Open Access Library Journal
2026, Volume 13, e14618
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Assessing Teacher Trainee's Misconception of Derived and Fundamental Quantities in Measurement: A Quantitative Survey in Gambaga College of Education

Issahaku Shahadu[1], Salifu Abdallah[1], Abdul-Ganiu Alhassan[1], Mumuni Musah[2]

[1]Department of Science Education, Gambaga College of Education, Gambaga, Ghana
[2]Department of Science, Fafraha Community Senior High School, Adenta, Ghana
Email: issahakushahadu@gmail.com

How to cite this paper: Shahadu, I., Abdallah, S., Alhassan, A.-G. and Musah, M. (2026) Assessing Teacher Trainee's Misconception of Derived and Fundamental Quantities in Measurement: A Quantitative Survey in Gambaga College of Education. *Open Access Library Journal*, **13**: e14618.
https://doi.org/10.4236/oalib.1114618

Received: November 16, 2025
Accepted: January 12, 2026
Published: January 15, 2026

Abstract

This study was conducted to uncover and analyze the misconceptions that teacher trainees have about derived and fundamental quantities in integrated science in Gambaga College of Education. This study empirically identifies common misconceptions, while the literature review section discusses their potential causes and remedies. The study employed a survey design in which one hundred and ten (110) Level 100 teacher trainees (63 males and 47 females) were selected using purposive sampling technique. Data were collected with the aid of semi-structured questions which were designed on a five point likert scale ranging from Strongly agree, Agree, Neutral, Disagree to Strongly disagree and the data was analyzed using descriptive statistics. Analysis of the data of the study revealed that teacher trainees have less understanding and cannot adequately differentiate between the derived and the fundamental quantities.

Subject Areas

Pedagogy

Keywords

Misconception, Teacher Trainees, Derived Quantities, Fundamental Quantities

1. Introduction

Measurement is very useful in our daily lives and it is an inseparable part of science [1]. Research has shown that scientist measure to prevent unnecessary wastage, avoid fraudulent behaviour, to ensure accurate dosing in the preparation and distribution of medication, to maintain integrity and honesty, show truthfulness and finally to guarantee uniformity and dependability [2]. Measurement is fundamental to the pharmaceutical industry, commerce, food processing, engineering, and construction, and it serves as a core principle that distinguishes scientific inquiry from fallacious assumptions [3]. Measurement is one of the concepts in integrated science that pre-service teachers practice in their daily activities. Some of the activities are as follows. Writing, decorating, sitting, cooking, bathing, running inside the classroom etc. Some of these activities have to do with measurement of different quantities. Quantities are aspects of matter that one can be measured [4].

Experts in measurement categorize physical quantities into basic quantities that serve as foundations, and derived quantities that are calculated from combinations of the basic ones as part of creating organized measurement systems [5]. The International System of Units (SI) is the most commonly adopted measurement framework of this type, built upon seven fundamental quantities: length, time, mass, thermodynamic temperature, electric current, amount of substance, and luminous intensity [6]. In the SI system, these fundamental quantities are expressed using the corresponding base units: the metre, the second, the kilogram, the Kelvin, the Ampere, the mole, and the candela as indicated in **Table 1** below.

Table 1. Some basic/fundamental quantities, their basic units and symbols.

Quantity of substance	Basic/Fundamental unit (S.I unit)	Symbol
Length	Metre	M
Mass	Kilogram	Kg
Time	Second	S
Amount of substance	Mole	Mol
Temperature	Kelvin	K
Luminous intensity	Candela	Cd
Electric current	Ampere	A

Source: [2].

From these, all other quantities and their units are defined as illustrated in **Table 2** below.

Table 2. Some derived quantities, their derived S.I units, the symbol of the units and the derived units expressed in basic units.

Quantity	Name of derived S.I unit	Symbol	Derived unit expressed in basic unit
Area	Square metre	m^2	m^2
Volume	Cubic metre	m^3	m^3
Speed	Metre per second	m/s	m/s or $m \cdot s^{-1}$
Density	Kilogram per cubic meter	Kg/m^3	Kg/m^3 or $kg \cdot m^{-3}$

Continued

Force	Newton	N	Kg m/s^2 or kgm·s^{-2}
Pressure	Pascal	Pa	N/m^2 or N·m^{-2}
Work, Energy	Joule	J	Nm
Power	Watt	W	J/s or J·s^{-1}
Quantity of charge	Coulomb	C	As
Electric potential	Volt	V	W/A or W·A^{-1}

Source: [2] [7].

This implies that the apparent independence of base quantities within the SI system should not be seen as representative of how they function in physical theories, since science might treat some of these quantities as strongly interconnected rather than independent. However, it implies that while evaluating a quantity's definitional independence, we must differentiate between a quantity's unit being definitionally independent and the quantity itself being (definitionally) independent of other quantities. Even if the latter fails, the former may succeed. All of this should cause us to reconsider the approach of beginning with the difference between base and derived quantities.

2. Understanding the Meaning of Misconception and Its Types in Science Education

According to [8], a misconception in science is an internal framework or mental model that students create to make sense of scientific concepts but that deviates from the expert-established, scientifically accepted explanations. In other words, a misconception is an incorrect conclusion that results from faulty reasoning or erroneous information [9]. Misconceptions in the context of science education are commonly held but scientifically incorrect ideas or perceptions of scientific phenomena [10]. These misunderstandings could also be the result of deeply held assumptions that have been influenced by culture or religion. Scientific misconceptions can be put under the following categories below.

1) The non-scientific beliefs: The first category of misconception is the non-scientific belief, which come from sources outside the realm of science, like myths, cultural narratives, or religious teachings, and frequently run counter to empirical data. These ideas may be at odds with scientific theories such as the Big Bang or evolution [11] [12].

2) Vernacular misconceptions: The second category of misconception is the vernacular misconceptions, commonplace language usage gives rise to this category of misconceptions. When students misuse language they are familiar with, it can cause confusion because terms that are frequently used in non-scientific contexts can have different meanings in scientific discourse [1] [11].

3) Factual misconceptions: This misconception are persistent errors that are formed in early childhood and carried into adulthood; they can be caused by parents, teachers, or even textbooks, which may unintentionally spread false information [11] [13]. Notably, even famous scientists have recognized the challenge of eradicating such deeply ingrained misconceptions.

4) Conceptual misconception: This category of misconception occurs when there are unresolved conflicts between new information and preexisting beliefs, students may misinterpret scientifically accurate information, falling into this type of misconception. This may result in incomplete comprehension and the development of false mental models that impede subsequent learning [11] [12].

5) Preconceived notions: This is one of the categories of misconception called the preconceived notions. This refers to the intuitive ideas of the learners based on their shared experiences and are often formed before formal science education [11] [13]. These early ideas are frequently hard to alter and can be in direct opposition to accepted scientific theories, especially when it comes to concepts like gravity, heat, and energy. Because these misconceptions closely match their intuitive understanding, many students continue to hold them even after being exposed to information that is scientifically accurate [11] [14] [15].

3. Causes of Students Misconceptions in Scientific Concepts

Misconception in science can be categorised into four (4) based on its cause [16]. Below are some of the causes of misconception in science.

1) The learners

2) The teaching and learning resources

3) The instructor teachers

4) The teaching methodology employed by the instructor

a) **The learners:** There are a number of ways to gather misconceptions from learners, including their initial knowledge, preconceptions, or prior knowledge, associative thinking, humanistic thinking, incomplete or incorrect reasoning, incorrect intuition, cognitive development stages, ability, and interest [16].

i) **Basic information:** Many learners already have a basic idea, preconception, or prior knowledge of a topic before they begin formal instruction under the teacher's direction. Misconceptions were frequently included in this original idea. This first misunderstanding will lead to other misunderstandings in subsequent physics classes until the mistake is fixed [17] [18] [16] [15].

ii) **Learners' associative reasoning skills:** Sometimes, learners' associations with common terminology lead to mistakes as well [16]. For instance, kids think that "style" means force or displacement. Many pupils believe that displacement is always the result of force. Students ensure that there is no force if they do not observe a moving item. For instance, despite the fact that physics is not always accurate, some students continue to believe that a human-driven train is not subject to force since it continues to stop. In actuality, the train is still moving with force; it is only that the force is insufficient to propel it. Misconceptions can also arise from distinct word meanings between teachers and students [19].

iii) **Humanistic reasoning:** Pupils usually use their own experiences to interpret situations from a human perspective, which causes them to incorrectly equate the behavior of objects with that of living people [15].

iv) **Inaccurate or insufficient reasoning:** Students may form misconceptions as a result of incorrect inferences made by them due to incomplete or improper reasoning, which frequently results from incomplete data or information.

iv) **Inaccurate judgment**: Emotional biases and intuitive thinking, which are predicated more on repeated observations and gut feelings than on logical analysis, can lead to misconceptions among students [15]. Students frequently have these epiphanies when they come across particular physics problems.

vi) **Phases of the cognitive development of students:** Students' misunderstandings may be the result of cognitive growth that is out of step with the subject they are studying [15]. Students who are still in the concrete operational stage of acquiring abstract content are generally hard to spot and frequently misinterpret the notion.

vii) **Students' abilities:** Students who are less gifted in physics or less able to understand physics often have difficulty capturing the correct concepts in the learning process [20].

viii) **An interest in learning:** In general, students who are disinterested in physics are less motivated to learn the subject and pay less attention when their teachers explain new concepts [21].

b) **Teaching and learning resources:** Physics textbooks play a crucial role in the teaching and learning processes and have a big impact on how the subject is taught and comprehended [15]. Throughout instruction, they are vital resources for both educators and learners. Nonetheless, textbooks may lead to the formation of misunderstandings among teachers if they are used as the only teaching resource [22] [23]. Textbook material that is inaccurate or badly written can mislead students and reinforce conceptual mistakes [16]. Therefore, to guarantee conceptual accuracy and clarity, textbook content must go through a rigorous review and validation process.

c) **The instructors:** Students will develop misconceptions if their instructors lack mastery of the subject or have a poor understanding of physics [16]. Research indicated that some physics instructors experience some difficulties in trying to grasp some concepts in physics which they then impart the knowledge obtained to their learners [23] [24]. [16] asserts that teachers' misconceptions stem from their lack of subject-matter expertise, lack of physics degrees, failure to give students a platform to voice their opinions, and poor teacher-student relationships.

d) **The teaching methodology employed by the instructor:** Several teaching methods are used by instructors, especially those that emphasize only one aspect of the concept of the material being worked on, even though they help learners understand the material being taught, but often have a negative impact, which raises student misconceptions [15]. So the teacher needs to be critical with the method used and not limit it with just one method [16].

Teacher trainees misconceptions related to derived and fundamental qualities can arise from learner-related factors, instructional resources, instructors' content knowledge and the teaching methodologies employed. These causes, the associated challenges and potential instructional strategies for addressing them are summarised in **Table 3** below.

Table 3. Causes of misconception of derived and fundamental quantities, potential challenges and strategies to address these misconceptions.

Causes of misconception of derived and fundamental quantities	Challenges or Problems	Potential strategies to address these misconceptions
Teaching and Learning Resources related cause	• Lack of interactive materials • Textbooks may not clearly distinguish the concepts • Limited visual representations	• **Visual hierarchies**: Use concept maps showing fundamental quantities as "building blocks" • **Interactive simulations**: Digital tools that let students build derived quantities from fundamental ones • **Analogy-rich materials**: Resources comparing quantities to familiar systems (like cooking ingredients vs. recipes) • **Multiple representations**: Combine symbolic, graphical, and verbal explanations • **Real-world examples**: Materials showing both types in engineering and scientific contexts
Learner-Related Causes	• Difficulty with abstract thinking • Prior knowledge interference from everyday language • Lack of mathematical foundation	• **Pre-assessment**: Test students' existing conceptions before instruction • **Conceptual bridging**: Connect new concepts to familiar experiences (e.g., cooking recipes use both basic ingredients and combinations) • **Metacognitive strategies**: Teach students to recognize when they are confusing the concepts • **Peer discussion**: Use think-pair-share activities to surface and address misconceptions • **Self-reflection**: Have students explain their reasoning to identify gaps
Instructor-Related Issues	• Treating the distinction as trivial • Insufficient content knowledge depth • Unaware of common student misconceptions	• **Professional development**: Training on the philosophical and practical importance of the distinction • **Misconception awareness**: Educate teachers about predictable student errors • **Content knowledge enhancement**: Deepen understanding of dimensional analysis and unit systems • **Pedagogical content knowledge**: Train teachers in specific strategies for this topic • **Collaborative planning**: Teachers work together to develop effective approaches

Continued

Teaching Methodology related	• Rote memorization without understanding • Treating it as purely definitional • Skipping the conceptual foundation	• **Inquiry-based learning**: Have students investigate why we need both types of quantities • **Constructivist approach**: Build understanding step-by-step from simple to complex • **Problem-based learning**: Use real engineering problems requiring both types • **Conceptual change strategies**: ○ Expose misconceptions through challenging examples ○ Create cognitive conflict ○ Provide alternative frameworks • **Active learning techniques**: ○ Dimensional analysis workshops ○ Unit conversion challenges ○ "Build the quantity" activities

Source: Authors construct (2025).

4. The Misconception among Teacher Trainees about Derived and Fundamental Quantities in Science

Solving the problem of student's misconception in integrated science is very crucial in science education [25]. Students' ability to apply scientific concepts to explain facts is enhanced when their misunderstanding of such concepts are changed and they are given the chance to reference their worldview [26]. Many studies in science education have focused on students' misconceptions in the area of biology, especially those related to photosynthesis and respiration [25].

Student's misconceptions about basic and derived quantities in science can originate from several factors including complexity of concepts, an already existing misconceptions and inadequate teaching approaches [27]. Research according to [28] states that students may struggle to differentiate between fundamental and derived quantities and how they understand how derived quantities are calculated with basic quantities. This study stated that science learners always confuse derived quantities with fundamental quantities in physical science and always find it challenging in applying correct formulas and units.

Study indicated that students have parallel intrinsic misapprehension about the physical characteristics of basic and derived quantities in physics [29]. Research also depicted that, there is learners' misunderstanding about the relationship between derived and basic quantities and their nature in chemistry [30]. This misunderstanding makes it difficult for scientist to perform simple scientific calculations and interpretations scientific data during scientific experimentation. [31] discovered that science students frequently struggle to differentiate between basic quantities like mass, time, and length that are derived from quantities like velocity and acceleration. This results in the learners' incapacity to accurately conduct and comprehend computations.

As science professionals with extensive teaching experience, we have observed that students misunderstand how derived quantities are obtained by combining two or more fundamental quantities and fail to grasp the interrelationship between these quantity types. This can pose a significant negative damage in the academic performance of students in scientific calculations. Research show how science learners use derived and basic quantities interchangeably in scientific context and circumstances indicating their misapprehension of the two quantities [26]. According to a study by [32], science students often fail to recognize the dynamic nature of fundamental and derived quantities in physical science and find it difficult to apply them correctly in problem-solving tasks, which can impede their comprehension of how fundamental and derived quantities can interact in various scientific phenomena.

According to [33], students have the habit of relating physical properties to derived quantities, resulting to errors in data interpretation and scientific reasoning. This misunderstanding highlights the importance of clarifying the nature and definition of derived quantities in science education. This similar misconceptions were identified by the researchers during their teaching in Gambaga College of Education that is why the researchers want to investigate and address some of the misconceptions among teacher trainees.

5. Methodology

The study was a quantitative study using survey. Surveys are an essential tool for collecting data from a sample of individual to gather insights in to their opinions and attitudes on a specific subject [34]. The study participants were made of 63 males and 47 females of level 100 teacher trainees. The participants were selected using purposive sampling technique because these group of teacher trainees (level 100 student teachers) were introduced to some concepts under measurement in introduction to integrated science (BES 109) and the instrument for the data collection was questionnaire (made up of some common misconceptions of student teachers, about derived and fundamental quantities). The questionnaire were designed using five likert scale ranging from Strongly Agree, Agree, Neutral, Disagree to Strongly Disagree. Data were analysed using IBM SPSS Statistic 25 with the aid of descriptive statistics such as tables with percentages.

6. Results and Discussion

Figure 1 gives the study participants (teacher trainees) sex. The teacher trainees who took part in the study consisted of fifty seven point three percent males (57.3%) and fourty two point seven percent (42.7%) female with the male's participants forming the majority.

Table 4 gave the age distribution of one hundred and ten (110) particpants in the study. The age results reveals that the majority of teacher trainees (55.4%) were aged 25 or younger, with the 21 - 25 age category representing the largest group

(32.7%, n = 36). The 15 - 20 age group constituted 22.7% (n = 25) of the sample. The remaining 44.6% of the participants were aged 26 years and above, distributed across three categories; 26 - 30 years (19.1%, n = 21), 31 - 35 years (14.4%, n = 16), and 36 - 40 years (10.9%, n = 12). The distribution indicates a predominantly young adult's population with significant representation of mature students, reflecting a diverse entry pathways into teacher education at Gambaga College of Education.

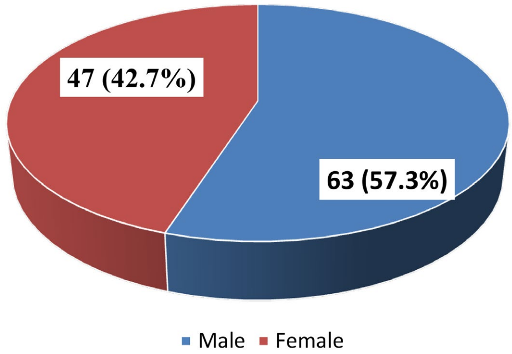

Figure 1. Sex of participants (teacher trainees).

Table 4. Age of participants.

Age	Frequency	Percentage%
15 - 20	25	22.7
21 - 25	36	32.7
26 - 30	21	19.1
31 - 35	16	14.5
36 - 40	12	10.9
Total	**110**	**100.0**

Table 5. Participants response on derived quantities are obtained when you combine two or more fundamental quantities.

Level of Agreement	Frequency	Percentage%
Strongly Disagree	1	0.9
Disagree	21	19.1
Neutral	1	0.9
Agree	82	74.5
Strongly Agree	5	4.5
Total	**110**	**100.0**

This particular item of the questionnaire examined teacher trainee's comprehension of the definition of derived and fundamental quantities. Table 5 presented the results of teacher trainee's responses on that item. The results show that whiles only zero point nine percent (0.9 %) of the trainees remain neutral to the statement, the same percentage of respondents (0.9 %) also expressed strongly disagreement to the statement and nineteen point one percent (19.1%) with the statement. However, substantial majority of respondents, specifically seventy four point five percent (74.5%) agreed to the statement and four point five (4.5%) strongly agreed to the statement indicating a high level of student teachers conception between derived and fundamental quantities.

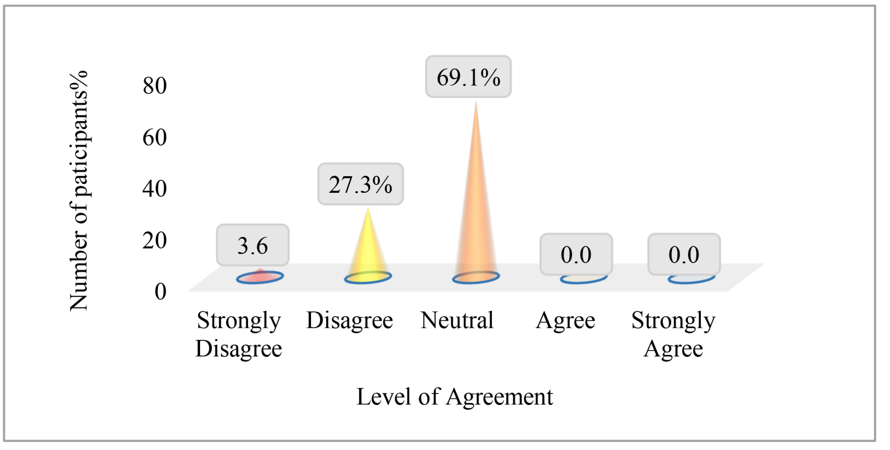

Figure 2. Participants response on heat and temperature are sometimes used in the same context.

Many thermal phenomena in science education use temperature and heat simultaneously. **Figure 2** above gives information about participant's (teacher trainee's) knowledge on whether temperature and heat can be used in the same context or not. According to the data presented in **Figure 2** above, majority of the respondents, exactly sixty nine point one percent (69.1%) remain neutral to the this item of the questionnaire depicting a high level of misconception of teacher trainees between the quantity heat and temperature. However, twenty seven point three percent (27.3%) disagreed and three point six percent (3.6%) of participants strongly disagreed with this assertion. This result aligns with research by [35] that majority of students possessed misconceptions and were unable to articulate the distinctions between heat and temperature. Additionally, no respondents agreed and strongly agreed to the statement that heat and temperature are sometimes used in the same context.

Table 6. Participants response on mass is defined as the force that an object or body exerts on the ground or anything that freely supports it due to force of gravity.

Level of Agreement	Frequency	Percentage%
Strongly Disagree	2	1.8
Disagree	86	78.2
Neutral	21	19.1
Agree	1	0.9
Strongly Agree	0	0
Total	**110**	**100.0**

The data presented in Table 6 is the data about the definition of mass of an object. Majority of the participants, exactly seventy eight point two percent (78.2%) disagreed to the statement that mass is defined as the force that an object or body exerts on the ground or anything that freely supports it due to force of gravity, nineteen point one percent (19.1%) of the them remain neutral to the statement with only one point eight percent (1.8%) strongly disagreeing the statement. On the other hand, zero point nine percent of the respondents agreed with no respondent strongly agreeing to the assertion.

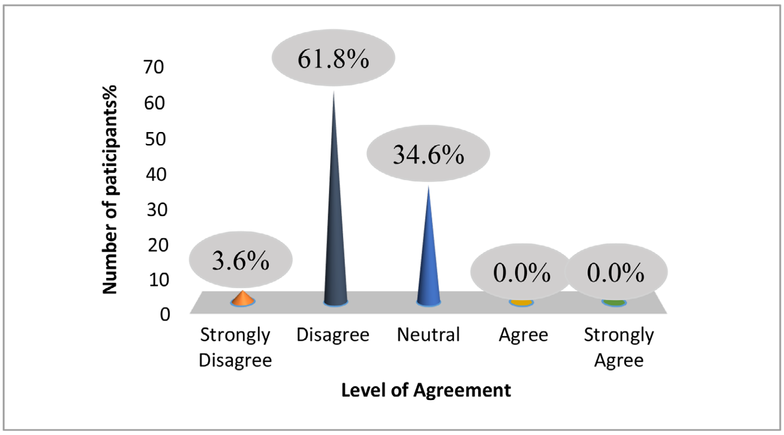

Figure 3. Participants response on the higher the altitude the higher the temperature.

Figure 3 illustrates participants' responses to the statement that higher altitude corresponds to higher temperature. Theoretically, altitude is inversely proportional to temperature, the higher the altitude the lower the temperature and vice versa. Sixty one point eight percent (61.8%) of the participants constituting the majority is in disagreement with the statement with thirty four point six percent (34.6%) remaining neutral to the statement and three point six percent (3.6%) strongly disagreeing to the statement. No respondent indicated their level of disagreement and strongly disagreement with the assertion. The distribution of the responses indicates that while the majority of participants demonstrated correct conceptual understanding by disagreeing with the statement, the high percentage of neutral responses suggests the need for further instructional support to strengthen conceptual clarity and reduce uncertainty among learners (teacher trainees).

Table 7. Participants response on length is a scalar quantity whiles area is a vector quantity.

Level of Agreement	Frequency	Percentage%
Strongly Disagree	0	0.0
Disagree	5	4.5
Neutral	4	3.6
Agree	99	90.0
Strongly Agree	2	1.8
Total	**110.0**	**100.0**

As demonstrated in Table 7, ninety one point eight percent (91.8%) of the participants endorsed the statement that length is a scalar quantity whiles area is a vector quantity. On the other hand, whiles three point six percent (3.6%) of the respondents remaining neutral to the assertion, four point five percent (4.5%) of the participants expressed their disagreement and with no respondent strongly disagreeing to the statement.

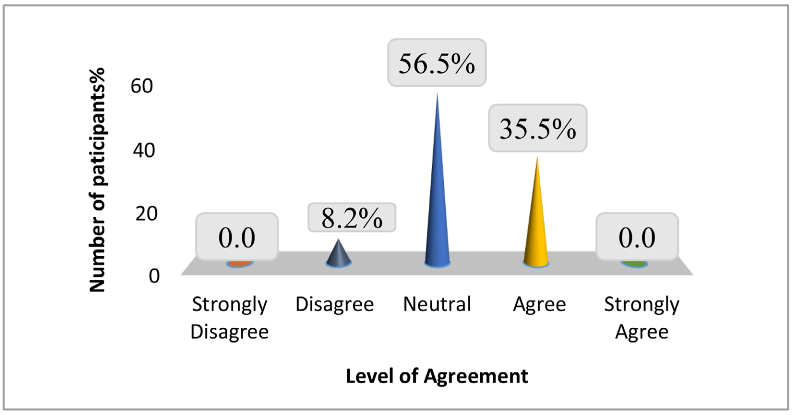

Figure 4. Participants response on meters per second square is the unit for measuring acceleration.

Figure 4 above presented the data on participant's responses on the unit of acceleration. Meters per second square (ms^{-2}) is actually the unit we used to measure the acceleration of a body. The data indicated that majority (56.5%) of the participants expressed their neutral position regarding this statement and thirty five point five percent (35.5%) of the participants agreed to the assertion, whiles only eight point two percent of the participants disagreed to the statement. However, no participant strongly disagreeing and strongly agreeing to the statement.

Table 8. Participants response on mole is the same as concentration.

Level of Agreement	Frequency	Percentage%
Strongly Disagree	14	12.7
Disagree	96	87.3
Neutral	0	0.0
Agree	0	0.0
Strongly Agree	0	0.0
Total	**110.0**	**100.0**

This specific item within the questionnaire assessed the extent to which teacher trainees understood the conceptual distinction between mole (fundamental quantity) and concentration (derived quantity). The findings from teacher trainee responses to this item are displayed in Table 8. The data reveal that no proportion of participants, zero point zero percent (0.0%) maintained a neutral stance regarding the statement, an equally zero point zero percent (0.0%) indicated strong disagreement and agreement with the assertion. Nevertheless, an overwhelming majority of respondents with eighty seven point three percent (87.3%) indicated their level of disagreement and an additional twelve point seven percent (12.7%) expressing their strong disagreement with the given statement.

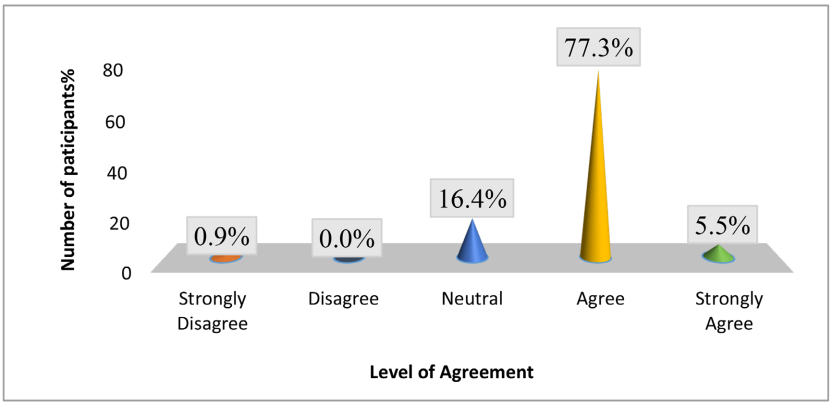

Figure 5. Participants response on acceleration moves forward and deceleration slows down.

As shown in **Figure 5**, participants' responses to the statement that acceleration moves forward while deceleration slows down reveal a high level of misconception among teacher trainees. This specific Item of the instrument talks about the differences between acceleration and deceleration. Acceleration is the time rate of change of velocity (speed) which takes place in any direction and not just forward direction alone whiles deceleration or negative acceleration or a decrease or slowing down, but it is still acceleration. A small portion of participants, about zero point nine percent (0.9%) opted for strongly disagreement to the assertion and no participants (0%) disagreed to the statement. Sixteen point four percent (16.4%) remain neutral to the statement whiles majority, exactly seventy seven point three percent (77.3%) of the participants agreed statement and five point five percent (5.5%) expressed their strongly agreement to the statement. However, student teachers were unaware that an object can accelerate backward, sideways, upward, or in any direction. The eighty two point eight percent (82.8%) agreement among student teachers on this statement was alarming and can pose a widespread of misunderstanding of physics concepts in science education.

Table 9. Participants response on the unit for amount substance is the same as the unit for concentration.

Level of Agreement	Frequency	Percentage%
Strongly Disagree	21	19.1
Disagree	89	80.9
Neutral	0	0
Agree	0	0
Strongly Agree	0	0
Total	**110**	**100.00**

Table 9 above present data on participants' responses on the unit for amount of substance (mole) is the same as the unit for concentration. Basically, the mole is the amount of substance that contains as many elementary particles as there are atoms in 12g of carbon-1 whiles concentration is the amount of a substance dissolved in 1 dm^3 or litre of a solution. According to that data presented in Table 9, majority of the participants, exactly eighty point nine percent (80.9%) in disagreement with the statement whiles nineteen point one percent (19.1%) are in strong disagreement with the assertion. However, no participant remain neutral to the statement and also agreed and strongly agreed to the statement indicating that pre-service teachers or teacher trainees have more understanding on the two quantities.

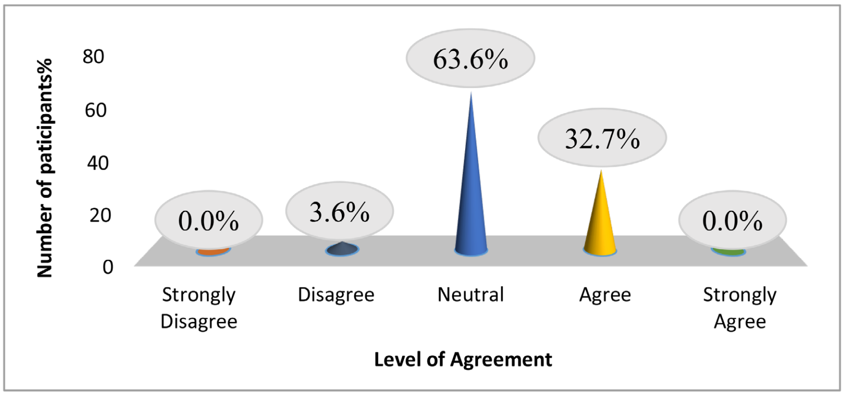

Figure 6. Participants response on displacement and distance are used interchangeably.

Figure 6 about presented the data of respondents on the assertion that displacement and distance are used interchangeably. The interval between two points in a straight line is distance whiles the distance covered in a specified direction is the displacement. Though they have the same unit as the metre (m) but they are different. From Figure 6, sixty three point six percent (63.6%) of the respondents remain neutral to the statement, no one strongly agreed and strongly disagreed to the statement and only three point six percent (3.6%) of them only disagreed to the assertion. The interpretation of the data in Figure 6 indicate that the participants (student teachers) could not differentiate between displacement (derived quantity) and distance (fundamental quantity) since majority (63.6%) of them remain neutral to the statement.

Table 10. Participants response on the larger the size of an object the greater the mass.

Level of Agreement	Frequency	Percentage%
Strongly Disagree	67	60.9
Disagree	27	24.5
Neutral	1	0.9
Agree	15	13.9
Strongly Agree	0	0.0
Total	**110**	**100.0**

Based on the level of agreement of teacher trainees on Table 10 above of the statement the larger the size of an object the greater the mass of that object, no teacher trainee strongly disagreed to the statement, thirteen point nine percent agreed (13.9%), zero point nine percent been neutral (0.9%), twenty four point five percent (24.5%) disagreed and sixty point nine percent (60.9%) strongly disagreed to the statement. The relationship between size and mass of an object depends on the objects' density. Size is independent on the mass of an object in science. Thus the results of teacher trainees on the statement depicted a high level of understanding between size and mass.

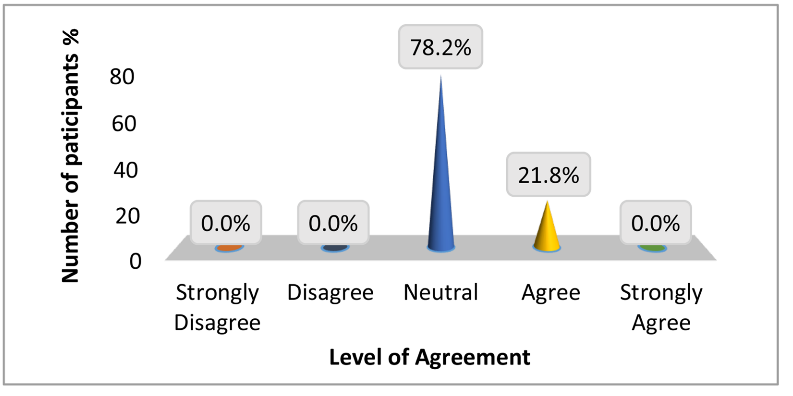

Figure 7. Participants response on speed is not different from velocity.

Figure 7 illustrated above looked at how teacher trainees understand the differences between speed and velocity as derived and fundamental quantities in science. The level of agreement indicated that seventy eight point two percent (78.2%) of the participants remain neutral to the statement and twenty one point eight percent (21.8%) of them agreed to the statement. However no respondent disagreed and strongly disagreed to that statement and no respondent also strongly agreed to the statement. Majority (78.2%) of the teacher trainees were uncertain to the statement indicating a high level of misconception between speed and velocity.

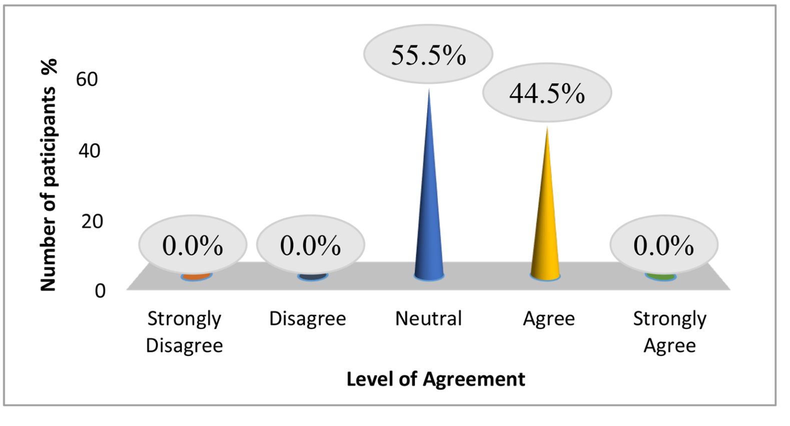

Figure 8. Participants response on the unit metre depends on the metre square.

Figure 8 seven above presented the data on teacher trainee's responses to the relationship between metre and metre square. Majority of them, exactly fifty five point five percent (55.5%) remain neutral to level of agreement. Fourty four point five percent (44.5%) agreed to the statement whiles no teacher trainee (0.0%) strongly disagreed, disagreed and strongly agreed to the statement. Nevertheless, in measurement, the unit metre (m) is a fundamental unit whiles metre square is a derived unit, thus metre square (m^2) depends on the unit meter (m) and not the opposite. Therefore, teacher trainees have high degree of misconception regarding this two units since majority (55.5%) are indeterminate to the statement.

7. Potential Limitations of the Study

The study examined teacher trainee's misconceptions of derived and fundamental quantities in Gambaga College of Education, restricting findings to only this institution. Thus, the results of this study may not be generalizable to other Colleges of Education in Ghana or beyond because resources, student teachers demographics and instructional approaches may vary from one college to another, producing a very distinctive patterns but not a representation of teacher education nationally.

8. Conclusion

The study has revealed critical and common misconceptions among trainee teachers at Gambaga College of Education regarding fundamental and derived quantities in measurement, posing a serious threats to the quality of science education in Ghana. Most worrying, the 82.8% of teacher trainees incorrectly believed that "acceleration moves forward and deceleration slows down", demonstrated a fundamental misunderstanding of acceleration as a vector quantity that can take place in any direction. However, the presence of these misconceptions reveals a fundamental gap in conceptual understanding that will inevitably be transmitted to the next generation of learners unless it is urgently addressed. By implementing targeted pedagogical interventions diagnostic assessment, conceptual change strategies, inquiry-based learning, cooperative learning, and metacognitive instruction specifically designed to address the derived and fundamental quantities confusion and other related measurement misconceptions, teacher educators can transform understanding and break the cycle of misconception transmission. Finally, improving teacher trainees' understanding of derived and fundamental quantities in measurement is not merely an academic exercise but also an investment in Ghana's scientific literacy, technological capacity, and educational quality. When teacher trainees develop accurate, deep understanding of measurement concepts, they will be equipped to inspire and guide their own students genuine scientific thinking, preparing Ghana's youth for the demands of an increasingly science and technology driven world.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Mensah, C., Owusu, A. and Semordziurse, W. (2019) General Physics. University of Cape Coast, Wilson Books & Stationery Ent. Ltd.

[2] Asiedu, P. and Simpi, L. (2024) Integrated Science for Senior High Schools. Aki-Ola Publication.

[3] Buabeng, I., Bandoh, B.F., Eric, A. and Cynthia, J.-A. (2019) Fundamental Physics for Beginners. Patmo Print.

[4] Mari, L., Ehrlich, C. and Pendrill, L. (2018) Measurement Units as Quantities of Objects or Values of Quantities: A Discussion. *Metrologia*, **55**, 716-721. https://doi.org/10.1088/1681-7575/aad8d8

[5] Wolff, J.E. (2020) Fundamental and Derived Quantities. In: Glick, D., *et al.*, Eds., *The Foundation of Reality*: *Fundamentality*, *Space*, *and Time*, Oxford University Press, 87-101. https://doi.org/10.1093/oso/9780198831501.003.0005

[6] Goebel, E., Mills, I. and Wallard, A. (2006) The International System of Units (SI). Bureau International des Poids et Mesures (BIMP).

[7] Renner, T. (2007) Quantities, Units and Symbols in Physical Chemistry. Royal Society of Chemistry.

[8] Prokop, P. and Faněovičová, J. (2006) Students' Ideas about the Human Body: Do They Really Draw What They Know? *Journal of Baltic Science Education*, **2**, 86-95.

[9] Reagle, J. and Koerner, J. (2020) Wikipedia@20: Stories of an Incomplete Revolution. The MIT Press.

[10] Acheampong, S.A. (2023) Remediating Students' Misconceptions in Some Integrated Science Topics through the Conceptual Change Model. Doctoral Dissertation, University of Education.

[11] CUSE (1997) Committee on Undergraduate Science Education and National Research Council. National Research Council, National Academies Press.

[12] Podolner, A.S. (2000) Eradicating Physics Misconceptions Using the Conceptual Change Method. Department of Education Kalamazoo College Kalamazoo.

[13] Marshall, H.A. (2003) Countering Astronomy Misconceptions in High School Students. In Partial Fulfilment of SCE 5305 the University of Texas at Dallas April 28.

[14] McDermott (1991) What We Teach and What Is Learned: Closing the Gap. *American Journal of Physics*, **59**, 301-305.

[15] Suprapto, N. (2020) Do We Experience Misconceptions? An Ontological Review of Misconceptions in Science. *Studies in Philosophy of Science and Education*, **1**, 50-55. https://doi.org/10.46627/sipose.v1i2.24

[16] Suparno, P. (2005) Miskonsepsi & Perubahan Konsep Fisika. Grasindo.

[17] den Berg, E.V. (1991) Miskonsepsi fisika dan remediasi. Universitas Kristen Satya Wacana.

[18] Chi, M.T.H. (2008) Three Types of Conceptual Change: Belief Revision, Mental Model Transformation, and Categorical Shift. In: Vosniadou, S., Ed., *Handbook of Research on Conceptual Change*, Routledge, 61-82.

[19] Marshall, S. and Gilmour, M. (1990) Problematical Words and Concepts in Physics Education: A Study of Papua New Guinean Students' Comprehension of Non-Technical Words Used in Science. *Physics Education*, **25**, 330-337. https://doi.org/10.1088/0031-9120/25/6/309

[20] Tsai, K.F. and Fu, G. (2016) Underachievement in Gifted Students: A Case Study of

Three College Physics Students in Taiwan Region. *Universal Journal of Educational Research*, **4**, 688-695. https://doi.org/10.13189/ujer.2016.040405

[21] Hong, H.Y. and Lin-Siegler, X. (2012) How Learning about Scientists' Struggles Influences Students' Interest and Learning in Physics. *Journal of Educational Psychology*, **104**, 469-484. https://doi.org/10.1037/a0026224

[22] Lambi, E.A. (2009) A Case Study on the Use of a Formative Assessment Probe to Determine the Presence of Science Misconception in Elementary School Students: Implications for Teaching and Curriculum. Ph.D. Thesis, Widener University, Chester.

[23] Chiu, M.H., Guo, C.J. and Treagust, D.F. (2007) Assessing Students' Conceptual Understanding in Science: An Introduction about a National Project in Taiwan Region. *International Journal of Science Education*, **29**, 379-390. https://doi.org/10.1080/09500690601072774

[24] Simanek, D.E. (2008) The Dangers of Analogies.

[25] Ameyaw, Y. (2016) Evaluating Students' Misconceptions of Photosynthesis and Respiration in a Ghanaian Senior High School. *International Journal of Advanced Biological Research*, **6**, 202-209.

[26] Fisher, K.M. and Wandersee, J.H. (2001) Mapping Biology Knowledge. Kluwer Academic Publishers.

[27] Slotta, J.D., Chi, M.T.H. and Joram, E. (1995) Assessing Students' Misclassifications of Physics Concepts: An Ontological Basis for Conceptual Change. *Cognition and Instruction*, **13**, 373-400. https://doi.org/10.1207/s1532690xci1303_2

[28] Chun, J. (2017) Construction of the Sum of Two Covarying Oriented Quantities.

[29] Liu, G. and Fang, N. (2016) Student Misconceptions about Force and Acceleration in Physics and Engineering Mechanics Education. *International Journal of Engineering Education*, **32**, 19-29.

[30] Smith, S.M. (2022) Understanding High School Students' Misconceptions about Chemistry Using Particulate Level Drawings: Focusing on the Third Angle. Doctoral Dissertation, University of Cincinnati.

[31] Cebesoy, Ü.B. and Yeniterzi, B. (2016) 7th Grade Students' Mathematical Difficulties in Force and Motion Unit. *Turkish Journal of Education*, **5**, 18-32. https://doi.org/10.19128/turje.51242

[32] Simon, D.P. and Simon, H.A. (2013) Individual Differences in Solving Physics Problems. In *Children's Thinking*, Psychology Press, 325-348.

[33] White Brahmia, S., Olsho, A., Smith, T.I., Boudreaux, A., Eaton, P. and Zimmerman, C. (2021) Physics Inventory of Quantitative Literacy: A Tool for Assessing Mathematical Reasoning in Introductory Physics. *Physical Review Physics Education Research*, **17**, Article ID: 020129. https://doi.org/10.1103/physrevphyseducres.17.020129

[34] Nardi, P.M. (2018) Doing Survey Research: A Guide to Quantitative Methods. Routledge.

[35] Alwan, A.A. (2011) Misconception of Heat and Temperature among Physics Students. *Procedia—Social and Behavioral Sciences*, **12**, 600-614. https://doi.org/10.1016/j.sbspro.2011.02.074