Unearthing Teachers' Understanding of Gravity: Theoretical and Experimental Perspective

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ABSTRACT

A natural force of attraction known as gravity can be found between any two masses, objects, or particles. To study the theoretical and experimental understanding of gravity heads of departments and teachers were selected. The selection of these responders was done using purposive sampling. This study employed a qualitative research methodology, uncovered secondary school teachers' theoretical and experimental understanding on gravity. The respondents were 15 science teachers and secondary school department heads from the Western province. According to the findings, some teachers just understand gravity as the force that pulls objects downward (toward the Earth), while others have a more thorough understanding that takes into account gravity's function in celestial mechanics.

Depending on their experience, knowledge, and method of instruction, teachers have different perspectives on gravity. Teachers acknowledge gravity as a fundamental idea in physics and science instruction that is necessary to comprehend more general subjects like motion, energy, and the cosmos.

Keywords: gravity, theory, fact, theoretical, experimental, knowledge, misconceptions, teacher

INTRODUCTION

Gravity is one of the fundamental forces of nature and a cornerstone concept in both physics and general science education. However, teachers' conceptual and practical understanding of gravity varies widely, influenced by their academic backgrounds, teaching experiences, and pedagogical approaches.

This study seeks to explore teachers' understanding of gravity from both theoretical and experimental perspectives, employing qualitative approaches to gain an in-depth comprehension of their knowledge, beliefs, and practices. It adopts a qualitative research approach, which is particularly well-suited to exploring the subjective experiences, beliefs, and practices of teachers. Semi-structured interviews and focus group discussion were data collection methods.

By focusing on qualitative methods, the research aims to go beyond quantifiable metrics to uncover the nuanced and context-specific factors that influence teachers' understanding. For instance, how do teachers reconcile Newtonian and Einsteinian concepts of gravity in their teaching? How do they address students' misconceptions?

Context

The study targeted teachers of science in the western region of Zambia and is represented by two public secondary schools, KATOBO and CHALE (Pseudonym). Newton (1687) asserted that gravity operates at a distance between two masses. Newton came to the realization that, in spite of its success, his theory did not describe how gravity truly worked; rather, it merely explained how to compute its effects. Gravity was redefined by Albert Einstein's General Theory of Relativity, which was published in 1915 and described gravity as a curvature of space-time caused by mass and energy rather than a force.

The theory explained events that Newton's theory was unable to explain, the precession of Mercury's orbit, in addition to foreseeing novel phenomena like gravitational waves, which were subsequently confirmed by tests (LIGO,2015). This discovery served as additional evidence of the legitimacy. A frequent term for any observation or acknowledged truth is a fact. Mass-containing objects are drawn to one another by gravity. An apple that is dropped will eventually fall to the earth; this is an illustration of how gravity manifests itself.

However, the hypothesis provides an explanation for the existence and operation of gravity. Theories elucidate facts rather than refute them. This hypothesis is incompatible with quantum mechanics, which governs the other fundamental forces of reality. If new data contradicts established theories, the theory might need to be revised or updated. Gravity is a theory and not fact as it depends on ideas in science.

Statement of the problem

Gravity controls numerous phenomena in cosmology and astrophysics, motion of celestial bodies and items on Earth. Although gravity's indisputable effects lead people to consider it a fact in everyday situations, science classifies gravity as a theory—an explanation of natural events that is backed by a substantial body of empirical evidence. Though well-supported by evidence, scientific ideas—such as the theory of gravity—remain subject to revision to improve speculations. In spite of the overwhelming weight of experimental evidence, gravity remains a theory rather than an unchangeable truth. This entails acknowledging advancement and the possibility that new findings could modify or improve our comprehension of gravity.

Research Objective

Unearthing teachers understanding of Gravity from both theoretical and experimental viewpoints.

Significance of the study

The study may also benefit physics instructors and education policymakers. By dispelling myths and providing a strong conceptual framework, the study can assist educators in developing a deeper theoretical grasp of gravity. Understanding how teachers conceptualize gravity is essential because their perceptions directly shape students' learning experiences. Misconceptions or gaps in teachers' knowledge may propagate errors in students' understanding, which can persist into higher education and beyond (Vosniadou, 1994).

The study may provide teachers with useful resources to help them explain gravity to pupils by exposing them to creative approaches. The study's conclusions can help designers of curricula correct widespread misconceptions about gravity and enhance the focus on experimental learning. By using the study's findings to inform the creation of focused professional development initiatives, policymakers can guarantee that educators have the necessary tools.

Hence, a detailed exploration of teachers’ perspectives can illuminate areas requiring support and professional development, ultimately contributing to improved science education.

Theoretical Framework

Constructivism

The study is grounded in a constructivist framework, emphasizing that teachers' understanding of gravity is shaped by their prior knowledge, professional experiences, and interactions with peers and students (Fosnot & Perry, 1996). Constructivism provides a lens to examine how teachers integrate theoretical knowledge with experimental practices, fostering a holistic approach to science instruction.

According to social constructivists like Bruno Latour (1979) and Steve Woolgar, scientific practices and human action shape scientific facts. This viewpoint contends that social agreements, scientific community consensus, and experimentation are how facts are "discovered" rather than just happening. Constructivists emphasize human subjectivity and the significance of aspects in the production of scientific knowledge, challenging the idea that facts are objective truths about the world. This frequently compromised science's objectivity.

Critics contend that although social influences certainly play a part, facts are only social constructions that have no bearing on reality.

LITERATURE REVIEW

The theoretical and experimental components of the investigation on teachers' perceptions of gravity are the main emphasis of this chapter.

Gravity, a well-established scientific principle, characterizes objects with mass (Newton, 1687). Polchinski (1998) discovered that although a "theory" is often a "fact" because of the overwhelming amount of evidence supporting it, it is actually founded on a body of data and can make predictions about natural processes. Newton's theory works well in real-world situations. Understanding the universe or doing high-precision calculations requires an understanding of general relativity. Diverse frameworks provide unique insights into gravity, highlighting the adaptability and robustness of scientific theories (Verlinde, 2011).

Conceptual Models of Gravity

Many theoretical frameworks have been used to study gravity over time (Chandrasekhar,1995). These frameworks often align with teachers' understanding.

The Newtonian Perspective

According to Newton's theory, a medium is not necessary for the gravitational force to work instantly over any distance(Newton, Isaac, 1687). Interpretations of Newton's work characterized gravity as a field that gives each point in space a gravitational force vector, even though Newton did not define this concept directly (Capra, 2000).

Depending on their masses and starting conditions, objects travel in predictable patterns (orbits, trajectories) due to the interaction of gravitational forces. This is necessary to explain things like planetary motion, tides, and free-fall (Halliday, Resnick, & Walker, 2018). According to research, many teachers mostly adopt the Newtonian framework due to its simplicity and wide inclusion into school curricula (Brown, 2015; Carter, 2018).

A Viewpoint Based on Einstein

The arc that mass causes in space-time is called gravity (Einstein, 1915). Research indicates that teachers in secondary schools hardly ever employ this viewpoint because they consider it abstract (Smith & Allen, 2020).

Conceptual Knowledge and Misconceptions of Teachers

False beliefs

A common misconception among educators is that gravity is a force of attraction that exclusively acts downward (Knight, 2016). The connection between mass, distance, and gravitational force is frequently oversimplified by teachers (Trowbridge & McDermott, 1980). Teachers' perceptions of gravity are greatly influenced by their past experiences and education (Sadler et al., 2000). It has been demonstrated that professional development programs deepen theoretical knowledge and dispel myths (Hewson et al., 1998).

Teachers' Conceptual Understanding and Misconceptions

Numerous studies highlight gaps in teachers' conceptual understanding of gravity:

Misconceptions

Many teachers mistakenly describe gravity as acting only downwards, rather than as a universal attractive force (Knight, 2016).

Teachers often oversimplify the relationship between mass, distance, and gravitational force (Trowbridge & McDermott, 1980).

Teachers' prior experiences and training play a critical role in shaping their understanding of gravity (Sadler et al., 2000).

Professional development programs can correct misconceptions and deepen theoretical knowledge (Hewson et al., 1998).

Experimental Approaches to Teaching Gravity

Teaching gravitational principles through practical experimentation improves conceptual clarity:

Common Tests

It is common practice to illustrate gravitational acceleration using experiments like dropping items of varying masses (Galili & Hazan, 2000). The connection between motion and gravity is clarified by pendulum experiments (McCloskey, 1983).

Implementation Difficulties

Among the difficulties teachers encounter are insufficient lab supplies and insufficient time to properly integrate experiments (Shulman, 1986). Active learning is frequently hampered by teachers' personal uneasiness with experimental methods (Hodson, 1993).

Pedagogical Strategies

Learning Through Inquiry

Encourages pupils to investigate and ask questions in order to learn about gravitational principles (Bybee, 2002). Abstract ideas such as spacetime curvature and gravitational fields can be visualized with the aid of computer-based simulations (Wieman et al., 2008). Applications from the real world, such planetary orbits and satellite motion, improve student understanding and engagement (Chiarini et al., 2019).

A theoryclarifies that has been verified and tested through observation and experimentation. Theories explain why things happen; for instance, describes gravity around masses (Einstein,1915).

Although Newton's law is extremely helpful in calculating the gravitational interactions between objects, it does not provide an explanation for the nature of gravity. The understanding of gravity was enhanced by Albert Einstein's (1915) theory, which postulated that spacetime is bent by heavy objects.

Several tests have demonstrated the validity of general relativity, around enormous objects and the precise timing of planets and stars.Gravity remains a subject of current theoretical inquiry since we do not yet fully comprehend gravity on all scales.

Gravity as a Fact

Gravity is sometimes a "fact" due to its evident, measurable consequences, such as the fact that an object is dropped. Real-world occurrences like planet motions, falling items, and our anchoring to the Earth allow us to witness the impacts of gravity. That being said, when scientists refer to gravity as a "theory," they are referring to the most effective theories that exist today to explain why and how gravity operates. These justifications are supported by data and are always being examined, confirmed, or updated. Since theories are explanations rather than observations, they are not regarded as "facts".

It is sufficient to state that facts are phenomena that can be observed, and theories clarify the how and why of those facts. For example, while dropping an object to the ground, it explains why that occurs. The empirical data supporting gravity as a theory, including tests of its predictions as well as any shortcomings or potential improvements.

Experimental Perspective

Gravity as a Theory

A well-supported explanation that has evidence and repeatedly confirmed by testing and observation is a theory. It's critical to distinguish between "theory" in its scientific sense and its common usage, which sometimes interprets it as a hunch or conjecture. Scientific hypotheses are thorough explanations that hold up to repeated examination. In this sense, gravity explains how mass-containing objects attractanother due to gravitational force.

For explaining and forecasting occurrences, gravity is theory. Centuries of observation and experimentation have led to an evolution of the concept. The universal gravitational law of Isaac Newton (1687)clarified how celestial bodies like the moon orbit the Earth and why items fall to Earth.

Henry Cavendish (1798) measured the gravitational attraction between masses, verifying Newton's principles of gravitation. Because of the accuracy with which forecast planetary motion due toNewton's rules, the theory's concordance with observations was confirmed. Newton's theory was expanded upon by Einstein in his 1916. According to Einstein's theory, large things lead other objects to follow curved courses and give rise to what we feel as gravitational pull.

Why "Theory"

Even when a lot of supporting data, it is never "proven" in the strictest sense of the word. Rather, they are nevertheless subject to revision to challenge or supplement existing knowledge. Gravity is therefore still a theory even though it provides the best explanation to events at this time. However, theories can be refuted if new information becomes available. General relativity works effectively for large-scale systems, such as galaxies and stars, despite its flaws.

Experimental Implications

Uncover clues about quantum gravity, physicists are observing gravitational waves, black holes, and particle accelerator operations. Theories are constantly subject to change because gravity is implausible or insufficient in its current form. Though they are prone to revision, theories represent scientific understanding and possess great predictive and explanatory ability.

Gravity theories are a fascinating journey through scientific thought, spanning from Newtonian gravity and beyond. The force that draws one mass to another was described by Newton in his theory of universal gravitation (1687).

- **Formula**: $F=G\frac{m_1 m_2}{r^2}$

It provided a cogent explanation of gravity for a range of phenomena, including the motion of Earthly objects and planet orbits. According to Albert Einstein in1905, it moves at a constant fast speed. It introduced the idea that space and time merge to create a single continuum known as spacetime. Light, however, moves in a vacuum.

$E=mc^{2\,(}$Energy-mass equivalence)

General Relativity

Building on Special Relativity, deals with energy. It provides new insight into the nature of gravitational interactions.

$G\mu\nu=\frac{8\pi GT\mu\nu G}{c^4}$ describe influence spacetime curvature.

Quantum Field Theory and Beyond

Two methods for explaining gravity in terms of quantum physics are Dirac, Quantum Gravitation (1930). In contrast to being point-like objects, one-dimensional "strings" vibrate at different frequencies, according to Polchinski's (1998) String Theory. According to loop quantum gravity, spacetime itself has a unique structure even at the smallest scales (Rovelli, 2004). We refer to this phenomena as Newtonian gravity (1687). This theory was successful in explaining the solar system.

Post-Newtonian Developments

By measuring the gravitational pull between masses, the Cavendish Experiment (1797–1798) produced an experimental estimate for Newton's gravitational constant. Pierre-Simon Laplace (1796) proved that many astronomical phenomena could be explained by gravitational theory by expanding on Newton's work and providing a more rigorous mathematical explanation. By contending that they are two facets of a single continuum and that light is present for all observers, the idea fundamentally altered understanding in 1805. But this hypothesis did not address gravity. This theory provided explanations for known phenomena including large objects and Mercury's orbital precession (Will, 2014).

Post-Einsteinian Developments

They seek to explain gravity at quantum scales, however incomplete and untested experimentally (Rovelli, 2004). Current Perspectives and Cosmological Discoveries Universe-Wide Models General relativity has been applied to dark energy models (Hubble, 1929). Peebles (1993) noted that observations have enhanced cosmology. Modern theories of gravity are derived from Newtonian gravity, which is an illustration of how scientific concepts change over time by building on prior understanding and responding to new information (Carroll, 2019).

Quantum Gravity

The goal was to understand gravity at quantum scales. According to Rovelli (2004), a continuous fabric is not made up of discrete "chunks". It describes these quantized structures using a series of loops known as a spin network. According to this theory, space is distinct and varies gradually. Ambjorn, Jurkiewicz, & Loll (2005) characterize spacetime as simplexes (triangles or their higher-dimensional equivalents) whose structure and evolution dictate the characteristics of spacetime. The causal dynamical triangulation model is this one. Its fundamental goal was to maintain causality while offering a rigorous mathematical framework for investigating the implications.

String Theory

Polchinski (1998) suggested using one-dimensional "strings" that vibrate at various frequencies instead of point-like objects. According to the theory, all fundamental forces and particles combine to form a single, coherent entity. They all use a different class of branes, or objects that are more dimensional. Different gauge fields and symmetry types are involved in the theories. Witten (1995) drew attention to the extension of string theory that incorporates previously known string theories and suggests an 11-dimensional cosmos. It implies that strings vibrate higher than reality, essentially one-dimensional slices of a two-dimensional membrane. These theories aim to present and mirror the most recent advancements in theoretical physics research.

Concept MOND, questions Newton's laws at low accelerations (Abbott, et al., 2016). It suggests that a separate law of gravitational acceleration is below a given threshold, in contrast to Newtonian dynamics. At large accelerations, MOND gets closer to Newtonian gravity.

Emergent Gravity

In contrast to being a fundamental force, gravity is thermodynamic properties of small degrees of freedom, according to Verlinde's (2010) theory. The theory that gravity could originate from the entropic force arises from content of a system (Verlinde, 2017). Gravity is the entropy of small degrees of freedom. It could explain dark matter and cosmic acceleration (the latter by changing the traditional cosmological constant). There are several frameworks for comprehending gravitational phenomena offered by these theories and criticisms. Even though gravity is frequently described as both a law and a theory in scientific discourse, once one is familiar with the terminology, it can be simpler to comprehend.

The following mathematical formula defines the gravitational force amid two masses:

$$F=G\frac{m_1 m_2}{r^2}$$

Numerous activities, such as estimating planet orbits and computing spacecraft trajectories, have made extensive use of Newton's rule. It anticipates items correctly. As a law, it provides a precise mathematical account of how gravity operates under specific conditions.

Understanding gravity is crucial to comprehending how science explains and depicts the natural world. Comparisons with other important scientific ideas, like relativity and evolution, emphasize its theoretical features and place within the broader scientific context.

Newtonian vs. General Relativity

According to this hypothesis, which was put forth by Isaac Newton in 1687, every mass attracts every other mass. For centuries, this theory was the most widely accepted explanation for gravitational phenomena and it functions well in most practical applications. Einstein (1915) stated that gravity is actually not a force. This hypothesis explains phenomena like Mercury's exact orbit and gravitational lensing.

Newton's force-based on Einstein's geometric theory, demonstrated how scientific theories are subject to major change as new information and insights become available (Strominger, Andrew, 2017). This development also shows how ideas are expanded upon and improved upon rather than necessarily abandoned.

Additionally, it included the well-known equation $E=mc^2$, which illustrates how energy and mass are equivalent. The way humans understood gravity, space, and time was significantly altered by evolutionary changes to improve scientific understanding.

There is the greatest amount of empirical evidence supporting three theories: relativity, evolution, and gravity. Some of the ways that gravity is observed are through planetary motion, falling objects, and, more recently, gravitational waves. Evolution, fossil evidence, and observed species changes. Every theory has a considerable amount of predictive power (Eisend & Kuss, 2019). Newtonian gravity might predict planetary orbits, more complex phenomena, such as black holes. Evolution forecasts how species may change over time, whereas relativity predicts how things would behave in strong gravitational fields and at high speeds.

The fundamental theories of relativity, evolution, and gravity underpin physics, biology, and cosmology. Every hypothesis has wide implications that affect philosophical beliefs, technological advancements, and scientific theories alike. Just pointing out that, like evolution and relativity, gravity is an essential part of scientific theory is sufficient. Its theoretical aspects demonstrate the progression and improvement of scientific knowledge. Though they cover distinct fields of inquiry, all substantial empirical evidence, have predictive capacity, and have far-reaching implications.

Examining the classical and contemporary theories that have influenced our comprehension of gravitational forces is necessary when analyzing and contrasting various theoretical models of gravity. A force that acts instantly and at a distance is gravity. Equation $\mathbf{F= G\frac{m_1 m_2}{r^2}}$ efficient in providing an explanation for tides, planetary motion, and other macroscopic phenomena. Comparing and contrasting different theoretical models of gravity requires looking at the classical and modern theories that have shaped our understanding of gravitational forces (Kuhn, 1962).

The formula $\mathbf{F= G\frac{m_1 m_2}{r^2}}$ represents the gravitational constant, G. effective at explaining planetary motion, tides, and other macroscopic phenomena.

Although the idea of spacetime curvature is provided by General Relativity, Newtonian gravity is dependent on external forces (Einstein, 915). Newtonian gravity is a simple mathematical idea, while theories involve complex differential geometry and quantum (Russell,1912)

Empirical Success

Einstein (1915) asserts that numerous tests and observations in quantum gravity remains primarily theoretical. Despite usually lacking a comprehensive structure, modified gravity theories address specific problems. Among the many significant issues that quantum gravity raises are information, and the unification of physical principles.

Divergent perspectives regarding the future direction of gravity theories are revealed in interviews with physicists, including Edward Witten & Rovelli (2004). Witten thinks that string theory's unification of forces offers potential, while Rovelli favors Loop Quantum Gravity's discrete spacetime approach. New paradigms, like gravity originating from entropic forces, are proposed by researchers like Erik Verlinde as gravitational theory advances. It suffices to note that any theoretical model of gravity brings new discoveries and new issues. While general relativity has gained great empirical success, quantum gravity theories represent the edge of theoretical physics (Carroll, 2004).

Modified gravity theories underscore the necessity of developing new ideas to address unresolved cosmological problems. The intricacy of gravitational theories and the ongoing exploration of forces in existence are brought to light by this comparative analysis.

RESEARCH METHODOLOGY

Research Design

This study used a qualitative methodology (Creswell, 2013). It used a qualitative study methodology and treat gravity as a theory rather than a fact to examine the conceptual, historical, and philosophical aspects of gravity. Focus groups discussionsand semi-structured interviews might reveal expert opinions and philosophical questions. Thematic analysis, and common narratives on the theoretical status are presented. Discussions may focus on quantum mechanics as an immutable fact and gravity as a hypothesis that is always being updated by new discoveries.

Complexities of the theory is continually refined through scientific research, as opposed to considering gravity as an unchangeable reality (Yin, 2014). From an experimental and theoretical perspective, the study sought concerns raised by the researchers regarding the unmet expectations, revealing gravity as a theory rather than a fact.

Population and Sampling

The investigation was conducted in Western provincial schools. So, a total of fourteen teachers of science were selected deliberately. Ten teachers and five department heads were selected. Vasileiou, et al (2018)justifyingsample size. Lohr's (2010) define, as a population comprising of any set of humans, events, or things that researchers are keen on examining.

Data Collection and Analysis

An interview and focus group discussions were used for the participants tocollect data. Teachers and department heads received the aforementioned instruments in person. Respondents were given instructions by the researchers on how to fill out the surveys and an explanation of their aim. A suitable declaration of privacy for the provided information was made. A deduction comprising three theme areas: evaluating and interpreting the gathered evidence; alternative theories or models that exist and conflict with the theoretical model which relates to gravity now (Braun & Clarke, 2006).

Analysis and Interpretation

Inductive data analysis was used to analyze the study's data concurrently with the data collection process. Periodically, the emergent reflection notes were examined to find recurring themes and patterns. In accordance with Clarke & Braun (2013), the data were coded and processed thematically, and the co-researchers cross-checked the themes that were found.

Trustworthiness

Guba (1981) established four criteria, which were employed in this study: (i) credibility; (ii) transferability; (iii) dependability; and (iv) confirmability. Using observation, a reflective journal matrix, and a document review guide, the data generating process was triangulated. The reflexivity approach was employed by the researchers to extract meaning from the collected data. Furthermore, bounds were guaranteed to the applicability of the study's conclusions in other contexts. Furthermore, the study satisfies the dependability and confirmability requirements because participant checks were conducted in addition to verbatim presentations of the findings.

Ethical Considerations

In order to maintain their anonymity, the participants gave the researcher their consent. All participants were also given the assurance that the information collected would be handled strictly, with the utmost confidentiality, and used only for that reason. This was made possible by adhering to the ethical standards, which include obtaining ethical clearance, getting participants' agreement, ensuring their anonymity, and assigning them pseudonyms. As previously mentioned, Kimmel's (2014) highlighted ethical norms were fully taken into account.

In accordance with Cohen et al. (2018)'s ethical guidelines, included obtaining written or verbal agreement from each participant.Thus, to ensure privacy and confidentiality, pseudonyms were assigned in lieu of real identities (Cohen et al. 2018). The respondents' identities were concealed by pseudonym.

FINDINGS AND DISCUSSION

The theoretical and experimental understanding of gravity by head of departments (HODs) and teachers of science.

Teachers' Conceptual Understanding of Gravity

HOD 1 commented that,

"Teachers normally have inadequate ideas about gravity, such as assuming it just refers to the attraction of the Earth or failing to acknowledge its universality" (H1,12.09.2024).

This claim is consistent with that made by Duit (2009), who said that teachers often have insufficient or different ideas about gravity.

Teachers' understanding of gravitational theory and experimental methods can be enhanced and misconceptions can be addressed through focused professional development programs. Lesson plans to include Einstein's contributions to the understanding of gravity and Newtonian physics.More detailed explanations of gravity and its applications in real-world situations should be incorporated into physics curricula.

Experimental Approaches to Teaching Gravity

HOD 2 revealed that,

"Teachers often lack the resources and confidence to carry out experiments that illustrate gravitational ideas"(H 2,12.09.2024).

Teachers usually lack the resources necessary to carry out experiments that illustrate gravitational principles (such as pendulum motion or acceleration owing to gravity), Zambian Ministry of Education (2021). Using inexpensive, practical experiments (such as turning smartphones into accelerometers) improves understanding and participation. Students can practically investigate gravitational phenomena by using inquiry-based learning. Provide training in experimental pedagogy and set aside funds for lab equipment. Make experiential learning a mandatory part of science instruction.

Pedagogical Strategies and Students' Misconceptions

HOD 3 stated that,

"Teachers to clear misconceptions among their students, such as: heavier items fall more quickly than lighter ones" (H 3,12.09.2024).

This discovery supports Clement's (1982) assertion that instructors frequently deal with students' enduring misunderstandings about gravity, which states that heavier things fall more quickly than lighter ones and that gravity only operates when an object is falling. utilizing diagnostic tests to find and correct student misconceptions at an early stage. modeling gravitational interactions with visual simulations (like PhET). Promoting the use of interactive tools and digital materials in the classroom and workshops can address physics myths.

Contextual and Cultural Relevance

HOD 4 stated that,

"It isproblematic for teachers to connect gravitational principles to students' real-world experiences, particularly in rural areas" (H 4,12.09.2024).

This claim supports the findings of Ates (2005), who found that teachers occasionally find it difficult to connect gravitational principles to students' real-world experiences, particularly in settings with little resources or in rural areas. Learning becomes more relatable when gravity examples are tailored to local events, such as how gravity impacts weather patterns or agriculture. Encouraging pupils to relate societal issues to scientific concepts will be ideal. Modifications and localizing thecurriculum to represent the lived realities of the students can influence understanding of gravitational science.

Collaborative Learning

HOD 5 said that,

“Interactive educational settings allow educators to share ideas and improve their lesson plans” (H 5,12.09.2024).

Hestenes, Wells, & Swackhamer (1992) assert that collaborative learning help teachers share ideas and improve their methods. It permits the exchange of materials, tests, and methods for resolving difficulties in the classroom. Professional development, peer mentorship, online learning environments and regional teacher learning networks can enhance comprehension of gravity.

Teacher Acommented that,

Teacher JTT

“Treating gravity as a theory rather than a fact would be an approach to advances knowledge through experimental and theoretical underpinnings of gravity” (T A,12.09.2024).

Facts are evidencesuch the statement "objects fall toward the Earth." Stress that theories serve as explanations for facts and are always open to change. The fact that objects fall toward Earth can be explained by gravity as a theory. Theories are models that describe observations (facts), and they are subject to revision in light of new information. Even though gravity is a generally acknowledged theory, further research and understanding are still needed (LIGO, 2016).

Teacher B stated that,

"Gravity is rather than a proposition.” (T B,12.09.2024).

With an emphasis on promoting critical thinking about scientific knowledge and its provisional nature, this program seeks to give students a conceptual and empirical grasp of gravity(Will, 2014). Depending on context frameworks used to explain gravity. The formulation from 1687 provides a conventional framework for comprehending two objects that contain mass. The force is based on:

$$F= \mathbf{G}\frac{m_1 m_2}{r^2}$$

Although this theory explained phenomena it performed satisfactorily in most other applications. The modern and most commonly recognized explanation of gravity is given by Albert (1915). Under this approach, Einstein's field equations regulate the relationship instead of gravity being viewed as a force: This theory states that gravity causes curl around massive things. Objects follow this curvature, and this is how we interpret gravitational attraction. On enormous sizes (stars, galaxies), general relativity predicts gravity well; yet, (subatomic particles, black hole singularities), it falters (Abbott, et al., 2016). Many theoretical models are being investigated in order to unify.

Hypothetical particles that mediate the gravitational pull in the quantum domain are reasons for gravitons. Quantum Gravity Loops (LQG) is another attempt toreconcile Loop Quantum Gravity. According to this theory, spacetime is quantized with tiny loops or discrete structures called Planck lengths. The singularities (such as those within black holes) are prevented by this quantization, indicating that spacetime has a granular structure. Making the distinction between "theory" and "fact”.This is necessary to ensure that students fully understand the subject matter.

Theories predict and explain facts and observations.Although it offers a framework for comprehending observable occurrences, it is flexible and amenable to revision when new information becomes available. Facts and observations can be predicted and explained by theories.

Integration of Local Contexts

According to Teacher C,

“It is rare for me to connect gravity to locally relevant settings, like comprehending natural events” (T C,12.09.2024).

Teachers rarely relate gravity to locally relevant contexts, such as understanding natural phenomena (e.g., waterfalls or planetary motions) (Aikenhead, 1996). Encourage integration of real-world examples to enhance relatability and engagement. Encourage localized curriculum design that reflects cultural and geographical relevance.

By addressing these themes, stakeholders can enhance physics teaching, resulting in better conceptual understanding among students and ultimately fostering a scientifically literate society. Would you like more detailed analysis or specific teaching strategies?

Teacher Cfurther stated that,

“Theories offer a mental framework for comprehending difficult concepts or explain why something occurs. For instance, the economics explains market behavior, whereas the scientific theory of gravity explains why objects fall toward the Earth. Instructors stress that theories are not conjectures, but rather are backed by a wealth of data and are flexible enough to change as new information becomes available” (T C,12.09.2024).

This is consistent with Darwin’s theory of evolution through natural selection, which explains the gradual evolution of species (Darwin, 1859). Evidence for it comes from genetic research, fossil records, and the observation of species' evolutionary changes. Theoretical frameworks can change. A theory may be changed or, in extreme circumstances, replaced if fresh data refutes it. The idea of paradigm shifts, as proposed by Kuhn (1962), describes how scientific ideas change over time as one framework gives way to another in order to better explain real events. An objective reality or truth that can usually be confirmed by measurement or observation is called a fact. Unless fresh discoveries provide new measurements or interpretations that alter our understanding, facts are typically clear-cut and unquestionable.

According to TeacherD,

"Theory is built on facts." Teachers give pupils observable or quantifiable facts in the classroom, such as historical dates, mathematical formulas, or scientific data” (T D, 12.09.2024).

Although facts are usually unaffected until they are improved by new instruments or techniques(Russell, 1912).

Modern Physics

According to Teacher E,

“I hardlyexpress gravitational concepts from Einstein’s conception” (T E, 12.09.2024).

Teachers rarely address gravitational concepts from Einstein’s general relativity, missing an opportunity to connect classical and modern physics (Falk, & Storksdieck, 2005). Advanced training could include the basic experimental validations and modern physics.

Teacher E added to say,

“Explaining a fact to students helps them grasp the changing nature of knowledge in a teaching situation." While facts are pieces of confirmed data, theories provide a more thorough explanation of the facts and how they connect to one another. Teachers usually help students by providing knowledge and then using theories to assess or analyze the information” (T E, 12.09.2024).

The aforementioned assertion aligns with Kuhn's (1962) contention that, while facts are observed and verified, theories provide a more thorough explanation of the facts and their connections.

Experimentation

Teacher F said that,

“I frequently find it difficult to combine theoretical justifications with physical proofs of gravity.

” (T F, 12.09.2024).

This claim supports that made by Millar, R. (2004), who said that educators frequently find it difficult to reconcile theoretical explanations with experimental proofs of gravity. This gap can be closed by placing an emphasis on practical exercises like free-fall demonstrations or pendulum experiments. Provide funds to outfit schools with physics lab supplies and guarantee instruction in their efficient use.

Teacher F further added to say

“For example, in physics class, a teacher might introduce the idea that objects fall to the ground when they are dropped. We then introduce the idea of gravity to explain why this occurs from observable phenomenon” (T F, 12.09.2024).

This is consistent with Russell's (1912) claim that this occurs because of gravity. It expands on observable fact to account for occurrences, including planetary orbits and falling apples.

According to Teacher G,

“A theory is a conceptual explanation that both describes and predicts occurrences. It is usually supported by substantial evidence, but it is adaptable enough to be made better” (TG, 12.09.2024).

Since gravity provides a credible explanation for the observed behaviors of objects, it is a theory (Strominger, Andrew (2017). Although we can see gravity in action, our hypothesis of how it functions is still being refined and investigated by science. In a teaching setting, teachersclarify the distinction between "theory" and "fact" when discussing this subject. Theories account for observed phenomena, whereas facts describe them. Both observation and explanation of gravity exist, though the explanation is still being developed.

Teacher G added to say,

Simplistic Explanations

“I regularly use distortedclarifications without addressing the complexities of gravitational interactions” T G, 12.09.2024).

Teachers often use oversimplified explanationswithout addressing the complexities of gravitational interactions (Vosniadou, 1994). Professional learning workshops can provide techniques to scaffold learning, progressing from basic to advanced understanding. Design competency-based teacher training modules focused on scaffolding physics concepts.

Teacher Hstated,

"Gravity has numerous tests. One example of an anomaly that Newton's theory was unable to explain but was still able to predict for planetary motion is Mercury's orbit precession” (TH, 12.09.2024).

This is consistent with Einstein's theory, which yields greater precision in harsh environments (such as those close to black holes), inconsistent with quantum mechanics (Will, 2014). As a result, new theoretical frameworks have been developed, but they are still theoretical (Rovelli, 2004). Examples of these include string theory and quantum gravity.

Conceptual Gaps

Teacher I commented to say,

“Many teachers demonstrate incomplete or inaccurate understanding of gravitational concepts, including Newtonian and Einsteinian perspectives”(TI, 12.09.2024).

Many teachers demonstrate incomplete or inaccurate understanding of gravitational concepts, including Newtonian and Einsteinian perspectives.

Targeted professional development programs should address misconceptions and provide a robust theoretical framework.Curriculum guidelines should emphasize fundamental concepts of gravity in teacher education.

Challenges

Teacher J said that,

“It is challenging for me as a teacher to recognize and address students' misconceptions regarding gravity” (TI, 12.09.2024).

Derek Hodson (1985) claim that teachers struggle to spot and address pupils' misconceptions regarding gravity, such as the idea that "heavier objects fall faster." Training courses ought to cover methods for identifying and correcting misconceptionsamong students.

CONCLUSIONS

The majority of educators possess a fundamental understanding of gravity as the force that attracts mass-containing things. Gravity is widely acknowledged by educators as the force that causes planets to move and objects to fall toward the Earth. Nonetheless, there are some misconceptions, such as the notion that mass and weight are not the same thing or that gravity is stronger near the poles due to the Earth's rotation. Explaining the link between mass and gravitational acceleration for falling objects can be challenging (e.g., all objects fall at the same rate in a vacuum). Some can illustrate gravitational settings using digital tools and simulations.

Limited knowledge of or access to sophisticated experimental settings, such as Cavendish experiments used to estimate the gravitational constant (G). Designing experiments that faithfully depict intricate gravitational interactions, like those in space, can be challenging. challenges in helping students understand the subtleties of experimental data, including as dealing with variability and measurement errors.

Due to their own comprehension gaps, teachers may find it difficult to clear up pupils' misconceptions. To fill up knowledge gaps, effective education combines theoretical insights with approachable experimental tasks. These findings demonstrate how crucial it is to improve teacher preparation in both the theoretical and experimental facets of gravity in order to guarantee precise and successful classroom education.

RECOMMENDATIONS

The government should:

1. Provide funds to outfit schools with physics lab supplies and guarantee instruction in their efficient use.
2. Create competency-based modules for teacher preparation that emphasize physics idea scaffolding.
3. Include components of contemporary physics in teacher preparation programs for both pre-service and in-service teachers.
4. Promote locally relevant curriculum design that takes into account cultural and regional factors.
5. Provide workshops on complex subjects like contemporary gravity investigations and general relativity.
6. Teach educators how to demonstrate experiments using simulations and virtual labs.
7. Give schools access to reasonably priced experimental kits so that practical instruction can take place.
8. Stress active learning strategies that provide a balance between experimental practice and theoretical instruction.

FUTURE RESEARCH

1. Research on how cultural and contextual factors influence teachers’ understanding of gravity.
2. Studies on Einsteinian concepts into secondary school curricula.
3. Focus on professional development strategies tailored to address teachers' experimental competencies.

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