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Peer-Led Team Learning (PLTL): Unveiling the Learning Experiences of College Students in Biochemistry

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Abstract — Peer-Led Team Learning (PLTL) has been widely applied as a collaborative teaching methodology in science education; however, limited emphasis has been placed on the aspects of specific dimensions of students' learning experiences within structured peer-led settings and the relationship of these experiences to academic outcomes. This study examined the learning experiences of first-year nursing students enrolled in a Biochemistry course under a PLTL initiative and explored the extent to which these experiences predict academic performance. Anchored on the Basic Psychological Needs Theory, the study employed a cross-sectional, explanatory, non-experimental quantitative design involving 92 Bachelor of Science in Nursing students. A validated 69-item instrument was administered to measure students' PLTL learning experiences using a five-point scale, while academic performance was determined through final semester grades in Biochemistry. The Exploratory Factor Analysis (EFA) using principal axis factoring with orthogonal varimax rotation identified six distinct dimensions of learning experience, explaining 48.3% of the total variance. The multiple regression analysis showed that none of the six dimensions significantly predicted semester grades when the other experiential factors were controlled, although the overall model was significant. These findings indicate that students' PLTL learning experiences may be related to academic performance through indirect or distal processes, rather than exerting a unique or independent predictive effect on semester grades.

Keywords: Peer-Led Team Learning; Collaborative Learning; Learning Experience; Academic Performance; Basic Psychological Needs Theory; Exploratory Factor Analysis; Biochemistry Education

I. INTRODUCTION

Shifting from secondary to tertiary level of education gives a significant academic adjustment to first-year college students, most especially in science courses that are challenging, like Biochemistry. The study of the natural sciences involves students having to combine generalized ideas and participate in processes of multi-level problem-solving. In cases where instruction is offered mainly in lecture form, active participation might be constrained. Recent studies show that a passive instructional setting is correlated with a decreased level of student engagement in contrast to a collaborative learning setting, whereas structured peer-assisted learning strategies are related to an increase in academic engagement and conceptual learning as a result of student interaction (Børte et al., 2020; Li et al., 2025; Tang et al., 2025).

Peer-Led Team Learning (PLTL) is a guided team-based instructional model where small groups of students are engaged in workshops led by well-trained peer leaders who have already demonstrated academic proficiency in the course. Students in PLTL sessions are directed to solve problems, discuss, and clarify concepts in a supportive environment with peers. Recent studies of peer-assisted instructional programs have been linked to better academic outcomes, greater retention, and better engagement in higher education institutions (Brierley et al., 2022; Sloane et al., 2021). In the aspect of science instruction, peer-facilitated workshops give opportunities for students to elucidate concepts in their own words, receive feedback from their peers, and engage actively with course content, which has been associated with heightened examination outcomes and collaborative participation in activities (Upmacis, 2021; Young & Lewis, 2022).

In addition to the quantifiable academic performance, peer interaction has also been linked to higher-order thinking and conceptual mastery in a science learning context. Structured peer discussion enables the students to cocreate knowledge, express reasoning processes, and refine analytical problem-solving skills (Tullis & Goldstone, 2020; Xu, 2024). Moreover, peer-assisted learning settings cultivate shared responsibility and engagement among students, aiding active participation in the academe (Feng et al., 2024; Li, 2025).

In spite of the continuously growing body of literature concerning the effectiveness of PLTL in improving academic performance, persistence, and engagement in science education, including STEM education, published studies have widely treated the initiative as a general

intervention in instruction. Comparatively, limited attention has been given to identifying the specific factors of learning experiences that occur within peer-led settings and investigating how these experiential dimensions relate to their academic performance. Thus, the internal dimensions of the students' participation in the PLTL program remain inadequately characterized.

To this end, the current research endeavored to establish the latent dimensions of learning experiences in the context of college students undergoing PLTL sessions in Biochemistry and to determine the degree to which the experiential dimensions of learning experiences are predictive of academic performance in the course.

Literature Review

Peer-Led Team Learning (PLTL) is a facilitated collaborative learning strategy where small units of learners take part in directive workshops led by trained peer leaders, who have already demonstrated competence in the course (Yang et al., 2022; Tanveer et al., 2023). Peer-assisted instructional methods remain in use in the modern educational process of higher education institutions to improve student interaction, engagement, and professional growth in the educational environment (Tanveer et al., 2023; Yang et al., 2022). PLTL has also found application in science education as a supplement instructional approach in conceptually rigorous courses, such as chemistry and health-related fields, and is supported by peer-facilitated workshops helping students to discuss and exchange feedback and solve problems jointly (Young and Lewis, 2022; Zhang et al., 2022).

Recent empirical research findings indicate that engagement in institutionalized peer-learning programs is linked to higher performance in school and greater persistence in higher education programs (Brierley et al., 2022; Sloane et al., 2021). In the same way, structured peer-assisted learning was found to positively influence the performance in examinations and disciplinary learning of science and health-related subjects (Zhang et al., 2022). These results show that peer-mediated instructional settings are linked to quantifiable educational results, including the case of STEM education (Brierley et al., 2022; Zhang et al., 2022).

In addition to the performance indicators, peer-assisted learning settings have also been associated with the improvement of higher-order thinking and conceptual comprehension.

According to empirical studies, cooperative conversation and systematic peer thinking have a positive impact on analytical processing and increased interaction with disciplinary material (Tullis and Goldstone, 2020; Avonts et al., 2023). Moreover, peer-assisted environments have been linked to greater academic engagement and involvement in the form of shared responsibility and meaningful interaction between learners (Feng et al., 2024; Li, 2025). Engagement in peer-led instructional practices has also been linked to the acquisition of transferable skills, such as communication, teamwork, and collaborative problem-solving skills, and an increase in confidence and professional growth (Chase et al., 2020; McMahon, 2024; Yang et al., 2022).

Although there has been consistent evidence to support the idea that PLTL is associated with enhanced academic success, involvement, and perseverance (Brierley et al., 2022; Sloane et al., 2021; Zhang et al., 2022), recent studies have emphasized more on the aspect of PLTL as an instructional intervention instead of a multidimensional experiential process. The majority of the emphasized empirical work is centered around measurable outcomes, including grades, exam results, retention rates, and engagement indicators (Brierley et al., 2022; Sloane et al., 2021), but less systematic attention has been paid to defining internal aspects of the learning experiences of students within the framework of structured, peer-led activities. Though collaborative communication, high-order thinking, and engagement have been recorded as the results of peer-assisted learning (Tullis and Goldstone, 2020; Feng et al., 2024), such constructs are usually studied separately and without organizing them into empirically derived, interconnected, experiential dimensions within the context of the PLTL. Consequently, the mechanisms through which PLTL can aid learning in conceptually challenging courses like Biochemistry, in particular, are not well delineated.

To improve process-oriented interpretation of PLTL, it is necessary to address this limitation. By defining and empirically analyzing the unique, but interconnected, but interconnected aspects of students' learning experiences in peer-led settings, this study promotes further understanding of how collaborative instructional patterns facilitate academic performance outcomes in science courses in higher education.

II. METHODOLOGY

Research Design

A cross-sectional, explanatory, non-experimental quantitative design was used to investigate the underlying dimensions of the learning experience of students in Peer-Led Team Learning (PLTL) sessions and to assess whether the experiential dimensions significantly predict academic performance in Biochemistry. The data were measured at one point after all the PLTL sessions were completed within the semester.

Participants

The study comprised a total of 92 first-year Bachelor of Science in Nursing students taking biochemistry. The participants ranged from 18 to 41 years (M = 19.09, SD=2.60). The sex distribution included 69 females and 23 males. The respondents were enrolled in five sections, under the researcher's instruction: Brunner (n=26), Doenges (n=20), Kozier (n=15), Pilliteri (n=15), and Suddarth (n=16). The study gathered data from the respondents via the census method. This method is particularly appropriate for the study, considering that all the target participants comprised a small population; thus, a complete enumeration is most feasible. The number is acceptable for the Exploratory Factor Analysis (de Winter et al., 2009) and multiple regression (Green, 1991). Moreover, all participants were selected from the blocks or sections where the PLTL initiative was implemented under the supervision of the researcher. The PLTL was designed, structured, and implemented with uniformity across all classes attended by the participants.

Measures

Students' learning experiences were measured through a validated 69-item questionnaire. The model houses six factors determined through item loadings. All items in the instruments were rated on a 5-point scale (1=Strongly Disagree to 5=Strongly Agree). Factor scores were calculated as the mean of all items loading on each retained factor. The internal consistency reliability of the remaining dimensions was tested with the Omega (ω), which is suited to the congeneric measurement models (Hayes and Coutts, 2020). An Omega (ω) value ranging from .80 or higher

means good reliability (Kline, 2015). The coefficients were .94.94, .89, .89, .82, .88, and .85, for factors 1 to 6, respectively, indicating good to excellent internal consistency. The academic performance of the participants was based on their final semester grades in Biochemistry, which comprised quizzes, class participation, attendance, and major examinations that they had taken throughout the semester.

Research Procedure

The study began with the selection of qualified students to serve as peer leaders and members for each group based on their performance in the Biochemistry course during the first term. The study was conducted for a semester, where the data gathering phase occurred when all the PLTL sessions and grades per term were completed. Prior to the administration of the instrument, the researcher got approval from the school administrator to utilize the students under the researcher's instruction for data collection. Then, the peer leaders coordinated with the members in PLTL groups, relaying the written consent, which was acknowledged and signed by each participant, following the responding to the questionnaire. The data obtained from the survey were organized properly for the extraction of factors, whereas the final semester grades of each participant were also collated as the main basis for their academic performance. The extracted factors were named accordingly, capturing the items' specificity and core defining features, and taken as predictors of the academic performance of the participants.

Data Analysis

The Kaiser-Meyer Olkin (KMO) measure was used to determine sampling adequacy, and the appropriateness of data in factor analysis was determined using the Bartlett test of Sphericity. In order to identify the factor structure of the learning experiences in Peer-Led Team Learning (PLTL), the Exploratory Factor Analysis (EFA) was performed through principal axis factoring with orthogonal varimax rotation. The descriptive statistics were calculated to investigate the distribution of the variables and to verify the conceptual and statistical assumptions of the factors extracted. The internal consistency of the factors was measured through McDonald's Omega (ω) by taking into account the items as congeneric items, that is, they were measured by the same

underlying construct but with different loadings. Pearson correlations were calculated to test the association between the factors and the semester grades of the participants. A multiple regression analysis was conducted to test the predictive relationship of the extracted factors on semester grades, with assumptions of linearity, multicollinearity, independence of errors, and homoscedasticity tested and met.

Ethical Considerations

The study was voluntary, and all participants were informed about their involvement by signing the written consent form before collecting the data. The purpose of the study was clearly explained, and the participants were assured that their responses would remain confidential and would only be used in the research process.

III. RESULTS AND DISCUSSION

Dimensions of Learning Experience in PLTL

Exploratory Factor Analysis (EFA) involving principal axis factoring with orthogonal varimax rotation was applied to determine the latent dimensions of learning experience of students during Peer-Led Team Learning (PLTL) sessions. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was found to be 0.740, and the Test of Sphericity was statistically significant, $\chi^2(2346) = 6151.14$, $p < .001$, which implies that the data were appropriate for factor analysis.

Initial extraction of factors using Kaiser's criterion produced fourteen (14) factors. The eigenvalues beyond 1.0 rule keeps all factors whose eigenvalues are larger than 1.0, retaining only the factors with more variance than any of the variables measured (Zwick & Velicer, 1986). The rotated factor loadings revealed six dimensions that describe the students' experiences in biochemistry under the PLTL initiative. The initial analysis yielded 14 factors with eigenvalues greater than one; however, only six factors were retained. The number of factors to be retained was determined by their comprehensibility and interpretability into the context of the study (Suhr, 2006) and by the rule that a factor must contain at least three items to be considered reliable

(Costello & Osborne, 2005). The final six-factor solution accounted for 48.3% of the total variance in students' learning experiences.

TABLE 1
RETAINED FACTORS OF PLTL LEARNING EXPERIENCE BASED ON ROTATED SOLUTION

Factor	No. of Items	Loading Range	Eigenvalue	Variance Explained (%)	Cumulative Variance (%)
1	12	.428 – .759	30.473	12.7	12.7
2	8	.418 – .702	2.905	9.1	21.8
3	6	.453 – .789	2.614	8.1	29.9
4	4	.439 – .802	2.126	7.0	36.9
5	7	.406 – .663	2.022	6.1	43.0
6	6	.405 – .558	1.802	5.3	48.3

As shown in Table 1, six experiential dimensions of involvement in PLTL sessions were determined. Factor 1, **Using Deep Thinking Through Peer Collaboration**, demonstrates that PLTL encourages more analytical and critical thinking via reflective discussions and shared problem-solving in biochemistry. The peer interaction assists the students in evaluating strengths, tracking progress, building analytical skills, and applying concepts to real-life situations. In general, it underlines that higher-level thinking is the result of collaborative discovery, feedback, and collective problem-solving as opposed to studying in isolation. Some items that capture this experience are:

- PLTL sessions inspire me to explore biochemistry concepts in greater depth through engaging discussions and problem-solving.
- PLTL helps me identify my strengths in biochemistry through group discussions, practice exercises, peer feedback, and self-reflection.
- Through PLTL, I can track my progress in biochemistry by reflecting on my performance in group activities and tasks.

- PLTL makes me confident in using biochemistry knowledge to solve real-life problems and situations.
- PLTL helps prepare me to solve real-world biochemistry problems.

These results suggest that PLTL enhances analytical interaction in biochemistry since students are able to delve into ideas through discussion, reflection, and collective problem-solving with their peers. Studies indicate that higher-order reasoning and conceptual processing can be enhanced in students by providing instruction in a peer-based setting (Tullis & Goldstate, 2020). Peer-collaborative learning has also been shown to be beneficial in strengthening analytical thinking and problem-solving performance, such as in STEM learning settings (Meador et al., 2024).

Factor 2, **Acquired Support for Understanding Through Group Collaboration**, underscores PLTL as an academic and emotional support group. Respectful cooperation enables students to acquire a better understanding, become more confident, and be supported by their peers. Group practice contributes to independent solutions of problems, and shared responsibility creates intellectual support as well as the feeling of belonging. Items that loaded in this factor include:

- PLTL clarifies the biochemistry topics for me.
- PLTL has helped me to understand biochemistry better.
- PLTL makes me feel confident that I will get good grades in biochemistry.
- After PLTL sessions, activities such as practice exercises and reviewing group solutions help me solve difficult biochemistry problems independently.
- My PLTL peers and I respect each other's ideas and contributions, which strengthens our teamwork and learning.
- My PLTL peers help keep me on track academically by encouraging participation and supporting me during group activities.

The findings reveal that PLTL is an academic support model under which the students explain complicated biochemistry and build their confidence with the help of a collective interaction with their peers. It has been demonstrated that peer-assisted learning settings can be

used to improve conceptual knowledge and student interaction in health and science education (Feng et al., 2024). On the same note, peer-led instructional workshops have been linked to better student learning achievements in chemistry courses (Young and Lewis, 2022).

Factor 3, **Building Peer Connections for Collaborative Learning**, embodies the social principles of productive teamwork in PLTL. Participation and engagement are increased by trust, friendship, and positive group relationships. Learning is supported by peer teaching and cooperative problem-solving, which demonstrate that effective interpersonal relationships are the key to long-lasting and valuable learning. Examples of items that loaded in factor 3 include:

- PLTL has helped me build friendships that support my learning and motivate me to engage more in biochemistry.
- I enjoy being in my PLTL group because of the supportive environment and collaborative learning experiences.
- I trust my PLTL group members to provide accurate information during group discussions and problem-solving.
- My PLTL group helps me understand biochemistry concepts through collaborative discussions, peer teaching, and solving problems together.

This aspect implies that PLTL develops meaningful peer relationships that enhance active engagement and participation in collaborative learning activities. Research has also indicated that collaborative learning networks also have a significant role in student engagement and academic participation in higher-education programs (Li et al., 2025). It has also been shown that the quality of interaction with peers is significant to facilitate active engagement in collaborative learning settings (Tang et al., 2025).

Factor 4, **Open Contribution to Group Learning**, attests to the psychological safe and inclusive space of PLTL where students feel at liberty and are inspired to share ideas without risking disapproval. Individualized learning speed and appreciation of contribution is a guarantee that every participant contributes constructively and significantly to the group learning process. Some of the items that loaded into this factor are:

- I am free to express my ideas in PLTL group discussions.

- In PLTL discussions, I am encouraged to share my own ideas and thoughts.
- In PLTL sessions, I can decide on the pace of learning activities based on the group's or my personal needs.
- I feel that I play an important role in my PLTL group by contributing ideas, collaborating on tasks, and supporting my peers.

The results show that PLTL provides a conducive learning atmosphere in which students are motivated to exchange ideas and contribute to discussions within groups. There is evidence indicating that properly supported peer discussions positively impact conceptual learning and ameliorate the quality of classroom dialogue of students (Tang et al., 2026). It has also been revealed that peer-learning contexts tend to promote meaningful learner participation and communication (Avonts et al., 2023).

Factor 5, **Valuing Individual Role in Contributing to Group Learning**, underlines the awareness of students of their significance in the group. Consultation and valuing of contributions enhance accountability, trust, and interest. Teamwork improves performance in exams and strengthens student confidence in their significant contribution to group achievement. Some items that represent this factor are:

- During PLTL sessions, my peers and the PLTL leader consult me about how to approach activities.
- My PLTL group values my contributions, such as sharing ideas, explaining concepts, and offering solutions during group tasks.
- PLTL sessions make me feel better prepared for exams by practicing challenging problems.
- Through PLTL, activities such as solving problems with my group and reviewing solutions have increased my confidence in biochemistry.
- I enjoy working with my PLTL group on challenging assignments that require collaborative problem-solving.

This aspect underscores the way in which PLTL promotes the realization of the value attached to individual input among students engaged in learning processes in groups. Research has proved that peer-support systems enhance motivation, accountability, and commitment among group students (Parmar et al., 2025). Another finding emphasizes that peer-teaching experiences were linked with augmented confidence and collaborative problem-solving skills among students (Yang et al., 2022).

Factor 6, **Self-Directed Learning in Group Tasks**, shows how PLTL promotes autonomy in teamwork. Students can formulate goals, select strategies of learning, and make contributions in a flexible manner and think independently with the advantage of the group interaction. This self-guided involvement helps in the understanding of concepts as well as attainment of individual academic objectives in biochemistry. The items that loaded in this factor comprise:

- PLTL sessions allow me to choose learning approaches that work for me.
- During PLTL sessions, I'm free to set personal learning goals.
- In PLTL, I have the freedom to decide how I contribute to group work, such as suggesting solutions, sharing ideas, or supporting my peers.
- In PLTL group settings, I am free to think independently.
- PLTL helps me achieve my academic goals in biochemistry by improving my understanding and application of concepts.

The results suggest that the concept of Peer-Led Team Learning (PLTL) contributes to self-directed learning, which allows students to set goals, choose the right learning approaches, and participate independently in group processes. Studies have proved the benefits of peer-based learning in which shared leadership positively contributes to the development of autonomy and self-directed learning among students (Gürbüz et al., 2026). Embedded academic support within collaborative learning settings has also been related to greater levels of academic self-efficacy and regulation of learning in students (Xu, 2024).

Taken together, these findings indicate that the cognitive engagement, peer-assisted understanding, active and valued participation, social connectedness, and self-regulated

participation in collaborative learning activities in PLTL sessions are multidimensional learning experiences of students.

Prediction of Academic Performance by PLTL Learning Experiences

Pearson correlation analysis showed that all six dimensions of the experiences positively and significantly correlated with semester grades (r = .25–.38, p < .01), indicating that higher engagement in the process of collaborative learning with peers relates to higher academic performance in Biochemistry.

A multiple regression analysis was performed to ascertain the degree to which the identified dimensions of the PLTL learning experience predicted academic performance. Linearity, independence of the residuals, homoscedasticity, and multicollinearity assumptions were assessed and satisfied. The Durbin-Watson statistic (2.20) suggested independence of residuals, and no undesirable multicollinearity was found.

TABLE 2
MULTIPLE REGRESSION RESULTS FOR FACTORS PREDICTING SEMESTER GRADES

Predictor	*B*	*SE B*	*t*	*p*	95% CI
Factor 1	-0.19	2.02	-0.10	.94	[-4.20, 3.82]
Factor 2	-0.24	2.25	-0.11	.91	[-4.71, 4.23]
Factor 3	0.38	1.91	0.20	.84	[-3.41, 4.17]
Factor 4	2.98	1.56	1.91	.06	[-0.12, 6.08]
Factor 5	0.22	2.11	0.11	.92	[-3.97, 4.41]
Factor 6	2.15	2.18	0.98	.33	[-2.19, 6.48]

The entire regression model was found to be significant, $F(6, 85) = 2.71$, $p = .02$, adjusted R^2 of .10, which showed that the six dimensions of the experience in their combination significantly explained the variance in the semester grades by about 10 percent. Nevertheless, there were no statistically significant unique effects of any of the individual predictors since all the confidence intervals had zero as the endpoint. Factor 4 (Open Contribution to Group Learning) did

not reach the level of statistical significance, even though it gave the biggest positive coefficient. These findings indicate that the PLTL dimensions work together and not as autonomous predictors of academic performance.

This small percentage of explained variance also suggests that the relationship between PLTL experiences and semester grades is indirect or, at most, distant. Rather than having direct performance implications, peer collaboration, perceived support, active participation, and self-regulation may influence academic outcomes indirectly via more proximate mechanisms, such as learning motivation, engagement, and self-efficacy. This interpretation is consistent with empirical evidence. Indirect effects through motivation and engagement on academic achievement have been observed (Shao et al., 2024), instructional support has been linked to higher performance through academic self-efficacy (Xu, 2024), and peer-assisted learning environments have been identified to have stronger collaborative competence and engagement, in spite of no immediate gains in grades (Ahmed and Haji, 2022). When combined, these results provide evidence that the PLTL effect on achievement is probably mediated by psychological and behavioral actions and not necessarily indicated directly by grade effects.

IV. CONCLUSION

The study investigated the learning experience of first-year nursing students in Peer-Led Team Learning (PLTL) in Biochemistry and how the experience relates to academic performance. A structure that appeared to be six-factor emerged, which showed deep peer-supported thinking, acquired support, peer connection, open participation, valued individual contribution, and self-directed engagement. These aspects indicate that PLTL is a complex process, which has cognitive, social, and self-regulatory components instead of a unitary instructional outcome. The six dimensions were correlated positively with semester grades, but none of them were independent predictors in the regression model. This implies that the combined and interactive effect of these experiential processes is linked to academic outcomes. The small proportion of variance also indicates that there may be an indirect and distal relationship in which PLTL influences motivational, cognitive, and relationship processes that consequently mediate academic functioning and not grades directly.

The relevance of this study lies in contributing to the process-oriented conceptualization of PLTL. Rather than using the observable grade results to gauge PLTL, the study determines the internal experiential facets upon which the peer-led instruction operates. The empirical evidence of the study that PLTL works in the context of interrelated cognitive involvement, social bonding, and independent involvement offers a better conceptualization of the role of collaborative instructional methods in student development in higher education. This view is especially applicable in the context of science education, in which the complexity of the concepts needed and necessitated by the learning process not only implies the content but also long-term engagement, confidence, and collaborative learning.

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