





Developing and Validating an Instrument to Measure Students' Experiences in a Further Mathematics Classroom

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ABSTRACT

The purpose of this study was to develop an instrument for measuring students' perception of teaching and learning variables in a Further Mathematics classroom with high psychometric properties of internal-consistency reliability and construct validity. A survey research design was used involving 318 students randomly selected from senior high schools. Enhancing Teaching and Learning Questionnaire (ETLQ) was used to solicit students' responses on the issues they experienced during lessons for Further Mathematics. Principal component factor analysis with Promax as an oblique rotation and using a factor loading of 0.40 as a cut-off was further conducted on the data to record a more accurate representation of the relationship among the factors to establish the construct validity and the internal reliability of the instrument. The 26 items resulted in a four-factor solution produced based on the parallel analysis. The four factors together accounted for a total of 54.543% of the variance. The Cronbach's alpha of the reduced 26 items is equal to 0.806. The subscales had acceptable internal consistency, as Cronbach's alpha ranges from 0.696-0.893. The study reliability coefficient is high. The instrument will be useful for mathematics educators and researchers in Ghana and the world at large for measuring students' perceptions of teaching and learning variables in a classroom. And the study recommends this instrument for use to measure the experiences of senior high school students in the classrooms.

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INTRODUCTION

Mathematics and mathematical modelling-teaching strategy is an innovative strategy, which enhances collaboration between students by granting them an opportunity to communicate and debate to generate new knowledge.¹ However, students over the years have demonstrated weakness in their attempt to solve Further Mathematics related problems as they sit for the West African Senior School Certificate Examination (WASSCE). Learning this subject is difficult for most students as they have

¹ Omprakash Mishra, "Mathematical Modelling - An Effective Method for Making Mathematics Learning Joyful At Lower Secondary Level," *IOSR Journal of Research & Method in Education (IOSRJME)* 07, no. 01 (January 2017): 44–50, <https://doi.org/10.9790/7388-0701034450>.

developed several misconceptions with regard to the difficulty of the subject. The misconceptions stem from the fact that Further Mathematics has highly inherent ideas and requires enormous processes, hence, students often encounter difficulties and commit errors when solving Mathematics related problems.² Also, teaching methods have not been effective due to the problem that both the teacher and students encounter during teaching and learning the subject. Bressoud et al. have maintained that some mathematics teachers think that mathematics is just a set of rules and procedures to be memorised and applied in routine tasks which prove to be a challenge when teaching and studying the subject.³

The Ghana Education Service has as one of its objectives to improve the quality of teaching and learning. Students and teachers' experiences of the teaching and learning environment can help provide possible solutions. For a complex field like teaching and learning mathematics, where there are interconnectedness of variables, instruments need to be robust to capture if not all, most aspects of the teaching and learning process. Meanwhile, a review of the literature revealed that not enough studies have validated and used ETLQ instrument for measuring senior high school students' experiences. To determine the categories that constitute senior high students' mathematics experiences in a further mathematics classroom, it is prudent to develop an instrument that will be geared at providing objective data from classroom variables. Sophisticated statistical tools will be required to analyse indigenous data generated from our students.

Therefore, the purpose of this study was to develop a tool to measure students' perception of teaching and learning variables in a Further Mathematics classroom with high psychometric properties of internal-consistency reliability and construct validity using the ETLQ. The study participants included 318 students from four different schools in a school district in Sagnarigu Municipality in the Northern Region of Ghana.

LITERATURE REVIEW

Recent studies have examined students' classroom experiences of teaching and learning in various subjects and have used questionnaires from the ETLQ.⁴ Teaching and learning environments instrument calls for a more concise instrument that could capture latent construct(s) of students' experiences of classroom variables.⁵

To collect valid data from Iranian nursing students, a study was conducted using the modified ETLQ.⁶ The result of the study recorded a Cronbach's alpha equal to 0.944 and a test-retest results equal to 0.88.⁷ The internal consistency evaluation for each of the three sections and seven factors of the questionnaire, Cronbach's alpha, was in the range of 0.756—0.942, which further supported their conclusion that the subscales possessed the necessary reliability.⁸ Also, the p-value 0.05 indicated the

² Nguyen Phu Loc, Tran Cong, and Thai Hoc, "A Survey Of 12 Th Grade Students' Errors In Solving Calculus Problems," *International Journal of Science & Technology Research* 3, no. 6 (2014): 1–2, www.ijstr.org.

³ David Bressoud et al., *Teaching and Learning of Calculus* (Cham: Springer International Publishing, 2016), <https://doi.org/10.1007/978-3-319-32975-8>.

⁴ Kim Jesper Herrmann, Anna Bager-Elsborg, and Anna Parpala, "Measuring Perceptions of the Learning Environment and Approaches to Learning: Validation of the Learn Questionnaire," *Scandinavian Journal of Educational Research* 61, no. 5 (September 3, 2017): 526–39, <https://doi.org/10.1080/00313831.2016.1172497>; Anna Parpala and Sari Lindblom-Ylänne, "Using a Research Instrument for Developing Quality at the University," *Quality in Higher Education* 18, no. 3 (November 16, 2012): 313–28, <https://doi.org/10.1080/13538322.2012.733493>; John Richardson, "Critical Synthesis Package: Experiences of Teaching and Learning Questionnaire (ETLQ)," *MedEdPORTAL*, August 1, 2014, https://doi.org/10.15766/mep_2374-8265.9857.

⁵ K. A. Tymruk- Skoropad, L M Tsizh, and Iuliia Pavlova, "Evaluating the Quality of Teaching and Education in Students of Specialty Physical Therapy, Occupational Therapy: Adaptation of the Ukrainian Version of the Questionnaire K. ETLQ," *Art of Medicine*, 2021; Anna Parpala et al., "Assessing Students' Experiences of Teaching–Learning Environments and Approaches to Learning: Validation of a Questionnaire in Different Countries and Varying Contexts," *Learning Environments Research* 16, no. 2 (July 10, 2013): 201–15, <https://doi.org/10.1007/s10984-013-9128-8>.

⁶ Mohammadali Hosseini, Amir Jalali, and Nader Salari, "Assessment of Psychometric Properties of the Modified Experiences of Teaching–Learning Questionnaire in Iranian Nursing Students," *BMC Medical Education* 22, no. 1 (December 25, 2022): 314, <https://doi.org/10.1186/s12909-022-03365-z>.

⁷ Hosseini, Jalali, and Salari, "Assessment of Psychometric Properties of the Modified..."

⁸ Hosseini, Jalali, and Salari, "Assessment of Psychometric Properties of the Modified..."

association between the variables. The tool was eventually recommended to measure the teaching and learning experience of nursing students because it “had acceptable and applied indices.”⁹ Another study conducted showed evidence of broadly satisfactory results concerning reliability and construct validity from bioscience students’ data on their teaching and learning experience.¹⁰ From these study results, it was found that the ETLQ produced values of Cronbach’s alpha between .73 and .84, and a factor analysis yielded four factors that 4 explained 47% of the variance.¹¹ Using a total of 2027 university students, an instrument was validated to measure the Learning Experiences of university students and recorded a Cronbach's Alpha =0.957 with 32 numbers of items.¹²

The Teaching and Learning Experience Questionnaire (ETLQ) questionnaire was validated in the Peruvian context with universities in 2022.¹³ The Cronbach's Alpha of 0.957 with 32 items was appropriate for its intended usage and may be used to assess university students' learning experiences.¹⁴

The ETLQ tool is a valuable instrument that can be used across cultures and different contexts to provide valuable information about the quality of teaching and learning.¹⁵ In Ghana, the revised version of the ETLQ instrument is to investigate the perception of tertiary students' approaches to teaching, and how this is influenced by the different dimensions of teaching and learning environments.¹⁶ It generated data from 245 students of the Kumasi Campus of the University of Education (currently referred to as AAMUSTED) and was able to demonstrate that the Enhanced Teaching and Learning (ETL) instruments can be applied in Ghana.

Meanwhile, a review of the literature above revealed that not enough studies have validated the use of the ETLQ instrument for measuring Ghanaian senior high school students’ experiences. To determine the categories that constitute senior high students’ mathematics experiences in a further mathematics classroom, it is prudent to develop an instrument that will be geared at providing objective data from classroom variables. sophisticated statistical tools will be required to analyse indigenous data generated from student respondents.

METHODOLOGY

This survey research was part of a sequential mixed-method study which described the experiences of teachers and students during the teaching and learning of further Mathematics as a subject in Senior High School within the context of what is undesirable in the Further Mathematics Curriculum.

The choice of student sample is significant to the study because students had formed a set of experiences during Further Mathematics teaching and learning in the classroom. Also, the performances of students in Further Mathematics in the final WASSCE in Further Mathematics will determine their chances of offering key courses at the tertiary level.

The student participants (N=318) were from fifteen classrooms from four different schools in a school district in Sagnarigu Municipality in the Northern Region. All schools are located in an urban centre (population 160,000) located within fifteen minutes drive of each school in the study. The SHSs used in this study have both boarding and day students. Tamale Senior High School (TAMASCO) has

⁹ Hosseini, Jalali, and Salari, “Assessment of Psychometric Properties of the Modified...”

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¹¹ Hosseini, Jalali, and Salari, “Assessment of Psychometric Properties of the Modified...”

¹² Yersi-Luis Huamán Román et al., “University Students’ Learning Experiences in the Virtual Environment,” *International Journal of Emerging Technology and Advanced Engineering* 12, no. 5 (May 1, 2022): 88–95, https://doi.org/10.46338/ijetae0522_10.

¹³ Román et al, “University Students’ Learning Experiences in the Virtual Environment.”

¹⁴ Román et al, “University Students’ Learning Experiences in the Virtual Environment.”

¹⁵ María-Elena Parra-González et al., “Spanish Adaptation and Validation of the Teaching and Learning Experiences Questionnaire,” *International Journal of Environmental Research and Public Health* 18, no. 7 (March 29, 2021): 3518, <https://doi.org/10.3390/ijerph18073518>.

¹⁶ Faisal Iddris and Ahmed Musa, “The Perception of Ghanaian Students on Teaching and Learning at The College of Technology Education, University of Education Winneba,” *International Journal of Educational Leadership (IJEL)* 6, no. 1 (2016): 163–71.

a population of about 2,800 and both Northern School of Business (NOBISCO) and Business Senior High School (BISCO), have about 2,600 each.

The aspect of ETLQ measuring students' experiences of teaching and learning was adapted for the study. The ETLQ questionnaire was designed and could be used for most subject areas and some items of the original questionnaires were reworded to bring to the context the teaching and learning of SHS Further Mathematics. The questionnaire had forty-nine (49) statements which were positively worded and covered teaching and learning variables of clear aims and organization, alignment and integration, teaching for understanding, choice, interest, enjoyment and relevance, staff enthusiasm and support, support from other students, assessment for understanding and guidance and feedback on assessment. The possible answers were 'Strongly agree', 'agree', 'neutral', 'disagree', and 'Strongly disagree,' rated respectively as 5, 4, 3, 2 and 1 points.

The researcher obtained a list of all final year Further Mathematics teachers from the heads of departments of mathematics at the various study centres. There were fifteen (15) teachers on the list and all of them were invited to participate and they all agreed. A paper questionnaire was administered to students and collected on the spot. This questionnaire collected students' responses on the bio-data-gender, age and program of study. Part II of the survey had a positive statement with a five-point Likert under the themes, Further Mathematics organisation and structure, teaching and learning, teacher and students support and assessment and other work. Student participants were told to tick the questionnaires carefully and objectively.

RESULTS AND DISCUSSIONS

SPSS (version 23) was used to analyse students' questionnaire data. Students' questionnaire responses were coded as 5 for strongly agree, 4 for agree, 3 for neutral, 2 for disagree and 1 for strongly disagree. These codes were entered into SPSS software. Principal component factor analysis with Promax as an oblique rotation and a factor loading of 0.40 as a cut-off were further conducted on the data to record a more accurate representation of the relationship among the factors and to check on the construct validity and the internal reliability of the instrument.

RESULTS

Principal components analysis (PCA)

SPSS allows Direct Oblimin as an oblique rotation to reveal whether the items correlate or not and so an initial factor analysis using Direct Oblimin as an oblique rotation was carried out. Principal component analysis with Direct Oblimin as an oblique rotation was conducted with the 32 items from the questionnaire to reproduce a data structure.

The communalities output brings to bear the relationship between the items and the component that emerges in the analyses. While all the initial extracted total variance was set at 1 as in the case of principal component analyses, the second column show that all items (except item 7 and 10) had extraction point greater than 0.3. Items 7 and 10 of the original questionnaires had loading greater and equal to .9, as a result, the First-factor analysis did not show outputs for KMO and Bartlett's Test. Therefore, items 7 and 10 were removed from further analysis.

A second principal component analysis with Direct Oblimin as an oblique rotation was conducted with the 30 items from the questionnaire to reproduce a data structure.

The overall determined value of Determinant = 4.53 from the correlation matrix was larger than 0.0001, indicating that the correlation is pretty fine and that items correlate sufficiently. This served as the first piece of evidence and can be used for factor analyses.

Also, the reliability of factor analyses depends on the sample size, checking sample size before running factor analyses is important. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was .939 greater than 0.5 and Bartlett's Test of Sphericity of sig value of 0.000 less than 0.05 is statistically

significant. This shows that the sample data satisfied the conditions for factor analysis after EFA was carried out and matched with the assumption of EFA on sample size.¹⁷

In line with the assumptions that to run an EFA, there should be at least one significant correlation between two of the items, the study results passed the minimum requirement of getting at least one correlation between the values somewhere in the data because the component correlation matrix results revealed that items had scores greater than 0.32. As the result from the component correlation matrix show basically that at least there is one significant correlation between two of the items somewhere in the data, the study settled on the usage of oblique rotation for the analysis.¹⁸

From the total variance explained output, the second principal component analysis with Direct Oblimin, a 5-factor solution was produced based on eigenvalues because it supports the existence of various factors compared to the scree plot. The 5-factors together accounted for a total of 57.254% of the variance.

Parallel analysis

Promax as an oblique rotation and the use of a factor loading of 0.40 as a cut-off was further conducted on the data to record a more accurate representation of the relationship among the factors. The table below shows a principal component factor analysis conducted. Cross-loaded items were removed and a principal component analysis with Promax on the 26 items resulted in a four-factor solution produced based on the parallel analysis. The four factors together accounted for a total of 54.543% of the variance.

The results of a principal component factor analyses all the *ETLQ* items relating to students’ perceptions of the Further Mathematics teaching-learning environment. This analysis is based on a sample of three hundred and eighteen (318) students from the earlier and later years of degree programs in the three program areas involved in the study.

Table 1. Pattern matrix of the loadings for the four-factor solution for the 26 items describing teaching and learning experiences

		Component			
		1	2	3	4
FACTOR 1 Cronbach's Alpha .893					
Q39	Guidance to make connections to my existing knowledge.	0.84			
Q40	The feedback given on my set work helped to clarify	0.71			
Q29	I found I could generally work comfortably with other students	0.71			
Q30	Plenty of opportunities for me to discuss important ideas	0.64			
Q26	I enjoyed being involved in Further Mathematics teaching.	0.63			
Q32	I was encouraged to think about how best to tackle the set work.	0.60			
Q33	Set work fitted in with what we were supposed to learn.	0.59			
Q35	Feedback helped me to improve my ways of learning and studying.	0.54			
Q28	Teacher helped us to see, think and reach conclusions in this subject.	0.51			
Q31	It was clear to me what was expected in the assessed work	0.43			

¹⁷ Yusuf F. Zakariya, “Development of Attitudes towards Mathematics Scale (ATMS) Using Nigerian Data - Factor Analysis as a Determinant of Attitude Subcategories.,” *International Journal of Progressive Education* 13, no. 2 (2017): 74–84.

¹⁸ Janet Krska, Barbra Katusiime, and Sarah Corlett, “Validation of an Instrument to Measure Patients’ Experiences of Medicine Use: The Living with Medicines Questionnaire,” *Patient Preference and Adherence* Volume 11 (March 2017): 671–79, <https://doi.org/10.2147/PPA.S126647>.

Q22	I found most of what I learned really interesting.	0.42			
FACTOR 2 Cronbach's Alpha.845					
Q3	We were given a good deal of choice over how we went about learning		0.78		
Q1	It was clear to me what I was supposed to learn.		0.76		
Q2	Topics seemed to follow each other in a way that made sense to me		0.71		
Q4	Topic was well organised and ran smoothly		0.63		
Q25	Teachers were patient in explaining things		0.47		
Q10	I was prompted to think about how well I was learning.		0.46		
FACTOR 3 Cronbach's Alpha.790					
Q21	Students supported each other when it was needed.			0.89	
Q24	Talking with other students helped me to develop my understanding.			0.66	
Q15	Plenty of examples and illustrations help us to grasp things better.			0.65	
Q9	The textbook and other materials helped me to understand the unit.			0.56	
Q13	Teaching encouraged me to rethink my understanding of the subject			0.53	
FACTOR4 Cronbach's Alpha.696					
Q11	I could see the relevance of most of what we were taught				0.63
Q19	Teaching encouraged me to relate to issues in the world.				0.57
Q14	The different types of teaching supported each other well.				0.56
Q23	Staff tried to share their enthusiasm about the subject with us.				0.46

From Table 1, Loading in factor 1 includes four items on guidance and feedback on assessment, three items on Staff enthusiasm and support, two item for both teaching and assessment for understanding (one each), two items on Interest, enjoyment, and relevance and an item on Support from another student. In all, the 12-item loaded in factor 1 depicts some elements of classroom interactions. Whiles item loading from Teaching and assessment for understanding, Staff enthusiasm and support and Interest, enjoyment and relevance define teacher roles in the classroom, interaction is also viewed within the classroom measure as support from other students and teaching for understanding.

Learning deals with items relating to students' interests, enjoyment and the relevance of a topic. The combination of classroom measures of teachers' roles, interaction, learning and constructive feedback relates to classroom interactions. Eight items loaded in factor 2 of which two items each belong to the categories of support from other students, teaching for understanding, interest, enjoyment and relevance and teaching for understanding. Construct in Support from other students and teaching for understanding depict students' roles whiles learning among students occurs with respect to statements from interest, enjoyment and relevance.

In the measure of alignment and integration in the classroom, whiles repetitive ideas are eliminated, the interconnectivity of concepts is demonstrated to help students see and understand the various concepts. The combination of measures of support from other students, teaching for understanding, interest, enjoyment and relevance and teaching for understanding supports features of constructive alignment in the teaching and learning process.

Factor 3 had six items loading of which three items are from the subscale category of clear, aim, and organisation and one item each from teaching for understanding, assessment for understanding and the choice students have on learning processes. Through the combination of loading from these three constructs, Factor 3 was named problem-based learning in the Further Mathematics

classroom. The items were all geared towards enhancing students learning of concepts as opposed to the direct presentation of principles and facts.

Three items were loaded in Factor 3 of which two items originated from the subscale of interest, enjoyment and relevance and one item from staff enthusiasm and support. All of this construct reveals the roles of the teacher.

To measure the experiences of students in the further mathematics classroom, ETLQ was adapted and validated to achieve this objective. The study results showed that the objective was achieved due to the statistical method employed, which led to the modification of the original version of the instrument, using principal component Factor analysis.

The classroom learning environment has lots of learning variables. These learning variables can be classified as desirable and undesirable depending on the context of the study environment. The undesirable learning environment causes certain teaching and learning challenges, which impede smooth teaching and learning in the classroom, and these teaching challenges pose lots of effects on teaching outcomes. Several studies have proposed the use of student evaluation of the teaching and learning environment to help remedy these problems.¹⁹ Teaching models within a subject area about a learning environment in a particular context can be implemented in a different context with similar characteristics of students to generate experiences within a learning environment.²⁰ Hence, the adaptation of previously designed tools in a particular context is important and can be implemented in a different context for the collection of data using scientific procedures to inform best learning practices.

Several studies have adapted the ETLQ to different countries and institutions using sophisticated statistical procedures, and in using these statistical procedures several versions of the ETLQ tools have been produced with varying numbers and length with regards to its appearance different from the original version.²¹

In this study, the ETLQ component measuring students' experiences with teaching and learning was modified. A principal component analysis with Promax on the 26 items resulted in a four-factor solution produced based on the parallel analysis. The four factors together accounted for a total of 54.543% of the variance. The validated instrument enabled students to evaluate their classroom teaching and learning of Further Mathematics and similar to the ones reported in various studies.²²

Internal-Consistency Reliability and Construct Validity

The process adopted to establish the internal consistency reliability and validity of constructs determined the following measures; Cronbach's alpha, Inter-item Correlation and Item-total correlation.²³ The Cronbach's alpha of the reduced 26 items is equal to $0.806 > 0.7$, then it can be concluded that the scale used to measure the 26 items measuring students' experience of teaching and

¹⁹ Skoropad, Tsizh, and Pavlova, "Evaluating the Quality of Teaching and Education in Students of Specialty Physical Therapy, Occupational Therapy: Adaptation of the Ukrainian Version of the Questionnaire K. ETLQ"; Parpala and Lindblom-Ylänne, "Using a Research Instrument for Developing Quality at the University"; Parpala et al., "Assessing Students' Experiences of Teaching-Learning Environments and Approaches to Learning: Validation of a Questionnaire in Different Countries and Varying Contexts."

²⁰ Parra-González et al., "Spanish Adaptation and Validation of the Teaching and Learning Experiences Questionnaire."

²¹ Parpala and Lindblom-Ylänne, "Using a Research Instrument for Developing Quality at the University"; Parpala et al., "Assessing Students' Experiences of Teaching-Learning Environments and Approaches to Learning..."

²² Herrmann, Bager-Elsborg, and Parpala, "Measuring Perceptions of the Learning Environment and Approaches to Learning: Validation of the Learn Questionnaire"; Parpala and Lindblom-Ylänne, "Using a Research Instrument for Developing Quality at the University"; Richardson, "Critical Synthesis Package: Experiences of Teaching and Learning Questionnaire (ETLQ)"; Skoropad, Tsizh, and Pavlova, "Evaluating the Quality of Teaching and Education in Students of Specialty Physical Therapy, Occupational Therapy: Adaptation of the Ukrainian Version of the Questionnaire K. ETLQ"; Parpala et al., "Assessing Students' Experiences of Teaching-Learning Environments and Approaches to Learning: Validation of a Questionnaire in Different Countries and Varying Contexts."

²³ S. T. Hajjar, "Statistical analysis: internal-consistency reliability and construct validity." *International Journal of Quantitative and Qualitative Research Methods*, 6(1), (2018): 46-57.

learning further mathematics is reliable. The study reliability coefficient is high and similar to the ones reported in the following study.²⁴

Table 2. Inter-Item Correlation Matrix

	Factor 4	Factor 3	Factor 2	Factor 1
Factor 4	1.000	.585	.568	.580
Factor 3	.585	1.000	.549	.547
Factor 2	.568	.549	1.000	.723
Factor 1	.580	.547	.723	1.000

Table 2 indicates that internal consistency values with respect to item-to-item correlation were more than 0.3 and lie within 0.50 and 1. This result indicates a strong correlation hence the construct validity is satisfied.²⁵

Table 3. Item-total correlation.

	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Factor 4	.672	.821
Factor 3	.645	.832
Factor 2	.726	.798
Factor 1	.736	.793

Item-Total correlation: An acceptable value should be > 0.50

Table 2 highlights the column containing the “Corrected Item – Total Correlation” for each of the four factors. This column displays the correlation between a given factor and the sum score of the other three items which are all greater than 0.500. This means that there is a strong and positive correlation between the scores of each factor and the combined score of the other three factors²⁶ and that all factors appear to be useful and contribute to the overall reliability of the ETLQ as seen in Cronbach’s Alpha if the item is deleted in the column.²⁷

SUMMARY

This survey research was a component of a mixed-method study that discussed what is undesirable in the Further Mathematics Curriculum about the experiences of teachers and students during the teaching and learning of further mathematics as a subject in Senior High School.

For the study, the ETLQ component measuring students' experiences with teaching and learning was modified. To record a more precise depiction of the relationship between the variables, a principal component factor analysis using Promax as an oblique rotation was performed on the data. A principal component analysis with Promax on the 26 items resulted in a four-factor solution produced based on the parallel analysis. The four factors together accounted for a total of 54.543% of the variance.

Cronbach's alpha, inter-item correlation, and item-total correlation were established as part of the procedure used to establish the internal consistency, reliability, and validity of constructs. The 26 items that were reduced had a Cronbach's alpha of 0.806. In terms of item-to-item correlation, the internal consistency values were more than 0.3. There is a strong, positive correlation between the scores on each factor and the combined score of the other three factors.¹²

The study reliability coefficient was high and similar to the ones reported in the following studies. Even though the reliability coefficient of the study proved inferior to the ones reported in the studies of Hosseini, Jalali & Salari and Pino, Huamán-Romaní, Juárez-Pulache, Carrillo-Riveros &

²⁴ Parpala and Lindblom-Ylänne, “Using a Research Instrument for Developing Quality at the University.”

²⁵ Iddris and Musa, “The Perception of Ghanaian Students on Teaching and Learning ...”

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Cruz-Girón the differences in Cronbach alpha values could be attributed to study samples, as larger samples produce higher Cronbach alpha values, as seen in these studies.²⁸

CONCLUSION

The goal of this study was to create an instrument with high psychometric properties of internal-consistency reliability and construct validity for measuring students' perceptions of teaching and learning variables in a further mathematics classroom. The student participants (N = 318) were from fifteen classrooms from four different schools in a school district in Sagnarigu Municipality. The Cronbach's alpha of our instrument was $0.806 > 0.7$. The subscales had acceptable internal consistency, as Cronbach's alpha ranges from 0.696-0.893.

The study created a new instrument with high psychometric properties of internal-consistency reliability and construct validity for measuring students' perceptions of teaching and learning variables in a further mathematics classroom. The instrument will be useful for mathematics educators and researchers in Ghana and the world at large even though the data for the study was drawn from senior high school students in the Sagnarigu municipality in the Northern region. The study further recommends this instrument for use to measure the experiences of senior high school mathematics classrooms.

BIBLIOGRAPHY

- Bressoud, David, Imène Ghedamsi, Victor Martinez-Luaces, and Günter Törner. *Teaching and Learning of Calculus*. Cham: Springer International Publishing, 2016.
<https://doi.org/10.1007/978-3-319-32975-8>.
- Herrmann, Kim Jesper, Anna Bager-Elsborg, and Anna Parpala. "Measuring Perceptions of the Learning Environment and Approaches to Learning: Validation of the Learn Questionnaire." *Scandinavian Journal of Educational Research* 61, no. 5 (September 3, 2017): 526–39.
<https://doi.org/10.1080/00313831.2016.1172497>.
- Hosseini, Mohammadali, Amir Jalali, and Nader Salari. "Assessment of Psychometric Properties of the Modified Experiences of Teaching–Learning Questionnaire in Iranian Nursing Students." *BMC Medical Education* 22, no. 1 (December 25, 2022): 314. <https://doi.org/10.1186/s12909-022-03365-z>.
- Iddris, Faisal, and Ahmed Musa. "The Perception of Ghanaian Students on Teaching and Learning at The College of Technology Education, University of Education Winneba." *International Journal of Educational Leadership (IJEL)* 6, no. 1 (2016): 163–71.
- Krska, Janet, Barbra Katusiime, and Sarah Corlett. "Validation of an Instrument to Measure Patients' Experiences of Medicine Use: The Living with Medicines Questionnaire." *Patient Preference and Adherence* Volume 11 (March 2017): 671–79.
<https://doi.org/10.2147/PPA.S126647>.
- Loc, Nguyen Phu, Tran Cong, and Thai Hoc. "A Survey Of 12 Th Grade Students' Errors In Solving Calculus Problems." *International Journal of Science & Technology Research* 3, no. 6 (2014): 1–2. www.ijstr.org.
- Mishra, Omprakash. "Mathematical Modelling - An Effective Method for Making Mathematics Learning Joyful At Lower Secondary Level." *IOSR Journal of Research & Method in Education (IOSRJRME)* 07, no. 01 (January 2017): 44–50. <https://doi.org/10.9790/7388-0701034450>.
- Parpala, Anna, and Sari Lindblom-Ylänne. "Using a Research Instrument for Developing Quality at the University." *Quality in Higher Education* 18, no. 3 (November 16, 2012): 313–28.
<https://doi.org/10.1080/13538322.2012.733493>.
- Parpala, Anna, Sari Lindblom-Ylänne, Erkki Komulainen, and Noel Entwistle. "Assessing Students'

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Experiences of Teaching–Learning Environments and Approaches to Learning: Validation of a Questionnaire in Different Countries and Varying Contexts.” *Learning Environments Research* 16, no. 2 (July 10, 2013): 201–15. <https://doi.org/10.1007/s10984-013-9128-8>.

Parra-González, María-Elena, Jesús López-Belmonte, Adrián Segura-Robles, and Antonio-José Moreno-Guerrero. “Spanish Adaptation and Validation of the Teaching and Learning Experiences Questionnaire.” *International Journal of Environmental Research and Public Health* 18, no. 7 (March 29, 2021): 3518. <https://doi.org/10.3390/ijerph18073518>.

Richardson, John. “Critical Synthesis Package: Experiences of Teaching and Learning Questionnaire (ETLQ).” *MedEdPORTAL*, August 1, 2014. https://doi.org/10.15766/mep_2374-8265.9857.

Romaní, Yersi-Luis Huamán, José-Carlos Juárez Pulache, Neisser Pino Romero, Elinar Carrillo Riveros, and Kevin-Arnold De la Cruz Girón. “University Students’ Learning Experiences in the Virtual Environment.” *International Journal of Emerging Technology and Advanced Engineering* 12, no. 5 (May 1, 2022): 88–95. https://doi.org/10.46338/ijetae0522_10.

Skoropad, K A Tymruk-, L M Tsizh, and Iuliia Pavlova. “Evaluating the Quality of Teaching and Education in Students of Specialty Physical Therapy, Occupational Therapy: Adaptation of the Ukrainian Version of the Questionnaire K. ETLQ.” *Art of Medicine*, 2021.

Zakariya, Yusuf F. “Development of Attitudes towards Mathematics Scale (ATMS) Using Nigerian Data - Factor Analysis as a Determinant of Attitude Subcategories.” *International Journal of Progressive Education* 13, no. 2 (2017): 74–84.

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