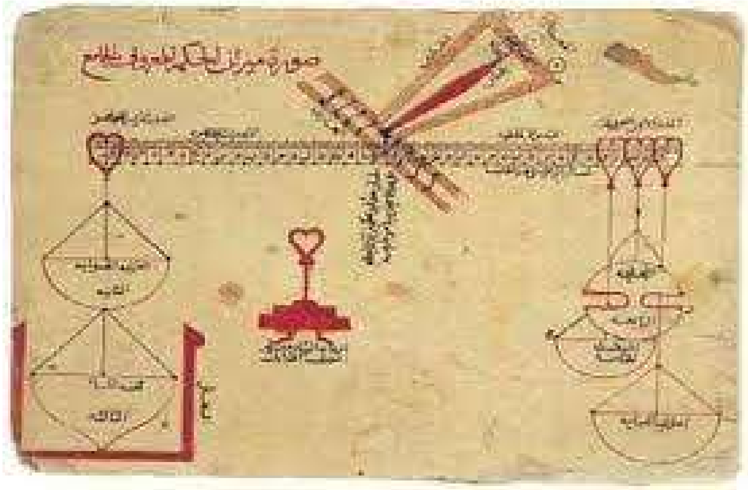


Figure 5. Hikmah Al-Khazini balance sheet

Al-Khazini's Balance of Wisdom explains that air has a pressure that comes from an upward thrust and also has weight, this also applies to liquid substances (Alawiyah, 2018). Until the weight causes the air to have pressure in all directions, this pressure is called air pressure. Al-Khazini made measuring instruments with five models. One of the tools is in the form of a balance accompanied by a barometer that functions as a density level measuring tool (Santi & Darajat, 2017). Based on the tool, there is a relationship between hot temperature and air density, so the measurement will be related to air temperature.

The results of this research are relevant to one of the theories in the book Islam and Traditional Science which explains several ancient ideas put forward by David King that: Muslim scholars were fortunate enough to be heirs to ancient sciences; Muslim scholars have cultivated these sciences for several centuries but have not presented them in detail; and the sciences discovered by Muslim scholars were available in Spain, at that time European scientists emerged from the dark ages and succeeded in translating the sciences discovered by Muslim scholars from Arabic to Latin and even studied them because they were eager to take advantage of Greek sciences. Ancient, even though Muslims were the first to inherit Ancient Greek knowledge which was then studied by Europeans (Iqbal, 2014).

Based on the historical development of the Philosophical approach, looking at the development of philosophy and its relationship with religion, it can generally be grouped into four periods, namely as follows:

The first period was from the 6th century BC to 0 AD or also known as the period of Greek philosophy at this time, the philosopher was Thales as an expert in philosophy, astronomy and geometry who used deductive patterns (Santi & Darajat, 2017). The inductive approach was used by Aristotle as a figure in empirical science and philosophy, the mystical and mathematical approach in arithmetic and geometry was used by Pythagoras, the deductive approach was used by Plato as an expert in philosophy and rational science. In this period, philosophers used empirical methods as well as deductive philosophical and inductive philosophical methods. These early philosophers aimed to discard myths from world histories that were not based on critical rationality to interpret the world in producing knowledge, they had high hopes of replacing these myths with knowledge that was more reasoned and reflective in explaining human life and experience.

The second period in the 0th century AD to 6 AD occurred at the time of the birth of the Prophet Isa, during this period there were differences between priests and kings and church figures which caused the decline of philosophy, because in this period the philosophers were limited in their freedom of thought by the kings so that knowledge did not develop, and the source of truth only existed in the authority of the church and kings (Kurniawan, 2015).

The third period was in the 6th century AD to 13 AD which was the period of Islamic revival which was marked by the large number of professional Islamic scientists resulting in the publication of many types of scientific books (Kurniawan, 2015). Islamic scientific figures who have contributed to the progress of Islam include those in the field of Islamic law, namely Hanafi, Maliki, Syafii, and Hanbali, as experts in the field of astronomy, namely Al-Farabi, as medical experts, namely Ibn Sina, whose ideas were written in one of his famous books with the title "*The Canon of Medicine*", in the field of philosophy, namely Al-kindi, the discoverer of the theory of planetary circulation, namely Anzahel, the inventor of the theory of gravity by Al-Khazini, in the field of sociology, namely Ibnu Kaldun, apart from that, Ibnu Kaldun also contributed his ideas in the fields of statehood, politics, economics and philosophy history, as well as Muslim scientists who are good at integrating various scientific fields into one sustainable whole obtained from the results of synthesizing the fields of philosophy, the field of mysticism, the field of religion and the field of Sufism named Al-Ghazali(Kurniawan, 2015). However, after the crusade, the Muslim community was devastated, causing decline.

The fourth period occurred in the 14th century AD to 20 AD which was the period of European revival, when at this time the one who initially determined truth and who was in power was Christianity but experienced destruction with resistance against oppressive kings and against religious figures, on the other hand developments science has increased in the intellectual and technical fields (Kurniawan, 2015). Whereas previously, Christians strongly rejected the religious approach in the study of philosophy based on Christian reasons, namely: (1) Christians rejected it because they did not want to make it a local worship that demanded perfect loyalty from everyone, (2) Christians rejected polytheistic myths by giving affirmations. that God is monotheistic and universal, (3) Christianity wants to continue to be a non-philosophical religion on the basis that belief does not require the support of reason because Christianity assumes that Hellenistic Greek culture does not contribute to religion (Kurniawan, 2015). The results of this successful resistance against church figures and kings gave rise to many scientists, one of whom was Newton and his theory of gravity. Apart from that, there was John Locke who argued that humans are free to argue, free have the right to live, free to speak, must be free and free to think. Another character, namely J.J. Rousseau contributed his thoughts by writing a book with the title *Social Contact*. This period also saw a figure emerge who succeeded in copying Ibn Sina's book with the title *The canon of medicine* he is Gerard Van Cromona. At that time there was also a figure who opposed the policies of the rulers because he adhered to the school of thought of realism and empiricism, this figure was named Franciscan Roger Bacon. In this era too, the figures Galileo and Copernicus were oppressed by the authorities (Kurniawan, 2015). As a result of this resistance, the Christian religion split into two, namely Catholic and Protestant.

From a philosophical perspective, it can be concluded that the period from the 6th century AD to the 13th century AD marked an Islamic revival, characterized by numerous Islamic scientists who were experts in their fields. One notable figure was Al-Khazini, who is credited with the theory of gravity. However, the Crusades caused significant setbacks for Muslims. In contrast, the European Renaissance, spanning from the 14th century AD to the 20th century AD, saw the decline of Christianity's dominance due to resistance against the oppressive church and monarchy. This period witnessed rapid advancements in science, leading to the emergence of many European scientists, including Newton, whose theory of gravity is more widely recognized today than that of Al-Khazini (Santi & Darajat, 2017).

The unfamiliarity of Al-Khazini among Muslim students necessitates attention from Muslim educators, particularly in teaching the history of Islamic figures in subjects like Physics, specifically in the context of gravity. This can be achieved through the concept of Revelation Guiding Knowledge (WMI), which encompasses four dimensions: metaphorical, philosophical, Sufistic, and scientific (Irawan, 2019).

The metaphorical approach involves describing concepts using metaphors. In the context of Wahyu Guiding Science, the metaphor is a wheel comprising axles, rims, and tires, each with its metaphorical meaning, collectively known as the Wheel of Wahyu Guiding Science Metaphor (MR-WMI). For instance, the axle symbolizes the core of faith, morals, and sharia, encapsulated in Allah's revelations, both Quraniyah and Kauniyah. The axle connects to the backbone, representing the cluster of scientific disciplines that continue to evolve. The tires symbolize control and knowledge, channeling useful energy for life, realized through righteous deeds (Wicaksono, 2019). On the other hand, the philosophical approach is divided into three major components: ontological-WMI, epistemological-WMI, and axiological-WMI. The epistemological framework integrates Islamic sciences as guidelines for general science, with faith, morals, and sharia forming the ontological basis, and pious deeds and noble morals constituting the axiological foundation (Wicaksono, 2019).

The Sufistic approach is guided by the principle that "all paths lead to God." This approach is depicted through two types of pyramids: upright and inverted. The upright pyramid illustrates the progression from knowledge, faith, and pious deeds at the base, tapering to science and technology, and culminating in revelation. Conversely, the inverted pyramid condenses knowledge, faith, and pious deeds (Wicaksono, 2019).

The scientific approach positions religious science as the overarching framework for general sciences, rather than as one among many disciplines. Consequently, Islamic religious sciences are seen as the fulcrum of a pendulum, analogous to pendulum theory, rather than merely a pendulum. This perspective has led to the development of various fields, including Islamic Philosophy, Islamic Law, and Islamic Education (Wicaksono, 2019).

Based on the four dimensions of the concept of Revelation Guiding Knowledge, it is evident from the philosophical approach, particularly the epistemological aspect, that Al-Khazini, as a pioneering Muslim scientist in the theory of gravity, served as a reference for subsequent figures. One such figure who further developed Al-Khazini's discovery was Newton.

Challenges of Integrating Islamic Scientific Concepts into the Physics education

The primary challenge in integrating Islamic scientific concepts, such as Al-Khazini's theory of gravity, into the curriculum lies in the differences in terminology and scientific approaches between Western and Islamic traditions. Teaching these concepts requires adjustments to ensure students can understand and relate to scientific ideas from both traditions coherently. Additionally, teachers need further training to teach the material accurately and effectively.

Physics learning strategies with a historical approach can be implemented through case studies of Muslim scientists. For example, when teaching a physics topic, teachers can introduce Muslim scientists who have contributed to that field. When discussing the theory of gravity, teachers can present the biography and contributions of Al-Khazini and explain their relationship to modern gravity theory. Subsequently, students can be assigned research projects to explore the work of other Muslim scientists. Research findings can be presented as posters, videos, or PowerPoint presentations, allowing students to learn from each other's work.

An effective physics learning strategy integrates ethical, spiritual, and historical aspects. For instance, when introducing physics concepts, teachers can begin with discussions on scientific ethics, addressing the responsibilities of scientists towards society and the environment. This discussion could focus on how gravity-based technologies, such as satellites, can be used for peaceful or destructive purposes. This approach encourages students to reflect on how natural laws reflect the greatness of God, thereby connecting physical concepts with spiritual values.

Furthermore, teachers can enhance students' understanding through experiments and demonstrations that connect physical theory with real practice. For example, simple experiments on gravity, such as dropping objects from different heights, can be linked to stories about how Muslim scientists like Al-Khazini made similar observations. This not only reinforces the concept of gravity but also introduces the history of Muslim scientists who contributed to science. Digital simulations and models can also be used to extend these experiments through mobile applications that illustrate how gravity works, allowing students to experiment with various variables (Yusuf et al., 2018). This approach provides a deeper understanding of how the concept of gravity was studied in the context of Islamic history while strengthening the connection between modern physical theory and the history of science.

To broaden the scope of learning, teachers can involve students in collaborative projects that integrate other subjects such as history and religious studies. For example, a project charting the development of the theory of gravity from Al-Khazini to Newton could help students see the connections between scientific disciplines. Group discussions on practical applications of the theory of gravity also encourage students to connect physics knowledge with the ethical and spiritual values they study. Through these interrelated strategies, students not only gain a richer understanding of physics concepts but also develop an appreciation for the contributions of Muslim scientists, the relevance of religious values, and the link between science and ethics.

The induction in the theory of gravity is exemplified by Newton's observation of an apple falling from a tree. He hypothesized that an attractive force, which he later termed gravitational force, caused the apple to fall towards the center of the Earth. Further research by Newton identified that this force is influenced by the distance and mass of objects. Historical references suggest that Isaac Newton formulated the mathematical equation of the law of gravity in the 17th century, while Al-Khazini had discovered the theory of gravity earlier. Therefore, it is plausible that Newton's research on gravity was influenced by Al-Khazini's earlier work.

Conclusion

This study results indicate that Al-Khazini's contributions are often not being introduced in Physicseducation, leading to a greater familiarity with Isaac Newton's theory of gravity among students. Al-Khazini, a Muslim scientist, was the first to conceptualize the theory of gravity, while Newton later formulated it mathematically. The findings suggest that integrating Al-Khazini's theory can enhance students' understanding of the history of science, particularly the concept of gravity.

The novelty of this research lies in its approach, which combines conventional science learning with a historical and Islamic perspectives. Previous studies in Science education has largely focused on modern teaching methods, often neglecting the contributions of Muslim scientists and the connection of Physicsconcepts to the Islamic worldview. For Science education, this study implicates that that there is an opportunity to enrich the Physicscurriculum by incorporating perspectives from the Islamic science. This can foster a deeper and more holistic understanding among students and encourage greater engagement, particularly from those with Islamic cultural backgrounds.

This study recommends teachers and curriculum developers to integrate Al-Khazini's theory of gravity and the contributions of other Muslim scientists into Physicslearning materials. This integration can provide students with a more comprehensive view of the history of scientific development. Future research should explore the application of similar approaches in other disciplines and educational settings to assess their impact on students' understanding and interest.

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