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Exploratory and Confirmatory Factor Analysis of Student Teacher Evaluation Questionnaire (STEQ) for Teacher

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Abstract

Philippines currently facing a learning crisis in the K to 12 evaluations. With exploratory and confirmatory factor analysis, this study developed a teacher evaluation questionnaire for effective teaching mathematics. Participants are coming from math teachers (N1 = 65), students (N2 = 76), principals and math supervisors (N3 = 61). Exploratory factor Analysis identified 15 factors. Multiple factor characteristics and literature provides support for 61 items on 15 factors. Confirmatory factor analysis, using the second sample (N=202), examined the 15-factor model identified from the exploratory factor analysis. Fit indices were used to evaluate the model fit, and these indices were able to identify the seven most fit factors. The Cronbach alpha coefficient is (0.903) excellent from the third sample (N=71). These analyses provide support for the seven-factor structure of the final 17-items STEQ, which will serve as a valuable classroom teacher evaluation tool for both supervisors and researchers to assess teachers teaching effectiveness in the Southern part of Mindanao. It is recommended to utilize the STEQ to determine effective teachers in teaching mathematics to elevate the numeracy performance of the country.

Keywords

Teachers' evaluation tool, questionnaire, factor analysis, Soccsksargen Region, EFA and CFA, STEQ

1. Introduction

According to population world review, the IQ of the Filipino majority is below average (IQ=81.64) and it declines over time. The Philippines National achievement test (NAT) mirrors the educational challenges of the nation. Reading performance of learners at grade five majority pupil is at the first years of primary schooling. Only 27% of the students are still at the level where they can only pair single words at an image of a familiar object while 29% are on their level while 1% has the ability to write cohesive text with detailed ideas and a good range of appropriate vocabulary. Among the seven key issues and problems in the Philippine education, quality and relevance are the major importance.

Quality learning outcomes come from quality teachers supported by effective school leaders. But how do Filipinos view effective teachers, is a great question. Before pandemic, Bustos-Orosa study concludes that Filipino teachers' constructs on effective teacher involve personality-based trait which is rooted from Filipino cultural ideals and values which is supported by Stronge. Stronge top list of an effective teacher is the teacher as a person. The teacher is a strong representative of the content. The competence of the teacher of the content area may transfer those feelings to the learner. Early education is the most crucial stage in the development of the learner, teachers at this level are skillful to ask learners that guides their thinking. Buenviaje recommended that the most effective teachers are to be placed at the most critical stage of learning.

Effective teaching involves effective use of time. Adhering to planned schedules, striving to make classroom time, and strong internal controls and accountability are what makes time effectively used. Stronge describe effective teachers are someone that can be seen, heard, and sensed, submits feedback on time, he calls it with high professionalism. Jackson (2018) in his book never word harder than your students, he suggests that to be effective is to start from where the student at and carry them to where they wanted to be. It does not entail teachers to work less and laid backs waiting for nothing. Teaching is frustrating when it does not yield fruit. There is the right kind of hard work that pays off. Further, he confirms a lot of false beliefs on effective teaching. Master teacher can be anyone and every teacher should. There is no group of strategies that works for all, but a good principle does. Emerson Harrington said as to methods, there may be million and then some, but principles are few. The man who grasps the principles can successfully select his own methods. The man who tries methods but ignoring principles is sure to have troubles.

Teachers teaching for a long period of time does not guarantee an effective teacher. Jackson finds out that some teachers teaching of more than 20 years are still thinking and behaving like novice teachers. He expounds that effective teaching does not come from teaching experiences, it is not about time. However, it is what has been done over time that counts. Mastery and effective teaching go hand in hand. It is a teaching that requires specific and intentional practice. Hansen (2014) study that learners moving them from less effective to effective teachers pose a significant gain in learning equivalent to extra weeks of learning.

Burroughs et al. reviewed a large body of literature on measuring teacher effectiveness. However, despite the numerous research literature, evidence for the impact of teacher characteristics on student outcomes remains limited. His reviews found out that for secondary learners, there is a significant positive relationship between student outcomes to teachers training experiences specifically in mathematics. However, professional development, 16 studies showed significant effect to learners' outcome and an average size effect in mathematics. In terms of teachers' content knowledge and learners' outcome, the findings on significant relationships are not universal. But there is a more consistent relationship between student learning outcome to teachers' behavior spelled in teachers' time on task and teachers' instructional content [1-43].

In this research, we want to develop a student teacher evaluation questionnaire (STEQ) for secondary learners in the South-Central Part of Mindanao, Philippines. We will start from a review of what makes an effective math teacher and then make use of the exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to develop the STEQ.

2. Review on Teaching Theories in Mathematics

In a nutshell, K to 12 is a mixture of three teaching philosophies, constructivism, progressivism, and reconstructionism. However, there are teaching strategies that are almost applicable to all theory of teaching. One of which is the teacher shows sufficient knowledge about teaching and learning Mathematics [1] (Gonzalez & Maxwell), has a well-modulated voice [2] (Jalilova K.E.), checks and returns students outputs on time [3] (Kohnke & Moorhouse), gives constructive feedback on students' performance regularly, and tracks student's progress based on the learning competencies [4-8].

Behaviorism plays a vital role in teaching mathematics [60] (Junn Ree Montilla). In behaviorism, the teacher does a systematic way of conducting classroom activities, displays authoritative attitude in facilitating teaching-learning process [7] (Sayed Munna & Kalam), devotes majority of class time on board work or seat work [8], focuses only on easy tasks for mastery of basic concepts, confines discussion on mathematics concepts only [9-10], specifies what skill to master during the discussion, implements reward system for performing students [11], provides a clear and step-by-step demonstration of mathematical procedures [12], provides enough practice tests to enhance mastery [13], makes use of the time effectively, attends and ends class on time [57], administers paper-and-pencil tests after class discussions [59], maintains order and discipline in the classroom, neat and well-groomed [43] and employs activities solely on textbooks or modules.

Cognitive load theory as an instructional theory that there is an information overload to learners and thus the teacher demonstrates sensitivity to student’s ability to attend and absorb content information [15-16]. However, knowledge is not received passively by the respondents which means the learners must be able to construct his or her knowledge with the experiences provided, that is constructivism. There are three broad categories of constructivism, cognitive constructivism, social constructivism, and radical constructivism. In mathematics cognitive constructivism, the teacher designs activities to help develop new ways of thinking about mathematical ideas and methods. In constructivism, the teacher discusses things related to the lesson [17], the teacher allows students to move freely around the classroom even when necessary [18], gives students opportunities to ask questions and think out loud [19], allows students to feel welcome to share their mathematical ideas, provides students with opportunities to work independently to make sense of ideas, provides opportunities for students to acquire 21st century skills such as problem solving and reasoning [20-22].

Constructivism is the center of the K to 12 teaching theory, thus a teacher allows students to make multiple connections within and across topics [23], uses manipulatives, games, and calculators [24], uses concept maps, diagrams, and illustrations in teaching mathematics [25], uses student’s misconceptions constructively as learning opportunities [26], asks thought-provoking mathematical questions [27], uses prior knowledge as a basis for initiating learning [28], uses up-to-date and contextualized examples [29], knows how to guide and facilitate students' learning [30], adjusts teaching-learning context to facilitate attainment of learning objectives [31-33], solicits students’ voluntary responses and participation [34], adopts current and best practices in mathematics teaching [35], presents mathematics topic in an interesting manner (Mainali, 2020), communicates in a manner that is understandable by the students [36-37], uses effective non-verbal communication strategies in the classroom [38-50], communicates with parents regarding students' performance and behavior in school [50], maintains learning environments that promote fairness, respect and care [51], creates a healthy classroom environment to ensure and improve individual learning [52], provides students with opportunities to work collaboratively to make sense of ideas [53], asks questions that guides student's thinking [54-56], uses useful and interesting class content and activities, and communicates with parents regarding students' performance and behavior in school [50].

Humanistic teaching philosophy posited that student is good and the role of the teacher is to teach the child holistically to become better. Further, the student has the authority to learn and thus needs must be provided for them to learn. Hence, the teacher recognizes students' efforts in their academic tasks [41], and provides instructional activities suited to different learning styles and abilities [47].

Progressivism teaching philosophy suggested that learning comes from experiments and hands-on learning through questioning and seeking answers. Thus, the teacher demonstrates the connection of mathematical concepts in the real-world, [48], and provides ample time for students to finish tasks [49]. Inclusive education theory suggests a connection to free access of education and an education to all, this includes any type of students, and thus teachers accept all kinds of solutions that are presented by the students [31], assess the strengths and weaknesses of all students [32], and provides individual attention to the special needs of students [44].

Realistic mathematics education (RME) theory suggests that there is a need to present learning objective in mathematics classroom. Hence, the teacher presents learning objectives in mathematics classroom [39]. Sociocultural theory emphasizes learning is influenced by the social, cultural, and historical aspect. Thus, the teacher is proficient in the use of language to facilitate teaching and learning [45], gives challenging mathematical concepts and provides the necessary support [54]. The TDC framework extends TPACK focus on the skills and capabilities needed to integrate digital resources to support subject learning. Thus, teachers incorporate interplay of technology, pedagogy, and content knowledge into teaching [58].

From the numerous literature and epistemology, with the advent of technologies, with the impact of pandemic, the researcher would like also to determine what underlying principles and theories still holds for Math teachers as relevant and which are not relevant in the recent time.

3. Method

3.1. Sample

The sample consisted of Filipino public and private schools' math supervisors, principals, math teachers, and students: South Cotabato, Cotabato city, Koronadal City, North Cotabato, Sarangani, North Cotabato, Cotabato Province, Batangas City, Davao City, Davao del Sur, and General Santos City, Mindanao, Philippines. For exploratory factor analysis, participants are coming from math teachers (N1 = 65), students (N2 = 76), principals and math supervisors and principals (N3 = 61). For confirmatory factor analysis, the same number of participants (N=202), and a smaller sample (N=71) of learners was utilized to identify the reliability of the questionnaire.

3.2. Procedure

Initially, based on the literature, epistemologies of mathematics, and integration of various perspectives in teaching mathematics from an ideal teacher in mind, a description of an effective teacher was developed. The initial information from the STEQ was captured from analyzing the questionnaire formed by the 51 PhD Mathematics Education students at the University of Southern Mindanao, Kabacan, North Cotabato, Philippines. Each student was asked to write two Likert-scale items on good math teaching with reference and epistemology, theory, or studies from literature. Data were cleaned to ensure clarity, relevance, and appropriateness. Literatures were reviewed and identified the themes, language were refined, revised within the context of Mathematics teaching. In result there were 61 cleaned items. From the literature, epistemologies, and from initial information of the STEQ, 61 items with 8 dimensions were proposed as an initial indicator for STEQ. For the purpose of content validation, Mathematics professors at the university were asked to assess the quality of each item, verify the matching of items as indicators to the corresponding dimensions, and to provide further suggestions. It is recommended that the wordings have to be kept from its original to avoid misconceptions and include at least two negative statements to establish response quality control.

The preliminary 61 item questionnaire of STEQ were decided to have a 4-point Likert scales (from 1 strongly disagree to 4 strongly agree). The eight dimensions were: (i) instructional strategies, (ii) Cognitive learning strategies, (iii) non-conventional classroom strategies, (iv) In-depth content knowledge and evaluation (v) teacher time management and feedbacking (vi) creativity in mathematics teaching (vii) nurturing environment and (viii) structured learning process. Every dimension is captured by seven to eight indicators. These 61 item questionnaires were then floated to the first sample for exploratory factor analysis to identify the factor components. During this process, excluding items, identifying dimensions, and writing the second draft of the instrument was generated. Then, EFA was used to develop the structure and the preliminary model of STEQ. Furthermore, CFA was conducted to cross-validate the STEQ for the same number of samples as with EFA. Lastly, a classroom evaluation of a math teacher with the STEQ was used inside the classroom, one Grade 7, three grade 8, three grade 9, eleven grade 10, six grade 11, seventeen grade 12, five first year college student, ten second year college, twelve third year college, and eight fourth year college. Reliability was drawn.

4. Results

4.1. Exploratory Factor Analysis

Exploratory factor analysis is used to identify the smallest of factors revealing structure of the preliminary model of STEQ. Before conducting EFA, Kaiser-Meyer- Olkin (KMO) of sampling adequacy and Bartlett's test of Sphericity were examined. The KMO measure was substantial (KMO=0.869, Approx. chi-square =6664.38) while Bartlett's test was significant (df=1830, p = .000), indicating that the correlation matrix was significantly different from an identity matrix. Both results showed that performing EFA is allowed. Thus, varimax rotation was undertaken.

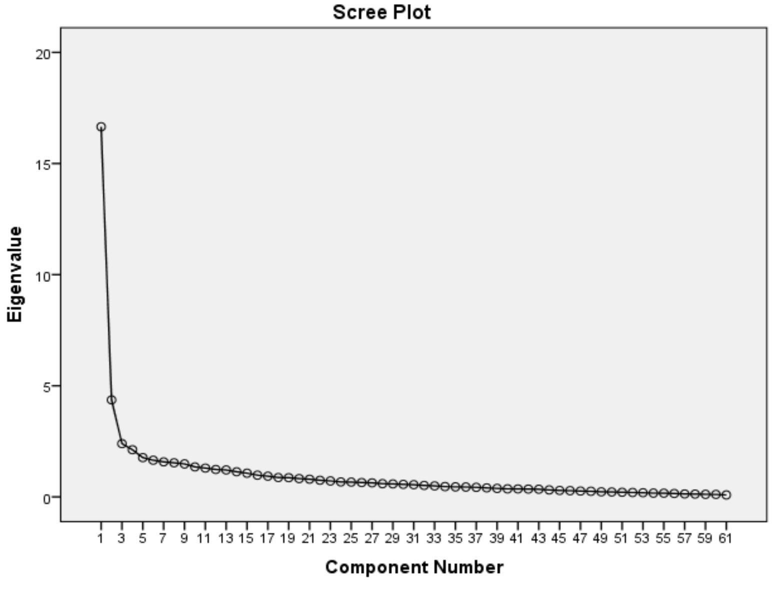

Figure 1. Scree plot diagram showing the Eigenvalues of the 61 items

4.2. Extraction Method

Principal component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 14 iterations. CESSL Cumulative Extraction Sums of Squared Loadings, F1 to F8 are the factors identified. From the scree plot (figure 1) and the Kaiser-Guttman rule for identifying factors with eigenvalues greater than 1, factor analysis of results on the 61 items indicated that 7 factors were most interpretable. The rotated principal factor loading matrix for the STEQ indicators was shown in Table 1. Items Q35, Q38, Q43, and Q44 were assigned to factor 1 which was revealed on Instructional Strategies of teachers. Items Q15, Q51 and Q52 were assigned to factor 2 which revealed cognitive learning strategies. Items Q26, Q22, Q27, Q25, and Q21 were assigned to factors 3 which revealed on the content knowledge and evaluation. Items Q3, Q6, and Q28 were assigned to factor 4 reflected on the classroom management. Items Q48, Q49 and Q58 were assigned to factor 5 reflected on the time management and feedbacking. Items Q57, Q59 were assigned to factor 6 reflected on the structured learning process. Items Q29, Q30, and Q10 were assigned to factor 7 reflected on the creativity in teaching mathematics. Items 33 and 32 were assigned for factor 8. Thus, there were 23 indicators distributed to 8 factors where there are at least 2 indicators per factor (Watkins, 2018).

Table 1. Item Communalities(C) & Final Exploratory Factor Analysis Results

Item	**Communalities**	**%**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**
			CESSL							
Q35	0.71	7.3	0.724							
Q43	0.66		0.657							
Q38	0.66		0.629							
Q44	0.63		0.574							
Q51	0.74	13.6		0.919						
Q52	0.69			0.740						
Q15	0.71			0.603						
Q27	0.61	19.6			0.689					
Q25	0.65				0.590					
Q21	0.69				0.532					
Q3	0.78	24.7				0.892				
Q6	0.76					0.846				
Q28	0.74					0.838				
Q48	0.70	29.5					0.811			
Q49	0.64						0.558			
Q58	0.53						0.517			
Q57	0.56	46.3						0.698		
Q59	0.65							0.589		
Q29	0.71	48.9							0.702	
Q30	0.66								0.609	
Q10	0.64								0.413	
Q33	0.69		52.64							0.639
Q32	0.68									0.648
Eigenvalue			16.65	4.36	2.39	1.76	1.64	1.35	1.29	1.27

Among the 61 items, there are 15 factors revealed. However, among the 15 factors, 7 of them have at most 2 indicators with loadings less than 0.4. Thus, the seven factors did not appear to be the best representation of the structure of STEQ. The overall percentage of variance extracted (52.64) supported the assertion of the 8 factors are sufficient.

5. Confirmatory Factor Analysis

EFA focuses on retaining factors that account for significant amounts of variance in the data, while CFA assesses goodness of fit based on the variance remaining after the factors are taken into account, (Floyd & Widaman, 1995). CFA is a procedure providing a comprehensive means for validating the measurement model of latent construct. It assesses unidimensionality, validity, and reliability of a latent construct. Thus, a model is a good fit after all. Any item with low factor loading should be removed but not exceeding 20% of total items in a model. Any item with low factor loading should be removed. Unidimensionality is achieved if factor loadings are positively above 0.5 for newly established and 0.6 for an established. Construct validity is achieved if fitness indexes are above 0.9. Discriminant validity is achieved if the correlation of independent (exogenous) constructs should not exceed 0.85. Composite Reliability of the model is achieved if the CR >0.6.

Table 2. Before deleting items 58, 27, 25, 15, 10, and 21

RMSEA = 0.102; Chi square (p<.01)

Fit indices

Index	Value
Comparative Fit Index (CFI)	0.878
Tucker-Lewis Index (TLI)	0.855
Bentler-Bonett Non-normed Fit Index (NNFI)	0.855
Bentler-Bonett Normed Fit Index (NFI)	0.735
Parsimony Normed Fit Index (PNFI)	0.622
Bollen's Relative Fit Index (RFI)	0.687
Bollen's Incremental Fit Index (IFI)	0.882
Relative Noncentrality Index (RNI)	0.878

Table 3. After deleting items 58, 27, 25, 10 and 21

RMSEA = 0.034; Chi square (p>.05)

Fit indices

Index	Value
Comparative Fit Index (CFI)	0.981
Tucker-Lewis Index (TLI)	0.974
Bentler-Bonett Non-normed Fit Index (NNFI)	0.974
Bentler-Bonett Normed Fit Index (NFI)	0.912
Parsimony Normed Fit Index (PNFI)	0.657
Bollen's Relative Fit Index (RFI)	0.878
Bollen's Incremental Fit Index (IFI)	0.982
Relative Noncentrality Index (RNI)	0.981

From the results of EFA, another sample where tested and run by CFA. Chi-square test shows significant difference among the factors. The Comparative fit index (CFI) is lower than the threshold by 0.90. This means that the model should be adjusted.

By deleting the 6 items (58, 27, 25, 15, 10 and 21) the CFI increases from 0.878 to 0.981. The increase in the Comparative Fit Index (CFI) from 0.878 to 0.981 after deleting the six items from the Exploratory Factor Analysis (EFA) suggests that the six items were not fitting well with the proposed factor structure. Removing these items improved the fit of the model, indicating that they were not adequately capturing the underlying constructs being measured in the STEQ. A CFI value closer to 1 indicates a better fit, with values above 0.95 generally considered as indicative of good model fit. Similarly, the decrease in the Root Mean Square Error of Approximation (RMSEA) from 0.102 to 0.034 after deleting the six items from the Exploratory Factor Analysis (EFA) indicates an improvement in model fit. It further suggests that the remaining items in the Confirmatory Factor Analysis (CFA) model better capture the underlying relationships among the observed variables. The original model with all items included had a higher RMSEA, indicating poorer fit, whereas the revised model with the six items removed has a substantially lower RMSEA, indicating a better fit to the data.

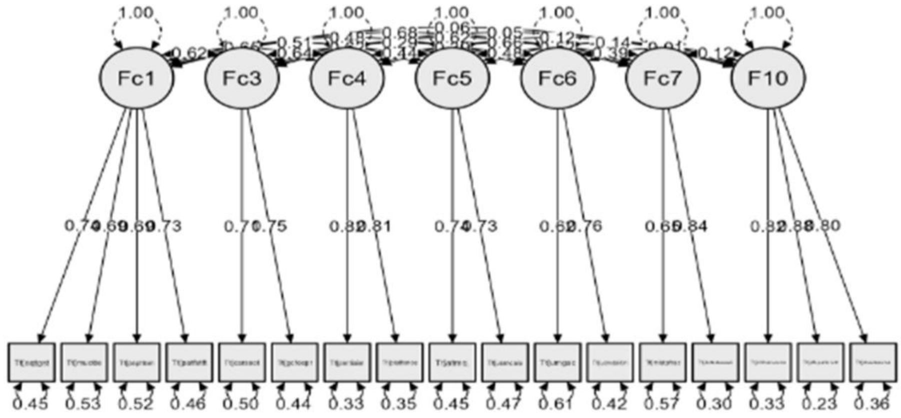

Figure 2. STEQ with 17 indicators distributed among the 7 factors

Hence, the better fit for the STEQ has 17 indicators distributed among the 7 factors. Thus, the remaining items are 35, 43, 44 and 38 for the new factor 1 items 51 and 52 for new factor 2, items 3, 6 and 28 stated in a positive constitutes for the new factor 3, items 48 and 49 for the new factor 4, items 57 and 59 for the new factor 5, items 29 and 30 for the new factor 6, and items 33 and 32 for the new factor 7.

Table 3. Defining the New Factors

Factor	Items	Reference	New Factor
Factor 1 Instructional Strategies of teachers	35, 43, 44 & 38	Caram, & Davis (2005), Konrad & Joseph (2011), Yip & Wilson (2010), Vogt & Echevarria (2008)	Strategies for Maximum Learning
Factor 2 Cognitive learning strategies	51 and 52	Bernstein, Wasserman, Thompson, & Freeman (2017), Sultana, Lim, & Liang, M. (2020)	Teaching Strategies
Factor 3 Content knowledge & evaluation	3, 6, and 28	Hennessey, Higley, & Chesnut, (2012), Jacob, Frenzel, & Stephens (2017), Silverman & Thompson (2008)	Strategies for Continuous Learning
Factor 4 Classroom management	48 & 49	Stevenson, VanLone, & Barber, (2020), Franklin & Harrington (2019).	Nurturing Environment
Factor 5 Time management and feedbacking	57 and 59	Jerše & Lokar (2018), Azmat & Iriberri (2010).	Feedback Mechanism
Factor 6 Creativity in teaching mathematics	29 and 30	Ummah, In'am, & Azmi, (2019) Pound & Lee (2021) Harris& De Bruin (2018).	Teaching Aids
Factor 7 Structured Learning Process	33 and 32	Fisher& Frey (2021) Carter, Rice, Yang, & Jackson, (2020).	Questioning Strategy

Based on literature, instructional strategies are translated into strategies for maximum learning (Caram, & Davis, (2005); Konrad & Joseph (2011); Yip & Wilson (2010); and Vogt & Echevarria (2008). It includes efficiency, mastery, waiting time anchored on their learning styles. Cognitive learning strategies are translated into teaching strategies, content knowledge and evaluation is translated into strategies for continuous learning. Further, classroom management is translated into nurturing environment, and time management and feedbacking is translated into feedback mechanism of the teacher. Creativity in teaching mathematics is translated into teaching aids and structured learning process is translated into questioning strategy.

6. Reliability

The new STEQ were then used by students and reliability were sought. A Cronbach's alpha coefficient of 0.903 for a Student Teacher Evaluation questionnaire indicates a high level of internal consistency reliability. Internal consistency reliability refers to the extent to which the items in a questionnaire or scale measure the same construct consistently. It suggests that the items in the Student Teacher Evaluation questionnaire are strongly interrelated and measure the same underlying construct consistently. This indicates that the questionnaire items are reliable and provide consistent results when assessing student teacher evaluations. Consequently, the final questionnaire consists of 17 indicators from 7 factors with 5 Likert-scale ratings.

7. Conclusion

The factor analysis conducted on the 61 items of the Student Teacher Evaluation questionnaire identified 7 interpretable factors. The scree plot and Kaiser-Guttman rule, which considers factors with eigenvalues greater than 1, supported the identification of these 7 factors. Each factor was interpreted based on the items that were loaded onto it. Factor 1 was related to Instructional Strategies, Factor 2 reflected Cognitive Learning Strategies, Factor 3 indicated Content Knowledge and Evaluation, Factor 4 represented Classroom Management, Factor 5 was associated with Time Management and Feedbacking, Factor 6 reflected Structured Learning Process, and Factor 7 related to Creativity in Teaching Mathematics.

The rotated principal factor loading matrix in Table 1 provided insights into the relationships between the items and the factors. The items were assigned to the factors based on their factor loadings, which indicate the strength of the relationship between an item and a factor. Each factor had at least two indicators associated with it. A total of 23 indicators were distributed across the 8 factors, suggesting that some factors had more indicators than others. However, the minimum requirement of having at least 2 indicators per factor was met.

The identification of interpretable factors is crucial in factor analysis, as it allows for a meaningful interpretation of the underlying constructs. Furthermore, the Cronbach's alpha coefficient of 0.903 indicates high internal consistency reliability for the Student Teacher Evaluation questionnaire, suggesting that the items consistently measure the same construct. The questionnaire also demonstrates high internal consistency reliability, indicating that the items are reliable and consistent in measuring the underlying constructs.

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