World Applied Sciences Journal 12 (11): 2092-2096, 2011
ISSN 1818-4952

Confirmatory Factor Analysis of the Mathematics Teachers' Teaching Practices Instrument

[1]Siti Mistima Maat, [2,4]Effandi Zakaria, [3]Norazah Mohd Nordin and [2,4]T. Subahan Mohd Meerah

[1]Mathematics Unit, Technical Foundation Section Universiti Kuala Lumpur Malaysia France Institute, 43600 Bangi, Selangor, Malaysia
[2]Department of Educational Methodology and Practice, Faculty of Education Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
[3]Department of Educational Foundation, Faculty of Education Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
[4]Educational Evaluation Centre, Faculty of Education Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Abstract: The purpose of this study was to examine the validity and reliability of a Malaysian application of the Teachers' Teaching Practices (TTP) instrument. The TTP originally consisted of 25 items with two subscales, for teacher-centered teaching and student-centered teaching. The study involved 254 respondents, all secondary school mathematics teachers, who were required to respond to a 5-point Likert scale. The collected data were analyzed using the SPSS 16.0 and Amos 16.0 software packages. An exploratory factor analysis was conducted prior to performing a confirmatory factor analysis, which showed good correlations for some factors. The results of the two analyses reveal the presence of a two-factor that represents the TTP.

Key words: Teaching practices · Mathematics · Exploratory factor analysis · Confirmatory factor analysis

INTRODUCTION

Teaching generally requires organizing and managing a classroom, explaining assignments, communicating effectively with students and conducting question-and-answer sessions with them [1]. The generic pedagogical features that now comprise the observed criteria for the quality of teaching practices include the time allocated to students for the completion of their tasks and the rewards, challenges and opportunities they are offered [2]. Researchers have lately been investigating the best ways of measuring teaching practices. Previous studies have explored the process of measuring teaching practices qualitatively through class observations and interviews [3]. These studies have considered teachers' reports, journals and related documentation as important sources of detailed information about the teachers under study and have investigated them through preliminary exploratory cross-sectional studies. Although some of the issues concerning the measurement of teaching practice appear to have been contradictory [4], researchers seemed to find important the attempt to validate the teaching practice instrument, especially in quantitative terms.

Consequently, measuring teaching practices quantitatively provides teachers with a new research direction. This study's findings should be explored further in order to accumulate information on teachers' teaching practices. That information could then be used to design professional development activities compatible with the teachers' pedagogical approaches, teaching experience and subject specialties. Past researchers have distinguished between two teaching practices—the teacher-centered approach and the student-centered approach. The evolution of pedagogical processes has contributed to a variability in teaching practice [5]. A shift from the behaviorist to the constructivist approach should be supported. The behaviorist approach leads to teacher-centered teaching while the constructivist approach espouses student-centered teaching. The criteria of each approach are discussed in the next section.

Corresponding Author: Effandi Zakaria, Department of Educational Methodology and Practice, Faculty of Education Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia, E-mail: effandi@ukm.my.

Teacher-centered teaching, widely known as the "traditional" method, is founded on the teacher's dominance of most of the teaching processes [6]. This type of teaching considers the teacher to be the "information provider." Teachers' knowledge is transmitted through direct instruction, which is based solely on the standardized syllabus. The students are passive sufferers of the learning process. [7] states that traditional teaching focuses on student achievement rather than on skill development. The students do not develop an interest in learning because most of the session is dominated by the teachers. Most teachers believe that the teacher-centered method is the best way to convey knowledge [8]. Teachers who employ traditional instruction tend to follow the same pedagogical routine for every class. Their students prefer to be passive while the teachers spend the entire class talking. This kind of scenario is reported by [8] as he observes a mathematics class in China.

The reform of mathematics education requires a change from teacher-centered to student-centered teaching [9], which will give students the opportunity to contribute to the teaching and learning processes. Teachers who use student-centered teaching allow students to do research, make hypotheses and manipulate objects in class [10]; students are also allowed to enhance their understanding through class discussion, group work and presentations. Previous studies have shown that this type of approach optimizes students' motivation for and attitudes about learning [11]. Furthermore, the knowledge gained through this approach can be retained better than that gained through the teacher-centered approach. The implementation of student-centered teaching will ensure that the teachers' style of instruction focuses on students' thinking [12]. Students should be enabled to construct their own knowledge base and lessen their misconceptions about mathematics. The two-way interaction between students and teachers is an important aspect of a successful learning process. Finally, measurements of Teachers' Teaching Practices (TTP) must be made through reliable and valid scores. Thus, it is important to validate the TTP instrument as a measurement method. Thus, we pose the following research questions:

- Does the measurement model for teaching practices fit with the collected data?
- Does the measurement model for teaching practices fulfill the construct validity?
- Does each indicator (or item) produce a nonzero loading for each construct of teachers' teaching practices?

MATERIALS AND METHODS

The researchers used a stratified sampling technique to choose the study sample, collecting a total of 254 respondents. The respondents were secondary school mathematics teachers working in Malaysia. Most of the teachers (79.9%) were female; only 20.1% were male. Out of 254 teachers, 124 (48.8%) had more than ten years' experience; 22 (8.7%) of them had between three and five years of teaching experience. Details are shown in Table 1.

Instrumentations: A set of instruments consisting of demographic information and Teachers' Teaching Practices (TTP) was administered to participants. Respondents were asked to rate them using a 5-point Likert scale ranging from 1 ("Never") to 5 ("Always"). The Teachers' Teaching Practices instrument, composed of 24 items, was developed by [13]. Thirteen of its items measure teacher-centered teaching; the remaining items measure student-centered teaching. After administering the TTP to 120 teachers, Swan found that his respondents preferred teacher-centered teaching [13] while obtaining a reliability of 0.85 for the instrument.

RESULTS

The data were analyzed using SPSS 16.0 and Amos 16.0 and the instrument was validated by both exploratory and confirmatory factor analyses.

Exploratory Factor Analysis (EFA): An exploratory factor analysis occurred prior to the confirmatory factor analysis. The EFA was intended to reduce the number of items in the instrument in order to maximize the explained variance and identify the appropriate number of items in each of the variables' factors [14]. The eigenvalue greater than the 1-rule and the scree plot test are often used to extract the required number of factors.

The Kaiser Meyer-Olkin Measure of Sampling Adequacy (KMO) value was equivalent to 0.77, which is considered good [15]. The correlation found in the R matrix for most of the items was higher than 0.3. The significance of Bartlett's test of sphericity ($p = 0.000$) supported the evidence that the items can be factored. Using a varimax orthogonal rotation, two factors with a factor loading higher than 0.4 were formed [16].

Table 1: Respondent Profiles

Type	N	Factor	Frequency	Percentage (%)
Gender	254	Male	51	20.1
		Female	203	79.9
Years of experience	254	1 - 3 years	48	18.9
		3 - 5 years	22	8.7
		5 - 10 years	60	23.6
		> 10 years	124	48.8

Table 2: The results of the CFA on teachers' teaching practices instrument (n = 254)

Fit Statistics	df	p	CMINDF	TLI	CFI	GFI	RMSEA
Value	39	0.026	1.488	0.954	0.966	0.962	0.043

Confirmatory Factor Analysis (CFA): A CFA was conducted to cross validate the findings of the exploratory factor analysis. Using the collected data from 254 samples, a two-factor measurement model for teachers' teaching practices was tested using AMOS 16.0. The two factors represent teacher-centered teaching and student-centered teaching, as theorized by [13]. The first factor was labeled "teacher-centered teaching" and consisted of 9 items; the second factor was labeled "student-centered teaching" and had 5 items, as indicated by the EFA results. The traditional chi-square test, the relative chi-square (CMINDF: the chi-square/degree of freedom), the Tucker Lewis Index (TLI), the Comparative Fit Index (CFI), the Goodness of Fit Index (GFI) and the Root Mean Square of Error Approximation (RMSEA) were chosen [15] to obtain a model fit. The non-significant traditional chi-square test indicates that the model achieves one of the fitness criteria. Likewise, the respective TLI, CFI and GFI values must exceed 0.90 and the RMSEA value must be lower than 0.08 [17] in order to obtain an acceptable fit with the data.

Table 2 shows the results of the CFA analysis on the TTP instrument for the study's 254 samples. The relative chi-square or CMINDF value falls between the suggested range of 1 to 5. The non-significant value of $p = 0.026 > 0.05$ shows that the model's fit with the collected data is acceptable. The respective TLI, CFI and GFI values are 0.954, 0.966 and 0.962, reflecting a close model fit. The RMSEA shows a value of 0.043, indicating a good model fit. The square represents the observed variables and the ellipses represent the latent variables.

Figure 1 shows the final measurement model of teachers' teaching practices. One item from teacher-centered teaching and two items from student-centered teaching were dropped due to their low loading factors. Each item of every construct for the teaching practices shows an acceptable factor loading, which is statistically significant. The covariance between the APG and APP values equals 0.28, significant at $p < 0.05$; this indicates a low correlation value, meaning the two factors are independent dimensions. The model creates covariances between A1 and A4, A11 and A13 and A23 and A17. These covariances are formed through the modification index produced by the AMOS analysis. The two-headed arrow stretches between the two observed variables in order to reduce the chi square value and achieve the acceptable model fit [15]. However, an assessment of the modification index should draw from the theoretical framework. Regression weights for all observed variables are higher than 0.4 and significant at $p = 0.0001$. Each factor of teaching practice produces an acceptable value of construct reliability and extracted variance.

The values for construct reliability (i.e. composite reliability or CR) and variance extracted (VE) were needed in order to obtain the divergent validity [15]. The accepted value for CR should be at least 0.70 and 0.50 for VE [15]. The formulae for CR and VE are shown in the next section.

where

$$CR = \frac{\left(\sum_{i=1}^{n} L_i\right)^2}{\left(\sum_{i=1}^{n} L_i\right)^2 + \left(\sum_{i=1}^{n} e_i\right)}$$

L_i is standardized factor loading and
e_i is error variance for each construct.

where

$$VE = \frac{\sum_{i-1}^{n} L_i{}^2}{\sum_{i-1}^{n} L_i{}^2 + \sum_{i-1}^{n} e_i}$$

L_i is standardized factor loading,
n is number of items and
e_i is error variance for each construct.

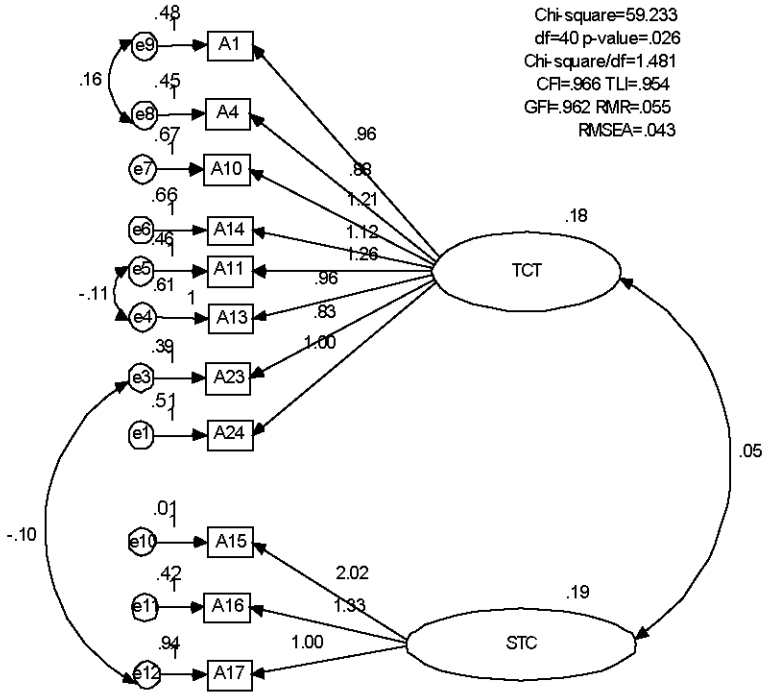

Fig. 1: The final measurement model of teachers' teaching practices, where APG refers to teacher-centered teaching and APP to student-centered teaching

Table 3:Items of the TTP, with factor loadings obtained from the CFA process

	Item	Regression weight
A1	Students learn by doing exercises.	0.51
A4	Students start with easy questions and work up to harder questions.	0.49
A10	I try to cover everything about a topic.	0.53
A14	I tend to follow the textbook or worksheets closely.	0.51
A11	I draw links between topics and move back and forth between topics.	0.62
A13	I prevent student mistakes by explaining things carefully first.	0.47
A23	I teach each student differently according to individual needs.	0.49
A24	I tend to teach each topic separately.	0.51
A15	Students learn by discussing their ideas.	0.99
A16	Students work collaboratively in pairs or small groups.	0.67
A17	Students invent their own methods.	0.41

Through the formulae, we found that the CR value for teacher-centered teaching (TCT) was 0.89 and that of student-centered teaching (SCT) was 0.78. Both constructs show an acceptable value (0.50) for VE. Thus, the CFA analysis shows that the TTP measurement model fit the collected data and fulfilled the requirement for construct validity. Each item produced a factor loading value higher than 0.40. The TTP measurement model, as set by the CFA, has therefore been validated.

DISCUSSION

This study was conducted to assess the reliability and validity of the teachers' teaching practices instrument by applying both exploratory and confirmatory factor analyses to a Malaysian case. The results of the EFA and CFA provide support for a two-factor model of teaching practice consisting of teacher-centered teaching and student-centered teaching, a result that is consistent with [13]. The low correlation between the two teaching practice factors suggests that they are independent dimensions of the same variable. The direction of the correlation was consistent with the findings in [5]. Nevertheless, teachers' responses flow from their perception rather than from what they actually do in the classroom. The complexity of the teaching and learning processes limits the production of a reliable teaching practice measurement [3]. Such a measurement should be

able to clarify what teachers do and describe the reality of the classroom environment, which is why most studies on teaching practice are conducted qualitatively. Thus, the limited trustworthiness of the sample's responses must be noted.

This study's results should enable teachers to identify gaps in their instructional methodology and help educational authorities prepare pedagogical development programs, particularly those designed to enhance teaching effectiveness. Mathematics teachers will be able to use the methods appropriate to their experience and reflective of what they believe the mission of mathematics teaching to be [18]. Teaching practices unfold solely through decisions made in the classroom [19]. Planning and delivering quality teaching will create a meaningful mathematics classroom and assist student success. Effective practices help teachers gather information on the strength of their capabilities and on the progress of student learning [5]. Teaching practice is crucial to the communication of teachers' values [20], the process of classroom management [21] and the furtherance of student achievement.

REFERENCES

1. Shulman, L.S., 1987. Knowledge and teaching: Foundation of the new reform. Harvard. Educational. Rev., 57: 1-22.
2. Stipek, D.J., K.B. Givvin, J.M. Salmon and V.L. MacGyvers, 2001. Teacher's Beliefs and practices related to mathematics instruction. Teaching and Teacher. Education, 17: 213-226.
3. Shim, M.K., R.D. Felner, E. Shim and S. Brand, 2000. Measures of Classroom Instructional Practices in Middle Grades. http://www. amstat. org/sections/ srms/ proceedings/papers/2000_145.pdf [29 October 2010].
4. Palardy, G.J. and R.W. Rumberger, 2008. Teacher Effectiveness: The Importance of Background Qualifications, Attitudes and Instructional Practices for Student Learning. Educational Evaluation and Policy. Analysis, 30(2): 111-140.
5. Hassad, R., 2009. Development and Validation of a Teaching Practices Scale (TISS) for Instructors of Introduction Statistics at The College Level. Institute Association for Statistical Education-In Statistical Institute. Retrieved 23rd December 2010. http://arxiv.org/ftp/arxiv/papers/1007/1007.3654.pdf
6. Walshaw, M.A., 2010. Book review: Teacher-centredness and student-centredness under interrogation. Educ. Stud. Math., 73: 99-103.
7. DeVillers, C., 1996. Cooperative learning notes. Proceedings of the SACLA. Conference.
8. Peng, G., 2002. Two Student-centred Teaching Methods in Mathematics. The China Papers, 12: 17.
9. NCTM. 2000. *Professional standards for teaching mathematics*. New York: NCTM.,
10. Isikoglu, N. and R. Basturk and F. Karaca, 2009. Assessing in-service teachers' instructional beliefs about student-centered education: A Turkish perspective. Teaching and Teacher. Education, 25: 350-356.
11. Cornelius-White, J., 2007. Learner-centered teacher-student relationships are effective: A Meta - Analysis. Review of Educational Res., pp: 77-113.
12. Eggen, P. and D. Kauchak, 2007. Educational Psychology: Windows on Classroom. 7th Edition. Prentice Hall: New Jersey.
13. Swan, M., 2006. Designing and using research instruments to describe the beliefs and practices of mathematics teacher, Research in Education, 75: 58-70.
14. Netemeyer, R.G., W.O. Bearden and S. Sharma, 2003. *Scaling Procedures*. Sage. Publications.
15. Hair, J.F., R.E. anderson, R.L. Tatham and W.C. Black, 2010. *Multivariate Data Analysis*. 7th ed. New Jersey: Prentice-Hall.
16. Stevens, J., 2002. *Applied Multivariate Statistics for the Social Sciences*. 4th ed. Mahwah, NJ: Lawrence Erlbaum Associates.
17. Schumacker, R.E. and R.G. Lomax, 2004. *A beginner's guide to structural equation modeling*. New Jersey: Lawrence Erlbaum Associates.
18. Wilkins, J.L.M., 2008. The relationship among elementary teachers' content knowledge, attitudes, beliefs and practices. J. Mathematics Teacher. Education, 11: 139-164.
19. Sung, T.L. and S.L. Huann, 2005. Using Argumentation to Investigate Science Teachers' Teaching Practices: The Perspective of Instructional Decisions and Justifications. International J. Science and Mathematics Education, 3: 429-461.
20. Ernest. 1989. The knowledge, beliefs and attitudes of the mathematics teacher: A Model. J. Education for Teaching, 15(1): 13-33.
21. Yilmas, H. and P.H. Cavas, 2008. The effect of the Teaching Practice on Pre-Service Elementary Teachers' Science Teaching Efficacy and Classroom Management Beliefs. Eurasia J. Mathematics, Science and Teaching. Education, 4(1): 45-54.