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Exploring Pre-Service Teachers Perceived Challenges and Learning Needs in Studying General Chemistry

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Abstract

The study explored pre-service teachers (PSTs) perceived challenges and learning needs in studying general chemistry using an embedded mixed-method design. A purposive sampling technique was used to select three colleges in the Ashanti, Bono, Bono-East, and Ahafo (ASHBA) zone whereas simple random sampling technique was used to select the 258 participants from level 100 primary education students across the selected colleges. Perceived challenges questionnaire (PCQ) and Learning needs questionnaire (LNQ) were the instruments used to collect data for the study. Descriptive statistics (mean and standard deviation) and inferential statistics (correlation analysis) were used to analyze the quantitative data, whiles qualitative data was assessed with thematic analysis (Braun and Clarke's framework). The study revealed conceptual and reasoning, experimental, laboratory resources, pedagogical difficulties as key perceived challenges in general chemistry. The study, also revealed learning engagement, conceptual mastery, learning style, and confidence and competence building as desired learning needs. PSTs perceived challenges correlated positively, $\rho\ (258) = 0.469$, $p < 0.01$ with their learning needs. The study recommended baseline assessment of PSTs entry behavior prior to the beginning of chemistry course and engagement of PSTs in learner-centered, technology-driven, and differentiated instructions to address PSTs challenges and learning needs in chemistry education programmes.

Subject Areas

Pedagogy

Keywords

General Chemistry, Perceived Challenges, Learning Needs, Pre-Service Teachers

1. Introduction

Modern instructional approaches are currently employed in chemistry classrooms to equip learners with knowledge, skills, and abilities to function effectively in their world of work [1] However, engaging learners in chemistry concepts is faced with numerous challenges, resulting in low academic performance, and weakened competencies [2]. Empirical evidences in Ghana suggest that learners face difficulties in studying chemistry concepts. [3] reported on PSTs' difficulties in understanding mole concepts. Moreover, [4] reported resources constraints (lab, chemical, apparatus) and time limitation as challenges facing Ghanaian students in learning chemistry. [5] also, found misconception as key challenge facing PSTs in learning chemistry. These challenges, according to [6], hampers PSTs' ability to teach effectively, due to their weaknesses in grasping scientific principles underlying concepts. Understanding learners' entry behavior (perceived challenges), particularly pre-service teachers (PSTs) in chemistry would assist greatly in the selection of suitable instruction approaches to address differentiations in chemistry classrooms. However, previous studies fail to assess the entry behaviors together with their corresponding learning needs. Learning needs are the learning preferences and requirements, mainly cognitive, motivational, emotional and contextual support that enhance learners' understanding, build their competencies and promote academic excellence [7]. Learning needs are the live wires to the acquisition of knowledge and competencies, particularly in chemistry. Addressing the diverse learning needs of PSTs provides fertile grounds for effective training of PSTs, by equipping them with academic and pedagogical competencies to relay onto their future students [8] [9]. PSTs pursuing chemistry programmes at the Colleges of Education require satisfaction in the basic learning needs, such as conceptual mastery, engagement and motivation and learning style and preference [10] [11]. They also need satisfaction in feedbacks, confidence and competence building, and digital literacy [12] [13]. In this vein, [14] explained that development of conceptual understanding help eradicates misconceptions in chemistry. [15] reported that motivation and engagement is the bedrock for effective learning, by improving both academic performance and psychological well-being. Furthering, [16] identified digital literacy as critical learning need for accessing, understating and applying digital resources for understanding of concepts and building practical competencies. [17] described feedback as a learning need that enables learners to identify and address misconception, developing autonomy and lifelong learning. Thus, identifying and addressing learning needs and challenges do not only support PSTs academic performance but also influence their pedagogical competence in their future classrooms. To resolve these challenges, [18] suggested the use scaffolding instructions to enhance students' problem-solving abilities. In the same way, [19] highlighted the effectiveness of computer-assisted instructions in resolving students' misconceptions in chemical bonding by improving their conceptual understanding. [20] employed inquiry-based learning approach to improve students' conceptual understanding in fundamental of analytical chemistry. Addressing these identified gaps in teacher education programmes help strengthens PSTs content knowledge, enhance self-efficacy and confidence, promote problem-solving abilities, and improve digital literacy in chemistry [21]-[23]. Furthermore, enhancing PSTs abilities of using technology in chemistry classroom improves their ability to integrate digital tools in diverse learning environment, facilitate their inquiry-process, and enhance easily access to digital teaching and learning resources [24]. Also, the awareness of PSTs learning needs in learning general chemistry help instructors to adopt suitable instructional strategies to engage them [25]. Moreover, the knowledge of PSTs learning needs with the accompanied challenges helps in their training process, by meeting the general chemistry course expectations and standards of the National Teaching Council (NTC) of Ghana [26]. This study is stemmed on social cognitivist theory (SCT), which emphasizes effective learning process that results from the interaction of learners' personal factors (confidence, self-efficacy), behavior (persistence and persistence), and environmental influences (instructional approach and resources) [27]. This theory guides learners' engagements in the classroom to achieve maximum learning outcome. Therefore, embarking on a study to investigate into PSTs perceived challenges and learning needs in studying general chemistry will go a long way to help in PSTs training process in chemistry education, by engaging them in effective instructional approaches that support their knowledge construction, and pedagogical skill development in 21st century educational settings.

Purpose of the Study

This study was purposed to explore the diverse dimensions of PSTs' perceived challenges and learning needs in general chemistry. The study sought to answer the following questions;

1) What are the perceived challenges of PSTs in studying general chemistry?

2) What key learning needs do PSTs require in studying general chemistry?

3) What is the relationship between PSTs perceived challenges and learning needs in studying general chemistry?

2. Methodology

2.1. Research Design

The study adopted an embedded mixed-method design to collect both numerical (quantitative) and non-numerical (qualitative) data, simultaneously. In this study, the qualitative (secondary) method was embedded into a quantitative (primary) method to perfectly understand PSTs perceived challenges and diverse learning needs [28].

2.2. Research Instruments

The instruments used to collect the data for the study were perceived challenges questionnaire (PCQ) and learning needs questionnaire (LNQ). The instruments were developed by the researchers, after carefully assessing the course expectations of the general chemistry curriculum and national teachers' standards of Ghana [26]. PCQ was used to collect data on PSTs perceived challenges whereas LNQ was used to collect data on learning needs required for studying general chemistry. PCQ is consisted of 24 negative item Likert-type which were categorized into eight (8) subscales. The subscales included; difficulties in interpreting symbols and formulas, difficulties in visualizing concepts, and difficulty in addressing misconceptions. The remaining were; difficulty in retention of concepts, difficulty in the conduct of experiment, limited resources, and difficulties with teaching approach. LNQ on the other hand consisted of 21 positive Likert scale type items which were categorized into seven (7) subscales, consisting of engagement and motivation, mastery of chemistry concepts, learning style and preference, and confidence and competence building. The remaining subscales were feedback systems, digital literacy, and skill development and application. Both (PCQ and LNQ) instruments consisted of open-ended questions. To ensure consistency in the direction of scoring, all negative worded items in the PCQ were reverse-coded by transforming, the responses on the 5-pont Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) whiles positive items of LNQ were not reverse coded. PSTs' background in chemistry were measured by both instruments for consistency. The study adopted Likert-type scale with open ended questions in the construct of PCQ and LNQ based on its ability to produce highest reliability when testing several formats [29]. Both PCQ and LNQ consisted of five point-Likert scales (Scale: 1 = strongly disagree to 5 = strongly agree). To obtain the overall score of each subscale, the means of the item responses were computed and interpreted with pre-defined ranges: 1.00 - 1.80 (very low), 1.81 - 2.60 (low), 2.61 - 3.40 (moderate), (3.41 - 4.20 high), and 4.1 - 5.0 (very high). Prior to their usage, the instruments (PCQ and LNQ) were validated, by assessing both the content and construct of the items. Six (6) psychometric experts were tasked to evaluate the items in PCQ, LNQ to improve clarity, enhance coverage and ensure accuracy. Each item in PCQ and LNQ were rated on the scale of 4-point Likert scale (1) = not relevant, 2 = somewhat relevant, 3 = quite relevant, and 4 = highly relevant for their relevance [30] Item-level Content Validity Index (I-CVI) was then calculated from expert ratings, and the items that did not meet the threshold of 0.78 or beyond were revised or removed entirely [31].

Content Validity Index (I-CVI) and Scale-level Content Validity Index (S-CVI) were determined from the relation relations;

$$\text{I-CVI} = \frac{\text{Number of experts rating 3 or 4}}{\text{6 expert reviewers}} \quad (1)$$

$$\text{S-CVI} = \frac{\text{Number of items with I-CVI}}{\text{Total number of items}} \quad (2)$$

S-CVI obtained from experts' validation for PCQ and LNQ were 0.99 and 0.96 respectively, which indicate excellent content validity [31]. After validation by a team of six (6) experts and adaption of the items in the instruments, a pilot study was conducted with 40 students pursuing general chemistry at ATECOE with PCQ and LNQ to assess the validity and reliability of the instruments. Internal consistency of PCQ and LNQ was determined using Cronbach's alpha. Alpha values obtained in Cronbach's alpha analysis of PCQ, and LNQ were 0.89 and 0.91 respectively, which indicate a good reliability of the items [32].

2.3. Sample and Sampling

A purposive sampling technique was used to select three colleges of education, affiliated to the University of Cape Coast in the Ashanti, Bono, Bono, Bono East and Ahafo (ASHBA) zone, and a simple random sampling was used to select 258 level 100 PSTs pursuing primary education programme across the three selected colleges. Out of this population, 35.3% (n = 91) were PSTs selected from Atebubu College of Education (ATECOE), 36.0% (n = 93) were selected from SDA College of Education (SDACOE), and 28.7% (n = 74) St. Ambrose College of Education (SACE) (**Figure 1**). Also, the participants consisted of 54.3% (n = 140) males and 45.7% (118) females (**Figure 1**). In the age brackets, 14.7% (n = 38) were at age 20, 21.7% (n = 56) were at age 21, 36.0% (n = 93) were at age 22, and 27.6 (n = 71) occupied the ages above 22 (**Figure 1**). Majority of the participants fell in age 22. Only, 30.2% (n = 98) of the participants have had previous experience in elective chemistry, the remaining 69.8 (n = 160) without prior experience chemistry.

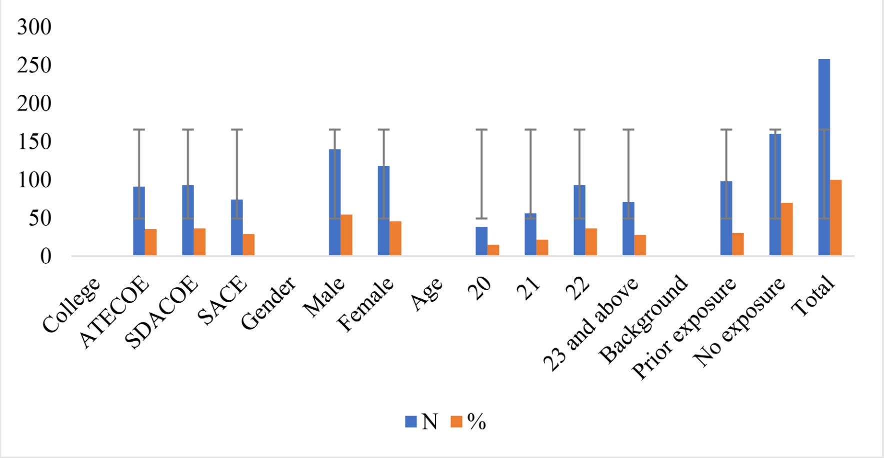

Figure 1. Demographic characteristics of participants.

2.4. Data Collection Procedure

The instruments, PCQ and LNQ were administered to the participants via google forms by sharing the links through their WhatsApp platforms, after seeking for their consent.

2.5. Data Analysis

Descriptive statistics (mean and standard) and inferential analysis (correlation analysis) were used to analyze the numerical data, using SPSS, whereas non-numerical data was assessed with thematic analysis. The thematic analysis was guided by Braun and Clarke's six-phase framework of analysis; familiarization with the data, generating the initial coding, searching for themes, reviewing themes, defining themes, and writing-up a report as described by [33]. Out of 258 questionnaires (PCQ and LNQ) administered, a total 150 and 151 participants responded to open ended questions of PCQ and LNQ, respectively. The qualitative data obtained from the participants were collected and coded for analysis. The coding was done by two independent researchers for robustness of the analysis. Inter-coder agreement was then checked to ensure theme credibility and trustworthiness.

3. Results

3.1. Test for Normality

Normality test was conducted on the numerical data obtained in the study to assess its distribution, with Kolmogorov-Smirnov and Shapiro-Wilk, and summary of the results recorded in **Table 1**. As shown in **Table 1**, both Kolmogorov-Smirnov and Shapiro-Wilk test yielded statistically significant results ($p < 0.001$), indicating that the data was not normally distributed. The results, thereby violated the assumption of normality for parametric analysis. Therefore, a non-parametric analysis (Spearman's rho correlation) was conducted.

Table 1. Test for normality for PSTs perceived challenges and learning needs in chemistry

Variable	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Perceived Challenges	0.105	257	0.000	0.959	257	0.000
Learning needs	0.123	257	0.000	0.966	257	0.000

In answering the research question 1, the quantitative and qualitative data obtained on participants perceived challenges were analyzed using descriptive statistics (mean and standard deviation) and theme, respectively.

Table 2 displays the results of participants perceived challenges in general chemistry. The results in **Table 2** indicate that the respondents reported high level of perceived challenges across the identified dimensions, with mean scores ranging from 4.12 to 4.21. Specifically, participants perceive challenge on interpretation of symbols and formulas recorded a high mean score ($M = 4.12$, $SD = 0.816$). This shows a greater number of participants expressed difficulties in decoding and interpreting symbols and formulas. Similarly, participants' rated visualization of chemistry high ($M = 4.14$, $SD = 0.791$). Participants perceived challenge in solving calculation questions, also recorded higher mean score ($M = 4.15$, $SD =$

Table 2. Pre-service teachers perceived challenges in studying general chemistry (quantitative results).

S/n	Perceived Challenge	N	Mean	SD	Interpretation
1	Difficulty in interpreting symbols and formulas	258	4.12	0.816	High
2	Difficulty in visualizing concepts	258	4.14	0.791	High
3	Difficulty in solving Calculations	258	4.15	0.692	High
4	Difficulty in addressing misconceptions	258	4.12	0.717	High
5	Difficulty in retention of concepts	258	4.17	0.685	High
6	Difficulty in the conduct of experiment	258	4.21	0.697	High
7	Limited resources	258	4.20	0.699	High
8	Difficulties with teaching approach	258	4.18	0.688	High
9	Overall perceived challenge	258	4.16	0.368	High

Note: S/n = serial number, M = mean, SD = standard deviation.

0.692). Moreover, participants perceived challenge on misconceptions and retention of chemistry concepts were equally high at the mean scores (M = 4.12, SD = 0.717) and (M = 4.17, SD = 0.685), respectively. Responses on the dimension, conduct of experiment was rated high (M = 4.21, SD = 0.697). Report on participants perceived difficulty on limited resources and teaching approach was also higher at mean scores (M = 4.20, SD = 0.699) and (M = 4.18, SD = 0.688), respectively. The overall perceive challenge for learning chemistry was rated high (M = 4.16, SD = 0.368). This result indicates that PSTs generally faces considerable challenges in learning chemistry at the colleges of education. This finding indicates that the difficulties in cut across multiple instructional dimensions.

3.2. Participants Perceived Challenges in Chemistry (Qualitative Data) (Table 3)

Data obtained in the open-ended questions were analyzed thematically, using Braun and Clarke's six-step frameworks. Four themes emerged from the analysis: conceptual and reasoning challenges, experimental challenges, laboratory resources challenges, and pedagogical challenges.

Theme 1: *Conceptual and reasoning challenges*

The participants expressed their perceived difficulties in conceptual understanding and reasoning, especially difficulty in mastering chemistry concepts by visualizing abstract chemical process and complex concepts, and difficulties in interpreting symbols and formulas. They also expressed their anxiety and misconceptions in chemistry.

Participant 1 *remarked*: *"I find it very difficult to visualize chemical process, for instance chemical bonding process"*.

Participant 3: *"Even though I am familiar with some chemical symbols, I don't understand how they combine in formulas"*.

Table 3. Integrated analysis of quantitative and qualitative findings on pre-service teachers' challenges in general chemistry

S/n	Quantitative finding (Mean ± SD)	Qualitative theme	Integrated Interpretation
1	Difficulties in interpreting symbols and formulas (4.12 ± 0.816)	Conceptual and reasoning challenges	Difficulties in symbolic representation result in conceptual and language difficulties.
2	Difficulties in visualizing concepts (4.14 ± 0.791)	Conceptual and reasoning challenges	Non-observable concepts limit cognitive reasoning, resulting in poor conceptualization.
3	Difficulties in solving Calculations (4.15 ± 0.692)	Conceptual and reasoning challenges	Mathematical abilities and lack of conceptual clarity resulting problem-solving difficulties
4	Difficulties in addressing misconceptions (4.12 ± 0.717)	Conceptual and reasoning challenges	Persistent misconceptions hinder conceptual understanding and change.
5	Difficulties in retention of concepts (4.17 ± 0.685)	Conceptual and reasoning challenges	Rote memorization affects retention.
6	Difficulties in the conduct of experiment (4.21 ± 0.697)	Experimental challenges	Low practical competence and anxiety reduce engagement in laboratory activities.
7	Limited resources (4.20 ± 0.699)	Laboratory resources challenges	Lack of instructional resources influences hands-on learning and skill development.
8	Difficulties with teaching approach	Pedagogical challenges	Teacher-centered methods limit active engagement, and conceptual understanding.
9	Overall perceived challenge (4.18 ± 0.688)	Conceptual and reasoning, experimental, laboratory resources, and pedagogical challenges	Learners overall challenges resulted from conceptual mastery, practical, resource, and pedagogical factors.

Participant 9 *remarked*: *"I struggle to understand chemical process, so I memorize"*.

Participant 13 *commented*: *"I get confused about some chemistry concepts, sometimes the concepts I thought are correct tends to be wrong"*.

Participant 14 *stated*: *"I am nervous about chemistry calculation"*.

Theme 2: *Experimental challenges*

Participants commented on their perceived difficulties in chemistry practical activities, how to connect theoretical concepts into practice, based on some level of anxiety they have.

Participant 3 *explained*: *I cannot connect theory into practice.*

Participant 6 *stated*: *I am terrified to handle dangerous chemicals like acids, and fragile apparatus and equipment.*

Theme 3: *Laboratory resources challenges*

Participants reported their perceived challenges on laboratory resources, citing unavailability of functional lab, and insufficient apparatus and equipment, to engage them in practical activities.

Participant 1 *remarked*: *We don't have lab in our college, so we don't do chemistry practical activities.*

Participant 10 *stated*: *Our lab doesn't have sufficient apparatus, equipment, and chemicals, so we don't do chemistry practical regularly.*

Theme 4: *Pedagogical challenges*

Participants demonstrated their frustration in the instructional approaches they are engaged in, especially when they are made passive in the instructional process.

Participant 2 *responded*: *"I don't enjoy chemistry lessons because the teacher does all the activities"*.

Participant 14 *commented*: *"chemistry lessons seems more teacher-centered to me"*.

In answering the research question 2, quantitative and qualitative data obtained on participants desired learning needs were analyzed with descriptive statistics (mean and standard deviation) and themes. Table 4 shows results of quantitative data on participants learning needs. As shown in Table 4, the participants reported a very high-level desire for learning needs to support their studies in chemistry, ranged 4.20 (SD = 0.652) to 4.31 (SD = 0.691) on a five-point Likert scale with the overall mean at (M = 4.25, SD = 3.0), with skill development and application recording the highest mean score (M = 4.31, SD = 0.691).

Table 4. Pre-service teachers learning needs in the study of general chemistry (quantitative results).

S/n	Learning need	Mean	SD	Interpretation
1	Engagement and motivation	4.21	0.652	Very High
2	Mastery of chemistry concepts	4.20	0.735	Very High
3	Learning style and preference	4.23	0.710	Very High
4	Confidence and competence building	4.28	0.687	Very High
5	Feedback systems	4.27	0.679	Very High
6	Digital literacy	4.26	0.666	Very High
7	Skill development and application	4.31	0.691	Very High
8	Overall learning need	4.25	0.301	Very High

Note: S/n = serial number, M = mean, SD = standard deviation.

Followed closely was confidence and competence building which recorded a very high mean score (M = 4.28, SD = 0.69) and feedback systems (M = 4.27, SD = 0.68). Participants also expressed a very high preference for digital literacy (M = 4.26, SD = 0.67), with learning style and preference (M = 4.23, SD = 0.71) and engagement and motivation (M = 4.21, SD = 0.65) following in that high order. Mastery of chemistry concepts recorded relatively lowest mean score (M = 4.20, SD = 0.74).

3.3. Participants Perceived Learning Needs in Chemistry (Qualitative Data) (Table 5)

The data obtained in the open-ended questions on PSTs perceived learning were examined with thematic analysis, guided by Braun and Clarke's six-step frameworks. Seven themes emerged from the analysis. They include perceived need for learning engagement, conceptual mastery, learning style, and confidence building.

Table 5. Integration of quantitative and qualitative findings on pre-service teachers' learning needs.

S/n	Quantitative finding (Mean ± SD)	Qualitative theme	Integrated Interpretation
1	Engagement and motivation (4.21 ± 0.652)	Learning engagement	Preference for student-centered learning environments that enhance active participation, interaction, and engagement.
2	Mastery of chemistry concepts (4.20 ± 0.735)	Conceptual mastery	Strong desire for conceptual understanding with consistent practice, repetition, and problem-solving activities.
3	Learning style and preference (4.23 ± 0.710)	Learning style	Strong need for differentiated instruction, personalized learning and systematic delivery of lessons for better understanding.
4	Confidence and competence building (4.28 ± 0.687)	Confidence building	Improvement of learners' emotions to overcome anxiety and past failure, and build confidence and competence.
5	Feedback systems (4.27 ± 0.679)	Feedback	Addressing misconceptions and improving learning outcomes with timely feedbacks.
6	Digital literacy (4.26 ± 0.666)	Digital literacy	Improving learners conceptual understanding and independent learning by integrating digital tools.
7	Skill development and application (4.31 ± 0.691)	Skill development	Addressing practical application, problem-solving, and transfer of knowledge to real-life contexts.
8	Overall learning needs (M = 4.25, SD = 301)	All themes	Addressing cognitive, affective, and technological domains holistically.

The remaining learning needs are preference for; feedback, digital literacy and skill development.

Theme 1: *Learning engagement*

Participants expressed their preference for more engaging and interactive lessons where they can actively participant in lessons, especially taking active role in group tasks, and asking questions and answering questions.

Participant 10 *explained*: *"I want regular engagement in chemistry to master concepts"*

Participant 12 *echoed*: *"I prefer lesson engagement that is systematic".*

Theme 2: *Conceptual mastery*

Participants demonstrated their readiness for lessons that enhance their understanding and mastery of chemistry concepts to construct new knowledge. Also, they expressed the need to develop proficiency in chemistry calculations and retain concepts learnt.

Participant 9 *remarked*: *"I want to master concepts through constant practices".*

Participant 13 *commented*: *"I wish to be proficient in chemistry calculations.*

Theme 3: *Learning style*

Participants expressed their preferences for instructions that align perfectly with learning styles to easily construct new knowledge. They also voiced for systematic pace of lesson delivery to enhance deeper understanding of chemistry concepts.

Participant 7: *"I enjoyed lessons presented on my preferred learning style"*

Theme 4: *Confidence building*

Participants reported on the need to overcome their nervousness, as a result of past failures in previous examination or chemistry tasks. They also expressed their preference for confidence to engage in practical and calculation tasks due to inherent complexity nature of general chemistry course.

Participant 3 *remarked*: *"I want to do away with my nervousness in chemistry".*

Theme 5: *feedback*

Participants expressed their need for timely and constructive feedbacks for corrections, clarification and addressing misconceptions.

"Participant 2 *stated*: *I want timely feedback to overcome my difficulties*".

Theme 6: *Digital literacy*

Participants expressed their desire for digital literacy to access online information, engage in virtual practical activities to enhance their conceptual understanding.

Participant 15: *"I want to know how simulations and digital tools can support my learning in chemistry".*

Theme 7: *Skill development*

Participants demonstrated their liking for skill development in chemistry to enhance their problem solving.

Participant 1 *stated*: *"I want to develop the ability to apply chemistry concepts in real life situations".*

3.4. Relationship between PSTs Perceived Challenges and Learning Needs

In answering the research question 3, Spearman's rank-order correlation was conducted to assess the relationship between participants perceived challenges and learning needs in chemistry, and the summary recorded in Table 3.

Table 6. Correlation between PSTs perceived challenges and learning needs.

Variable	Perceived challenge	Learning needs
Perceived challenge	1	0.469**
Learning needs	0.469	1
Sig (2-tailed)	-	0.000
N	258	258

Note: **. Correlation is significant at the 0.01 level (2-tailed).

As shown in Table 6, Spearman's rank-order correlation showed a significant moderate positive relationship between participants perceived challenges and learning needs in general chemistry, $\rho = 0.469$, $p < 0.001$ (two-tailed), N = 258.

4. Discussion

The study explored the diverse dimensions of PSTs' perceived challenges and learning needs in general chemistry. The integrated results show that PSTs faces substantial challenges in studying general chemistry with overall mean of 4.18 (SD = 0.688). These include conceptual, experimental, resource, and pedagogical challenges. These findings can best be explained by Social Cognitive Theory (SCT), which stated that effective learning results from the interaction between personal (cognitive and affective), behavioral, and environmental factors of learning. The finding on the difficulties in symbolic representation might have resulted from PSTs inability to understand chemistry symbols and formulas. In the lens of SCT, difficulty in symbolic representation is a reflective of PSTs limitation on cognitive processing, which affects their self-efficacy. Chemistry is full of abstract and unfamiliar symbols, which require learners to decode, make representations, and meaning. PSTs who face difficulties in the representations, encounter disruptive meaning-making processes which reduces their self-efficacy, and conceptual understanding. This finding agrees with the finding of [33], who reported students who struggle to translate submicroscopic representations faces difficulties in understanding chemistry symbols and formulas. The finding on PSTs weaknesses in visualization chemistry concepts could be attributed to limited exposure to models, simulations, and other laboratory experience to process and create mental models of concepts. This might also have resulted from pre-existed misconceptions which disrupts the correct visual models. According to SCT effective learning occurs through triadic factors [35]. In this context, limited exposure to resources and PSTs prior and misconceptions constrained the environmental and personal factors, respectively, which would result in conceptual difficulties. This finding aligns with what was reported by [27] that students exposed to simulations benefited from visualizing theory concepts. PSTs perceived difficulties in problem solving and persistent misconceptions might be a result of limited cognitive abilities, low self-efficacy, and in appropriate learning environment. In the perspective of SCT, these factors work together, and limitation of each would affect conceptual understanding and problems solving. PSTs' weak mathematics abilities might negatively influence their cognitive processing, which may affect their abilities to manipulate chemical relationships mathematically. This finding aligns with what is reported in [36] that students mathematical background influences their chemistry reasoning. The high challenge of practical competence and anxiety in chemistry concepts could be attributed to low engagement in practical activities. Reflecting on SCT, these difficulties were resultants of low self-efficacy, especially when PSTs doubted their abilities in laboratory activities, which would hinder their active participation. Moreover, abstinence from practical activities impedes their mastery and vicarious experiences, which fuel their low competence and anxiety [35] Students with low self-efficacy laboratory activities tend to adopt passive roles, which restrains skill development and conceptual understanding [37]. Also, lack of instructional resources affects hands-on engagements and skill acquisition [4]. Studies have shown that lack of laboratory, insufficient apparatus, equipment and chemicals impedes effective learning in chemistry [38]. Meanwhile, SCT framework indicates that environment (resources) is one of the triadic factors that enhances effective learning [35]. Therefore, limited laboratory and digital resources may reduce the opportunities for experiential learning and observational modeling. In addition, teacher-centered instructional approach was revealed as a critical factor that impedes PSTs active engagement and limits conceptual understanding. This challenge could have serious effect on PSTs academic success based on the fact that learning is an active process where PSTs construct knowledge by interacting with the classroom environment. Therefore, lack of laboratory resources, coupled with denial of accessible experimental activities may hamper material and environmental interactions, which negatively affect knowledge constructions. This, therefore, may deprived PSTs from meaningful engagement, denying them the opportunity to connect theory to practice and could lead to misconceptions. The perceived challenge on pedagogical approach revealed in the study may also have negative implications on PSTs learning in chemistry, especially when PSTs voiced that their teachers engaged them in teacher centered-instructional approach. This instructional approach, dominated by lectures makes PSTs passive learners, and restrict them from inquiry, and collaborative learning, thereby infringing on their conceptual mastery, motivation, and learning outcome. This challenge also impedes consistent provision of constructional feedback to eradicate misconceptions in chemistry. Also, teacher-centered approach might not promote their confidence building in chemistry since PSTs consistently remain passive during instructional activities. Engagement of PSTs in passive instructional process weakens their motivation in chemistry and cognitive engagement, and problem-solving abilities

4.1. Pre-Service Teachers Learning Needs in Chemistry

The integrated results of quantitative and qualitative revealed that PSTs reported very high-level learning needs across measured domains (M = 4.25, SD = 0.301). The pressing and consistent learning needs of PSTs necessitates immediate intervention to address such needs. The consistency in the standard deviation indicates that PSTs learning needs are broadly shared and systemic than individual-specific. The finding on a very high preference for skill development and application (M = 4.31, SD = 0.691) suggest that learners yearn for chemistry application to real-life situations, rather than a mere theoretical acquisition. This finding aligns with the behavioral component of SCT where learners exhibits knowledge application. The finding indicates that PSTs prefer an instructional approach that support real-life application and active engagement. This support what [39] reported that problem-based learning through real-world situations enhances learners problem-solving skills contexts and active participation. PSTs greater priority for learning engagement (M = 4.21, SD = 0.652) suggest the need to engage them in learner-centered instruction that arouse, sustain, and enhance their active participation in instructions. This finding reflects in the triadic framework of SCT which indicates that the interaction with the environment and other factors result in effective learning. This finding supports the outcome of [40] who reported that learner centered enhances PSTs active, cognitive, and behavioral engagement. A very high-level score for mastery of chemistry concepts (M = 4.20, SD = 0.735) underscore PSTs strong desire for in-depth understanding of concepts through consistent practice and problem solving. This learning need calls for urgent attention, based on the fact that chemistry is full of abstract and non-observable concepts where many learners struggle to master. Therefore, prioritizing instructions that foster active engagement, visualization, inquiry and knowledge construction would vitalize PSTs' ability to master chemistry. The desire for conceptual mastery aligns with the major source learners' self-efficacy-mastery experience, asserted by SCT. This learning need build PSTs confidence to embark on assigned tasks [35]. The finding corroborates [14], who reported that conceptual understanding enhances meaningful learning of PSTs, by supporting their knowledge transfer, critical thinking and problem solving. Learning style and preference in chemistry also came up in the integrated analysis as pressing need (M = 4.23, SD = 0.710). This finding suggests need to prioritize an instruction that cater differentiation and personalized learning. Chemistry classrooms are full of learners with diverse abilities, backgrounds, and cultures [41] Therefore, adopting instructional approaches, inquiry-based, technology-driven, and hands-on activities that accommodates auditory, visual, and kinesthetic learners might go a long way to address differentiations in the chemistry classrooms. This finding support what was reported by [42] that differentiated instruction that addresses learners' needs creates a more engaging and meaningful learning experiences. Similarly, the study revealed confidence building as a greater desire (M = 4.28, SD = 0.687) of PSTs in the studying chemistry. This finding is very important learning need that shape PSTs learning experience in the study of chemistry. Most chemistry practical activities are hazardous in nature and require caution, precision and confidence to engage in them [43]. PSTs with higher confidence and self-efficacy would always believe in themselves to attempt and execute chemistry tasks successfully. Confidence is an antidote to anxiety and fear of failure, particularly in executing complex chemistry tasks. Therefore, PSTs with a higher confidence would always be ready to take active role in chemistry activities by asking and engaging in practical and collaborative activities to build effective problem-solving abilities. There is therefore, the need to adopt an instructional approach that would build learners confidence. In line with SCT, [35] asserted that learners emotions influence their confidence in their capabilities. The greater desire (M = 4.27, SD = 0.679) PSTs attached to feedback systems shows its significant role in shaping their confidence and academic development. Timely and constructive feedback build confidence in PSTs by enhancing effective corrections, clarifications, and addresses misconceptions which improves learning outcome. Also, feedback provisions strengthen PSTs self-efficacy through social persuasion. This finding is consistent with formative assessment theory which tag feedbacks as essential elements for effective learning process [44]. PSTs high priority for digital literacy shows how technology integration improves their learning experience. This desire for digital literacy calls for seamless integration of technology in classroom instructions. Therefore, engaging PSTs in technology-driven instructions, such as simulations in chemistry classroom makes abstract and non-observable concepts very real and interactive. Digital literacy also, improves PSTs' abilities to integrate technology in curriculum planning and classroom instructions. practical and process skills. In a nut shell, the joint quantitative and qualitative findings of PSTs perceived challenges and learning need in chemistry are multifaceted in nature, and calls for immediate intervention, particularly technology-driven instructions to address perceived challenges and learning needs identified.

The study also revealed a positive relationship between PSTs' perceived challenges and learning needs in general chemistry. The coefficient (0.469) recorded indicates that the relationship between participants perceived challenges and learning needs was very moderate. This clearly shows that the participants perceived challenges for general chemistry significantly contributes to their learning needs. The positive correlation recorded suggest that PSTs with a higher challenge in general chemistry will exhibit a greater desire for learning needs. This finding aligns with what was reported by [45] that students with difficulties in chemistry require more interactive and technology-supported instruction to enhance understanding.

4.2. Educational Implications

The findings indicate that PSTs demonstrate a very high and multidimensional learning needs, which calls for instructional reform in chemistry education. Therefore, instructional practices in the colleges of Education should focus on learner-centered approaches that fosters skill development and real-life application. The strong desire for learning engagement calls for chemistry instruction that support active participation and collaborative learning. Moreover, high demand for conceptual mastery emphasizes the need to adopt instructional strategies that support in-depth understanding by enhancing visualization, multiple representations, and guided problem-solving. The finding also emphasizes differentiated instruction that accommodate diverse learning styles. There is also the need to adopt immediate feedback mechanisms that strengthens PSTs' self-efficacy and correct their misconceptions in chemistry education, particularly at the Colleges of Education. Furthermore, there is the need to enforce digital literacy and technology-driven instruction to make complex and abstract chemistry concepts real and accessible. The implications agree with Social Cognitive Theory which advocates for interaction of personal factors, environmental influences, and behavioral outcomes in learning.

5. Conclusion

The study which aimed at exploring PSTs perceived challenges and learning needs has provided insightful information on PSTs perceived challenges coupled with their diverse learning needs in studying general chemistry. The study found conceptual and reasoning, experimental, laboratory resources, and pedagogical issues as a compelling PSTs perceived challenges that needs immediate attention. The study also revealed learning engagement, conceptual mastery, learning style, confidence and competence building, digital literacy, feedbacks, and skill development as pressing PSTs learning needs in general chemistry. The study underscored the significance of learner-centered approaches, such inquiry-based instructions, technology-driven instructions, differentiated instructions, scaffolding activities, and other forms hands-on activities in addressing PSTs perceived challenges and learning needs. These perceived challenges identified with the corresponding learning needs, if not properly resolved could heighten PSTs misconceptions, demotivation, and eventually lower their academic outcome.

6. Recommendation

Recognizing the significant roles of teachers in fast evolving educational settings in 21st century era, the study recommends the:

1) conduct of baseline assessment to examine PSTs perceived challenges and learning needs to adopt suitable instructional approach that addresses their perceived challenges and satisfies their learning needs.

2) adoption of technology-driven instructions, differentiated instructions, and collaborative activities to arouse and sustain PSTs interest, and provide opportunities for visualizing microscopic chemistry concepts.

3) engagement of PSTs in scaffold learning and other learner-centered approaches to foster PSTs active participation of lessons and deeper conceptual understanding.

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Conflicts of Interest

The authors declare no conflicts of interest.

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