Analyze confirmatory factors of science and mathematics professional characteristics teacher in Thailand

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Abstract. The study aimed to study factor of professional teachers teaching Science and Mathematics in Thailand through the second-order confirmatory factor analysis. The samples were 132 Science and Mathematics teachers during 2019 academic year in Thailand. They were selected by using the Multi-stage random sampling. Research instrument included 86 items of the questionnaire asking professional teacher’s characteristic, the 5 Level Rating Scale with reliability of total issue = 0.943. Data were analysed by using the second-order confirmatory factor analysis. The findings were as follows: The second-order confirmatory factor analysis model regarding to characteristics of professional teachers in Science and Mathematics in Thailand, was fit and congruent the empirical data. \( \chi^2 = 83.490, df = 64, p\text{-value} = 0.0514, \text{CFI} = 0.989, \text{TLI} = 0.981, \text{RMSEA} = 0.048, \text{SRMR} = 0.049, \text{and} \, \chi^2/df = 1.304 \). (Every factor and indicator in the model, was significant and supportive with each other.

1. Introduction
The occurred changes during the 21st century, was the rapid change affecting each other in wide range [16]. Since it was due to the growth and advancement of information technology which caused the economic, social, and cultural changes. In addition, it could have an impact on various issues of educational management, for instance, the teacher development, instructional management, and students. Teacher development was important since they were valuable persons in providing the student development as well as national education development. The Education was to lay foundation and develop the quality of life. Consequently, teachers prepared people to step into new society firmly and to be aware of world. In future world, there would be many changes including: the technology world, trading world, globalization world, city world, individual world, aging world, environmental world, or the world leading to sustainable development [15]. According to the changing world and policy for moving Thailand movement by developing income from innovation or Thailand 4.0. The strong human power in SMT body of knowledge (Science, Mathematics and Technology) had to be promoted to be basis in innovation development. So, it was necessary for The Institute for the Promotion of Teaching Science and Technology of Thailand [17] to revise and improve curriculum of Science and Mathematics in 2018 to be relevant to human power development as well as national movement during innovative age.

Consequently, the stakeholders of human development in this period, had to involve with Science and Mathematics Teachers. The teachers were not only to have knowledge but also to obtain their thinking skill as well as provide the students’ learning through information communication and technology by focusing on learning design for students to be able to utilize instruments as well as information technology correctly and safely, and the systematic analytical thinking and problem
solving skills so that they would be innovative constructors from body of knowledge in Science, Mathematics, and Technology Progress [17]. Furthermore, teachers had to be ethical in being professional teachers, and have skill in instructional innovation construction by conducting their classroom research study and providing the students ’self-development to be good and intelligent people in society and country [14].

According to the changing world during 21st century and Thailand 4.0 movement policy, was moved through innovation. National movement based on that policy had to be depended on knowledge in Science and Mathematics. As a result, the Science and Mathematics Teachers needed to be alert and self-development continuously. It was very integral to study characteristics of Science and Mathematics Teachers in this period so that the data would be used for designing how to product the teacher student to be good and intelligent teachers. When they graduated, they would be able to be professional Science and Mathematics Teachers further.

The objective of this research was to study factors of professional teachers teaching Science and Mathematics in Thailand.

2. Theoretical Background
Office of The Higher Education Commission (OHEC) specified 6 aspects of new age teachers ’ standard learning outcome based on Thailand Qualifications Framework (TQF) [12] as follows: 1) the ethics and morality expressed in ethical and moral behavior as well as teacher code of conduct, 2) knowledge, 3) intellectual skill, 4) interpersonal relation and responsibility, 5) numerical analytical skill, communication, and information technology usage, and 6) learning management skills.

Learning Theories promoting human beings ’self-development, consisted of Self – Efficacy Theory and Self-Regulation Theory. Since self perception in one’s competence was personal factor for motivating one’s self-regulation. There were various techniques for self-efficacy. Bandura [2] believed that to provide persons ’Enactive Mastery Experience was a very efficient technique. Since it was one’s direct successful experience leading to be confident in behaving that behavior again. Besides, Vicarious Experience or one’s perception in other people’s similar experience, if that person accomplished goal, the observer would expect to be successful as well. For instance, when a teacher had successful experience, and the teacher learned from modeled teacher or successful teacher, the observer would have inspiration in self-development by setting goal to be professional teacher, planning according to objective, and using various startegies to achieve goal. Later on, they would have self-evaluation and reflection both of good point and to be developed one according to B.J. Zimmerman’s self-regulation model [3].

In sum, according to the study in both of Self – Efficacy and Self-regulation Theories, and new age teacher’s learning outcome standard of Office of The Higher Education Commission (OHEC), and Sangchan Kalam et.al.[8], characteristic of Science and Mathematics professional teachers were studied by researcher. The indicator of professional teachers from high educational standard countries such as the United States of America by North Carolina 2018 [11], New Zealand by www.otago.ac.nz/education.2018 [6], Japan by Atsushi Tsukui and Naomi Takasawa, 2017 [1], Singapore by Christine Kim-Eng Lee and Mei Ying Tan, 2010 [4], Finland by Paula Paronen and Olga Lappi, 2018 [13], Thailand by Teacher Council, 2019, and Teacher 4.0 ’s 7 C Skill by Pimpan Dechakup and Payao Yindesuk, 2018 [5]. Seven professional teacher’s indicators were synthesized by researcher including: 1) self-discipline, self-development and responsibilities, 2) child-centered design and instructional management for students ’learning, skill, and good habit, 3) classroom innovation and technologies implementation, 4) classroom learning measurement and evaluation for learning development, 5) classroom action research, 6) classroom management, and 7) creative collaboration in school and unity development in group.

3. Research Methodology
3.1 Population and Samples
Population were Science and Mathematics Teachers in Thailand.
Samples were Science and Mathematics Teachers in Thailand. They were selected by Multi-stage random sampling, using 4 regions criterion as stratified sampling. Then, the provinces, districts, schools were sampled.

The Second-order Confirmatory Factor Analysis was administered in this research. Five times of parameter number were determined based on the approaches of Hair, Anderson, Black, Babin, Aderson & Tatham [7]. The sample size was determined as 5-20 times of parameter number in order to obtain suitable and sufficient number for conducting Confirmatory Factor Analysis. Therefore, the minimum sample size was determined by the researcher into 4 regions including: the Central and Eastern Region, North Eastern Region, North Region, and Southern Region.

The samples size were determined as follows:

| Region                        | Minimum Number | Number of Province | Number of research samples | Percent |
|-------------------------------|----------------|--------------------|----------------------------|---------|
| 1. Central and Eastern Region | 25             | 3                  | 40                         | 30.31   |
| 2. North Eastern Region       | 25             | 2                  | 37                         | 28.03   |
| 3. North Region               | 25             | 2                  | 30                         | 22.72   |
| 4. Southern Region            | 25             | 2                  | 25                         | 18.94   |
| Total                         | 100            | 9                  | 132                        | 100     |

There were 132 samples which were higher than the minimum number of 100 samples.

3.2 The research instruments: the research instruments consisted of:
1) developed instrument included Questionnaire of Factor “Characteristic of Professional Teacher”.
2) the instrument using for quality investigation included Content Analysis.

3.3 The research instrument development: the research instrument development was implemented by researcher as follows:
1) the determined behavior with potential probability of professional teacher’s characteristic, was to express behavior in each indicator of factor by interviewing the instructors teaching the teacher students, the administrators, supervisors, and teachers.
2) the determined chart for question writing in each factor. Besides, the question items were validated the Content Validity with indicator in each factor of Rating Scale by considering the validation of Content validity.
3) the reliability of questionnaire was calculated. Reliability of total issue was = 0.943, the questionnaire including 86 items.

3.4 Data analysis: data were analyzed for factor confirmation of professional teacher’s characteristic by using statistic: CFA) Confirmatory Factor Analysis, and Mplus) Muthen & Muthen Program, [10].

4. Conclusions and Discussions:
The congruence investigation between the measurement hypothetical model of professional teacher teaching science and mathematics in Thailand and empirical data was investigated by using the Second-order Confirmatory Factors Analysis, and Mplus Version 7.4 Program. The research findings were as follows:

4.1 The correlation analysis between observed variables: Fifteen observed variables were analyzed by using Pearson Correlation Coefficient (r), r > 0.30. If r = -0.31 to -0.70 referred to Moderate level of correlation. Moreover, if r = 0.71 to 1.00, referred to the High Level of correlation. The analytic findings were shown in Table 2.
According to Table 3, considering the standard factor loading were shown in Tables 3, the latent variable in characteristic of professional teacher teaching science and mathematics in Thailand, the indicator with lowest loading was the indicator ET (R² = 0.19). Furthermore, 2 pairs including between PS and ET, and ID and ET, with equal value of r = 0.19.

The Simple Correlation Coefficients between Observed Variables were shown in Table 2.

Table 2: The Simple Correlation Coefficients between Observed Variables were shown.

| Variable | ET | RM | BL | DE | PS | TS | MT | AS | LD | ID | HT | GL | TC | PC | CC |
|----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| ET       | 1  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| RM       | .56** | 1  |    |    |    |    |    |    |    |    |    |    |    |    |    |
| BL       | .54** | .56** | 1  |    |    |    |    |    |    |    |    |    |    |    |    |
| DL       | .46** | .56** | .67** | 1  |    |    |    |    |    |    |    |    |    |    |    |
| PS       | .24** | .50** | .40** | .56** | 1  |    |    |    |    |    |    |    |    |    |    |
| TS       | .40** | .66** | .60** | .72** | .70** | 1  |    |    |    |    |    |    |    |    |    |
| MT       | .18** | .41** | .41** | .47** | .70** | .70** | 1  |    |    |    |    |    |    |    |    |
| AS       | .42** | .57** | .54** | .60** | .50** | .73** | .61** | 1  |    |    |    |    |    |    |    |
| LD       | .20** | .52** | .56** | .57** | .58** | .72** | .70** | .73** | 1  |    |    |    |    |    |    |
| HT       | .29** | .49** | .50** | .56** | .74** | .71** | .70** | .62** | .54** | 1  |    |    |    |    |    |
| HY       | .19** | .41** | .44** | .50** | .74** | .69** | .70** | .58** | .70** | .84** | 1  |    |    |    |    |
| GL       | .25** | .50** | .41** | .44** | .56** | .64** | .72** | .67** | .56** | .68** | .72** | 1  |    |    |    |
| TC       | .26** | .40** | .51** | .47** | .69** | .61** | .61** | .58** | .68** | .80** | .79** | .64** | 1  |    |    |
| PC       | .30** | .56** | .56** | .69** | .70** | .70** | .51** | .62** | .66** | .73** | .72** | .74** | .79** | .73** | 1  |
| CC       | .27** | .50** | .40** | .59** | .67** | .63** | .53** | .56** | .58** | .66** | .74** | .60** | .66** | .67** | 1  |

Note ** referred to .01 significant level

According to Table 2, considering Simple Correlation Coefficient between 2 observed variables, found that the correlation between HT and ID variables was in the Highest level, r = 0.84. The second order was correlation between TC and ID variables, r = 0.80. Besides, the second order was correlation between TC and HT, r = 0.79. The correlation between MT and ET was in the Lowest level, r = 0.18. The second order was the correlation between HT and ET, r = 0.19. Furthermore, 2 pairs including between PS and ET, and ID and ET, with equal value of r = 0.24.

4.2 The analytic findings of Second-order Confirmatory Factor Analysis: the observed variable of latent variable in characteristic of professional teacher teaching science and mathematics in Thailand, were shown in Tables 3-4.

According to Table 3, considering the standard factor loading β (in second-order confirmatory factor analysis of measurement model, every indicator in collaborative development, then standard factor loadings were ranged between 0.454 - 0.927). The indicator with highest factor loading was indicator ID (β = 0.927) the indicator of innovation and research to develop student learning. The second order was the indicator HT (β = 0.914) the indicator of higher order thinking skills. In addition, the indicator with lowest loading was the indicator ET (β = 0.454) indicator of ethic.

Considering the coefficient determination (R²) of every indicator, found that they were ranged between 0.206 - 0.859. The indicator with highest level of coefficient determination, was the indicator ID (R² = 0.859), the innovation and research to develop student learning. The second order was the indicator HT (R² = 0.835), higher order thinking skills. Besides, the lowest loading of coefficient determination was the indicator ET (R² = 0.206), the indicator of ethic.
Table 3: The analytical finding statistic of Second-order Confirmatory Factor Analysis, the observed variable of latent variable in characteristic of professional teacher teaching science and mathematics in Thailand.

| Latent Variable | Observed Variable | Factor Loading (b) | Standard Factor Loading (β) | S.E. | t   | R²   |
|-----------------|-------------------|--------------------|-----------------------------|------|-----|------|
| COT             | ET                | 1.000              | 0.454                       | 0.076| 6.011| 0.206|
|                 | RM                | 1.932              | 0.746                       | 0.046| 16.228| 0.556|
|                 | BL                | 2.141              | 0.757                       | 0.043| 17.412| 0.572|
|                 | DE                | 2.413              | 0.872                       | 0.034| 26.000| 0.760|
| TSL             | PS                | 1.000              | 0.842                       | 0.031| 27.397| 0.709|
|                 | TS                | 0.716              | 0.868                       | 0.024| 36.482| 0.754|
|                 | MT                | 0.863              | 0.814                       | 0.034| 23.932| 0.662|
|                 | AS                | 0.682              | 0.779                       | 0.038| 20.608| 0.607|
| SDT             | LD                | 1.000              | 0.814                       | 0.032| 25.501| 0.663|
|                 | ID                | 1.540              | 0.927                       | 0.016| 57.277| 0.859|
|                 | HT                | 1.935              | 0.914                       | 0.017| 52.581| 0.835|
|                 | GL                | 1.189              | 0.796                       | 0.035| 22.480| 0.634|
| PLC             | TC                | 1.000              | 0.849                       | 0.028| 30.424| 0.721|
|                 | PC                | 0.890              | 0.847                       | 0.028| 29.768| 0.717|
|                 | CC                | 0.991              | 0.777                       | 0.037| 20.887| 0.604|
| PRO             | COT               | 1.000              | 0.807                       | 0.041| 19.681| 0.652|
|                 | TSL               | 4.847              | 0.965                       | 0.017| 56.936| 0.931|
|                 | SDT               | 3.516              | 0.947                       | 0.015| 62.695| 0.897|
|                 | PLC               | 5.593              | 0.998                       | 0.017| 57.871| 0.997|

R² COT = 0.652, R² TSL = 0.931, R² SDT = 0.897, R² PLC = 0.997
χ² = 83.490, df = 64, p-value = 0.0514, CFI = 0.989, TLI = 0.981, RMSEA = 0.048, SRMR = 0.049 and χ²/df = 1.304

According to Table 4, the findings of validation in Second-order Confirmatory Factor Analysis of characteristic in professional teacher’s teaching Science and Mathematics in Thailand, found that the model consisted of construct validity considered by statistics using for validation of model including χ² = 83.490, df = 64, p-value =0.0514, CFI =0.989, TLI =0.981, RMSEA =0.048, SRMR = 0.049, and χ²/df =1.304

It could be concluded that the model measuring factor and indicator of latent variable in characteristics of teachers teaching Science and Mathematics in Thailand, in model analyzing the Second-order Confirmatory Factor Analysis Model in professional teacher teaching Science and Mathematics in Thailand, consisted of construct validity or being congruent with empirical data in quite high level. Since every factor and indicator in the model, was important factor and indicator, and related as well as supported with each other as shown in figure 1.
4.3 Conclusions of research findings: The model for analyzing Second-order Confirmatory Factor Analysis, found that the model consisted of construct validity ($\chi^2 = 83.490$, df = 64, p-value = 0.0514, CFI = 0.989, TLI = 0.981, RMSEA = 0.048, SRMR = 0.049 and $\chi^2$/df = 1.304), or it was congruent with empirical data in rather high level. Since every factor and indicator in model, was important factor and indicator, and related and supported with each other. Considering standard factor loading ($\beta$) in Second-order Confirmatory Factor Analysis of model analyzing the variable in every indicator at .01 significant level. The standard factor weights were ranged between 0.454 - 0.927. The indicator with highest factor loading was indicator ID ($\beta = 0.927$), the indicator of innovation and research to develop student learning. The second order was the indicator HT ($\beta = 0.914$), the indicator of higher order thinking skills. In addition, the lowest factor loading was the indicator ET ($\beta = 0.454$), indicator of ethic. Furthermore, considering the coefficient determination ($R^2$) of every indicator in Second-order Confirmatory Factor Analysis, found that the value were ranged between 0.206 - 0.859. The highest level of coefficient determination predictive coefficient was the indicator ID ($R^2 = 0.859$), the innovation and research to develop student learning. The second order was the indicator HT ($R^2 = 0.835$), higher order thinking skills. Moreover, the least value of coefficient determination was the indicator ET ($R^2 = 0.206$), the indicator of ethic.
It was congruent between the Second-order Confirmatory Factor Analysis, and 7 items of indicator in professional teacher. Since the characteristic in being professional teacher was congruent with item 1 of indicator, the self-discipline, the professional self-development to keep pace with development in technology, economic, and society regularly, being role model, and responsibilities. It was congruent between the learning management skill and item 2 of indicator, the learning design and management for student’s learning in good skill and habit in themselves by using child-centered instructional management. It was congruent with item 3 of indicator, the classroom innovation and technologies implementation. It was congruent with item 4 of indicator, the classroom learning measurement and evaluation for learning development. In addition, it was congruent with item 6, the classroom management, self-development in both of knowledge and thinking. It was congruent with indicator 5, the classroom action research. Furthermore, indicator item 4, the professional learning community was congruent with indicator 7, the creative collaboration in school with the others, and the unity development in group. The result shown that every indicator in Science and Mathematics professional characteristics’ teacher was supported with Thailand Qualifications Framework (TQF) [12], and Sangchan Kalam et.al.[8] that supported Self – Efficacy Theory [2] and Self-Regulation Theory [3], also supported to the indicator of professional teachers from high educational standard countries such as the United States of America by North Carolina 2018 [11], New Zealand by www.otago.ac.nz/education: 2018 [6], Japan by Atsushi Tsukui and Naomi Takasawa, 2017 [1], Singapore by Christine Kim-Eng Lee and Mei Ying Tan, 2010 [4], Finland by Paula Paronen and Olga Lappi, 2018 [13], Thailand by Teacher Council, 2019, and Teacher 4.0′s 7 C Skill by Pimpan Dechakup and Payao Yindaesuk, 2018 [5].

5. Recommendations for Future Research

According to the study of factor in professional teacher teaching Science and Mathematics in Thailand, found that the professional teacher’s factor, findings of factor study should be used for developing the teacher production curriculum to be ready for being professional teacher further.

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