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Research Article

A systematic review of self-efficacy studies among university students as pre-service teachers in science education

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Abstract

This paper was inspired by the author's concern in the theme of self-efficacy of learning and self-efficacy of teaching and it was initiated by a previous study (Suprapto & Chang, 2015). This study aimed at reviewing the factorial structure of self-efficacy of learning and teaching among university students as pre-service teachers. The review intended not only to summarise the context of self-efficacy in the domain of science education but it also planned to explore the instrument, sample selection, validity, and reliability as reported in empirical studies. A total of 25 articles that met the criteria set and deduced from the experiencing data by using selection study method. The criteria considered the articles were indexed in Scopus and Web of Science which published from January 2008 to December 2017. Each paper focused on biology education, chemistry education, and physics education. How the researchers conducted an analysis of data and their findings have been described. Additionally, the summary of the development process of the science self-efficacy scale and the implication for future research were also described in this study.

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Introduction

Even though, numerous studies have revealed student self-efficacy in education, however, a few studies dedicated on university students' self-efficacy in science education (SE) (Suprapto & Chang, 2015). Originally, Albert Bandura well-defined 'perceived self-efficacy' as "beliefs in one's capabilities to organise and execute courses of action required to produce given attainments" (Bandura, 1997). It means an individual's belief in their competency to manner with the tasks and actions for completing certain performance or goals. Self-efficacy is an important variable for students to reflect their learning because it gives more attention about their beliefs in order to achieve the usefulness of learning process (Zimmerman, Bonner & Kovach, 2006). The aim of self-efficacy reflection is to make students more precise in monitoring the learning process. Pajares and Schunk (2001) argued that self-efficacy should be explicitly into a specific domain or a dependent construct. This expression gives us an implication that self-efficacy was not constant and it should not be assessed in a general term. Therefore, self-efficacy needs a more specific factor and explicit dimension.

There are four sources that influence self-efficacy (Bandura, 1997): "enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological-affective states". Mastery experience is the most factor on self-efficacy since it provides the most authentic evidence among students to succeed. Vicarious experience is the experience in relating to an individual on how he/she observes the performance of others (Cone, 2009). Meanwhile, verbal persuasion represents the meaningful feedback when student gains some experiences from others. Besides, "physiological-affective states refer to those physical and emotional responses experienced due to stress, fear, and/or anxiety" (Bernadowski, Perry, & Del Greco, 2013).

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Since the era of Bandura, numerous studies have stressed on self-efficacy in SE either teaching or learning efficacy. The main focus has ranged from elementary science students to university levels (Suprapto, Chang, & Ku, 2017). However, only few studies focused on University students' self-efficacy scale (such as Bernadowski et al. (2013); Lindstrøm & Sharma (2011); Uzuntiryaki & Aydın (2009); etc.). For teaching efficacy, Mehdinezhad (2012) found that the faculty members had higher teaching efficacy in all dimensions that constructed the factor structures. For learning efficacy, Bernadowski et al. (2013) described that students' self-efficacy is value-added when their learning is associated with a specific goal. Self-efficacy beliefs give impact to students' self-regulatory learning, such as increasing students' score in the classroom (Zimmerman et al. 2006). Previous studies have sight seen the significant impact of students' self-efficacy on their conceptions of learning in science education (Chiou & Liang, 2012; Tsai, Ho, Liang, & Lin, 2011). "There was a positive correlation between students' performance in tasks and their self-efficacy beliefs" (Suprapto et al. 2017). Consequently, students who perceived substantial self-efficacy beliefs in engaging a given task they will enjoy in the task, while students who perceived weak self-efficacious, they will avoid the task (Pintrich & Schunk, 2002).

Research about self-efficacy in science education become essential issue due to this concept is owned by pre-service teachers that can make they prefer to act, have more desire to try new ideas and teaching strategies that can improve student learning processes, and persist in helping student learning processes in the future when they become teachers. In the current study, some previous researches of university students' learning efficacy in science education domain are analysed and reviewed. By using a selection method, then this study becomes more focused. Therefore, the objective of this study is reviewing how the preceding researchers developed the self-efficacy scale and how they examined their substantial information.

Problem of Study

In bare, this study is directed to analyse a questionnaire of previous inquiries. It is noted that this study is fixed in the earlier empirical studies only. This study is also supported by the author's experiences in dealing with developing scale studies through survey research (see Suprapto et al. 2017; Suprapto, 2019a; and Suprapto, 2019b). To sum up, this study was focused on the following research questions.

- To what extent do the developments process of the self-efficacy scale of pre-service teachers in science education?
- What are the dimensions of the self-efficacy in science education proposed by the author?

Method

The Procedure of Systematic Review

This study revised and made counterpart information of the previous study by Suprapto and Chang (2015). Therefore, the process of systematic review followed the direction of previous researchers (such as Suprapto, 2016). The process has started from defining the purpose of research and was followed by conducting of literature-searched. Then, the process continued by selecting the articles by reading abstracts to capture the main idea of the previous study. For clarification and depth understanding, reading a full paper became important. The procedure continued by data abstraction and analysing to describe the conclusion based on the objective of the study.

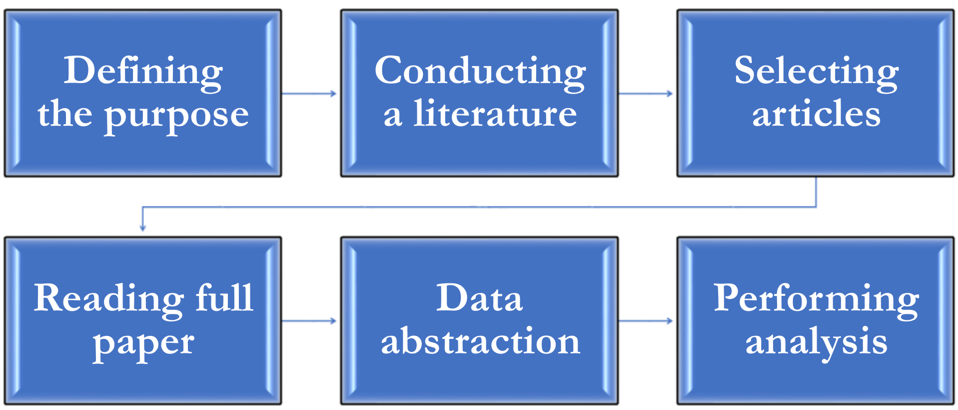

Figure 1.
The Procedure of Systematic Review (modified from Suprapto & Chang (2015))

Selection Studies Process

The review focused on four criteria: how researchers made sample selection, self-efficacy scale, analysis of data and findings, and the subjects were university science domains (physics, chemistry, and biology). To identify relevant studies on university students' self-efficacy, the articles that focused on self-efficacy of pre-service teachers in science education and indexed by the Scopus database and Web of Science were selected. The surveying approach utilised article abstracts and keywords of these journals published from January 2008 to December 2017.

Searching Criteria

A primary search using the words "self-efficacy" resulted in abundant results, many of which were not precisely at university level.

"[All: self-efficacy] AND [Publication Date: (01/01/2008 to 12/31/2017)]" Therefore, the next searching by narrowing the scope with terms: "university students" or "college students" or "undergraduate students", or "pre-service teachers", or "prospective teachers" or "student teachers". Additionally, the author specifically searched for studies in the four main science education disciplines: "physics", "chemistry", "biology", and "earth science". Paper has not fulfilled the criteria excluded, (such as if the participants were primary science teachers, teachers' self-efficacy, junior and senior high school students). Originally, 306 papers matched the keywords. However, only 25 articles met the criteria includes the context of self-efficacy with specific sample selection, instrument's validity and reliability, as shown in Table 1.

In the following step, from 25 articles within an interval of ten years (2008-2017) remained was eligible for the current study. From the obtained collections, those articles were selected that present empirical studies, including self-efficacy scale, validity, and reliability in the sense identified above. Some authors stated clearly the set of their disciplines; some did not provide any information at all. The descriptions of the papers were chosen as representative: Lin et al. (2015b), Lindstrøm & Sharma (2011), Lin et al. (2015a), Uzuntiryaki & Aydın (2009), Krause et al. (2017), and Tanel (2013).

Table 1.

Paper Selection and Sources of Journal

Stage	Number of papers based on keywords	Numbers of papers that met the criteria of the study	Sample of articles
1	222	7	Cartwright & Atwood (2014); Ibrahim, Aulls, & Shore (2016); Lin, Liang & Tsai (2015b); Lotter, Smiley, Thompson, & Dickenson (2016); Tuzuna & Topcu (2008); Shen, Lee, Tsai, & Chang, (2016); Yilmaz-Tuzun & Topcu (2008)
2	57	3	Kırık (2013); Lin, Liang, & Tsai (2015a); Uzuntiryaki & Aydın (2009)
3	9	3	Doğru (2017); Krause, M., Pietzner, V., Dori, Y. D., & Eilks, I. (2017); Šorgo et al. (2017)
4	14	11	Bursal (2015); Çalışkan, Selçuk, & Erol (2010); Efe (2015); Güzeller & Özkal (2013); Ilhan, Yilmaz, & Dede (2015); Kurbanoğlu & Akin (2012); Sadi & Uyar (2013); Suprapto, Chang, & Ku (2017); Tatar & Buldur (2013); Tanel (2013); Temel, Şen, & Yılmaz (2015)
5	4	1	Lindstrøm & Sharma (2011)
	306	25	

Results and Discussion

Previous researchers concerned the self-efficacy through survey study in science education major. They used a Likert type scale questionnaire in their instruments. Most of the researchers reported that the rating scales were belonged to interval data. An interval response scale used to indicate a respondent's level of opinion or perception based on the statements (Privitera, 2014). Therefore, a self-efficacy scale is discussed here as an interval scale. This situation in-lined with some scholars who remarked that in attempting item's factor analysis at least the ordinal level of data should be addressed (Brace, Kemp, & Snelgar, 2006).

Turning to the selection of the study method above, six articles from science education views were deduced from the empirical data. Each of the articles focused on physics, chemistry, and biology; three articles in the physics domain, while others come from the domains of chemistry and biology. In addition, two papers were conducted in university in Taiwan and Turkey while the others in Australia and Germany. Based on Table 2, the previous researchers developed the self-efficacy item scale in science major and how they analysed their data. Looking at the number of participants, some researchers used a large sample (more than 250). It was intended to obtain the stability of the data. Mainly, Lindstrøm & Sharma (2011) used participant between 122 and 281 each time over a year due to their Cohort study in the part of the methodology. As a general rule, most dimensions could be estimated with relative stability for 200 samples as respondents. This number is considered as the minimum number in survey study (Suprapto et al., 2017; Suprapto, 2019a). Additionally, the proportion between the number of item scale and participants should be at least 1:10 (Lin et al. 2015b; Suprapto, 2019b; Uzuntiryaki & Aydin, 2008). For example, if the number of items is 20 then the minimum of participant should be 200 respondents.

Regarding how the researchers conducted an analysis of data, the majority used exploratory factor analysis (EFA) to identify the factor structure of the questionnaire instrument (see Table 3). Some of them continued to confirmatory factor analysis (CFA) to create cross-validating each item and reliability coefficients to estimate each dimension's internal consistency. In working with an analysis of factor or dimension, the preliminary set of factor loadings was attained by referring a suitable calculation of the loadings as un-rotated or initial loadings. Then, all researchers in these cases considered the rotated loading to estimated simple configuration of items' structure. For instance, Uzuntiryaki and Aydin (2008) used an oblique rotation rather than orthogonal rotation. On the other hand, some researchers used *varimax* rotation as the well-known method for orthogonal rotation, such as two papers from Taiwan, (study A and study C) indicated a *varimax* rotation as a way to performance principal component extraction (PCA). Other ways, some researchers also provided farther content validity evidence. For the persistence of content validation, "some experts in science, measurement, and psychology view were asked to assess the quality of each item, verify matching of items to the corresponding dimensions, and provide further suggestions" (Suprapto & Chang, 2015).

Table 2.
Overview of Sample Articles Analysed in This Review

Author(s)	Level and total number of participants	Instrument: Questionnaire	
		Name of instrument and Dimension	Number of items
Lin et al. (2015a), Physics, Taiwan (study A)	Undergraduate, N=250	Physics learning self-efficacy (PLSE): "Conceptual Understanding, Higher-order cognitive skills Practical work, Everyday application, and Science communication"	32 items
Uzuntiryaki & Aydin (2008), chemistry, Turkey (study B)	College students, 1st phase, N= 363; 2nd phase, N =353	Chemistry Self-Efficacy Scale (CCSS): "Knowledge/ comprehension-level skills, Higher-order skills, Psychomotor skills, and Everyday applications"	22 items (original); 21 items (final)
Lin et al. (2015b), Biology, Taiwan (study C)	(18%) Master; (82%) Undergraduate; N= 293	Biology learning self-efficacy (BLSE): "Higher-order cognitive skills, Everyday application, Science communication, and Practical work"	27 items
Lindstrøm & Sharma (2011), Physics, Australia (study D)	Undergraduate (*N* = 122 to 281)	The Physical Self-Efficacy Questionnaire (only 1 factor/ dimension since the author only focused on Physics self-efficacy items)	5 items
Krause et al., (2017), Germany, Chemistry (Study E)	Prospective chemistry teachers (N = 239)	Totally 4 scales: "Attitudes towards using ICT in education in general; Self-efficacy on the use of ICT in education in general; Attitudes towards using ICT in chemistry education; Self-efficacy on the use of ICT in chemistry education"	40 items (10 items each scale)
Tanel (2013), Physics, Turkey (study F)	Prospective physics teachers (N=136)	SETFM scale: "self-efficacy about teaching the subjects of force and motion"	22 items

The Process of Developing a Self-Efficacy Questionnaire

For the recommendation of future research, Figure 2 summarises the development process of the science self-efficacy questionnaire. The diagram was also compatible with developing general self-efficacy and an alternative way of how to analyse the data. Both EFA and CFA have similarities: both methods are derived from general linear models and assume a normal distribution, these methods are valid if a certain assumption is met, and both incorporate measured variables and latent constructs. Moreover, there are several criteria for conducting data analysis, both EFA and CFA (summarised from the papers were discussed): Exploratory Factor Analysis (EFA):

- EFA was employed to explore the composition of factor structure among sets of the observed variable while CFA was utilised to confirm these structures among sets of observed variables.
- The validation criterion of EFA was the loading factors of the retained items must greater than .4 (Stevens, 2002). In other words, the items with a factor loading of less than .4 were excluded.
- The circumstance for factor extraction was the criteria of eigenvalue greater than 1 (e>1) indicating the estimated structures (at least four-factor loadings over .60) (Suprapto et al. 2017).
- For interpretability criteria, at least 3 items with significant loading over .30.
- The percentage of variance resulted for retaining a factor if it calculates for a cumulative number of the variance (i.e., 25%, 30%, 40%). The factor must enlighten at least 50% of the variance.

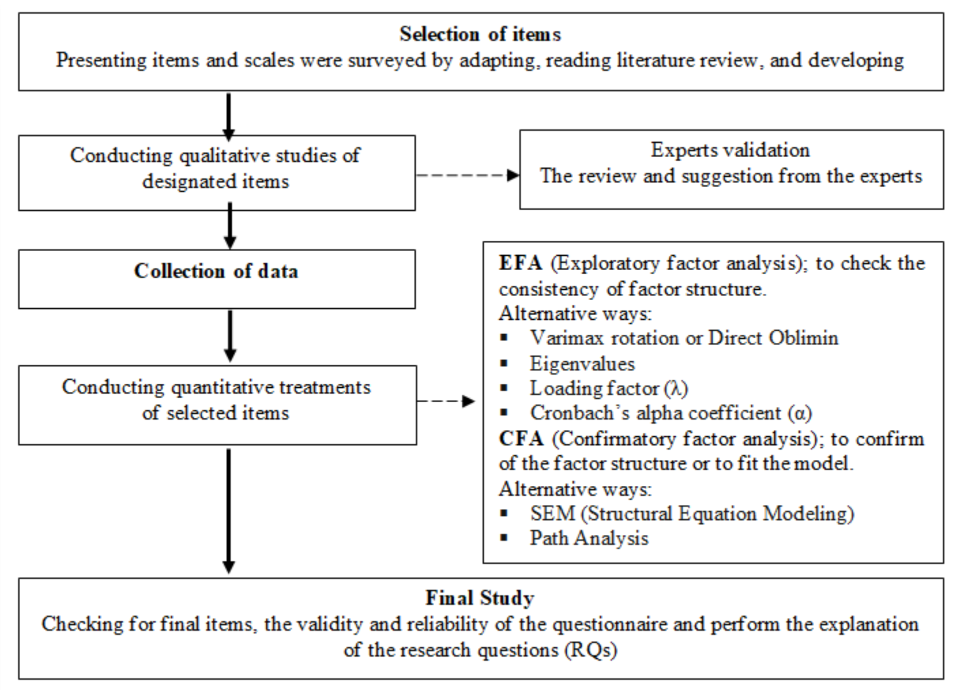

Figure 2.

The Development Process of Science Self-efficacy Questionnaire (Suprapto, 2019a)

Confirmatory Factor Analysis (CFA):

- The comparative fit index (CFI), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI) must .90 or greater from ranges 0 to 1, (a larger value indicating better model fit) (Lindstrøm & Sharma, 2011; Uzuntiryaki & Aydin, 2008).
- "The ratio of each parameter estimate to its standard error is distributed as z statistic, significant at the .05 level if its value exceeds 1.96 and at .01 level if its value exceeds 2.56" (Hoyle, 1995).
- Root Mean Square Error of Approximation (RMSEA) must .05 or less. However, the range between 0.05 and .08 are also tolerable for model fit (Joreskog & Sorbom, 1993).

Descriptive Analysis:

- Considering the pre and post survey, to determine a mean score for each group then the total points each item was calculated and divided by the total of participants (Lindstrøm & Sharma, 2011).
- The different mean score (Δ) can be calculated by using the formula: $\Delta = Pre - Post$.
- The combination of mean rating score was estimated for each item. For example, "the rating score was calculated by assigning a value of four points to an answer of strongly agree, 3 points to agree, 2 points to disagree and 1 point for strongly disagree" (Lindstrøm & Sharma, 2011).

Table 3.
Summary of Data Analysis in Paper Selected by Using EFA and CFA

Type of Analysis and the Results	
Content Validation and Factor Analysis	**Internal Consistency from Cronbach's Alpha (α)**
***Study A*- (no information about content validation provided)**	
EFA ✓ The criterion of loading factors is the reserved items must greater than .4. ✓ The rotation principle used principal component analysis (PCA) with a varimax rotation. ✓ The eigenvalues of all factors from the PCA were all larger than one. ✓ The EFA resulted a number of 65.60 % as a total variance explained.	✓ Cronbach's alpha coefficients for the five factors were .80; .80; .90; .86; and .90 respectively. ✓ The overall alpha was .95, indicated that these factors had high internal consistency in measuring the participants' five dimensions of PLSE.
***Study B:* 11 experts in chemistry education, chemistry, educational measurement and psychology**	
Exploratory Factor Analysis (EFA) for original sample ✓ The gained of Kaiser Meyer Olkin (KMO) was .92 and the Bartlett's test perform X^2=3067.45, p<.001. ✓ All 22 items were extracted into three factors with eigenvalues > 1. ✓ The rotation principle used direct oblimin as a variant of an oblique rotation. All items with loading factor λ>.30. ✓ Totally, the items explained 51% of the variance.	✓ The gained of alpha was indicated a satisfactory reliability ".92 for the SCS, .87 for the SPS, and .82 for the SEA" (Uzuntiryaki & Aydin, 2008), (the factor of self-efficacy for higher-order skills *was added as a new dimension after EFA*)
Confirmatory Factor Analysis (CFA) for final sample ✓ The gained of NFI=.98; CFI=.98; RMSEA=.08, indicating an acceptable model.	✓ All items in each dimension contributed to the internal consistency with value higher than .60.
***Study C*- (no information about content validation provided)**	
EFA ✓ The result of Bartlett's test was significant and it also supported by the KMO value was .95 and the total variance explained was 63.68% ✓ PCA with varimax-orthogonal rotation was piloted to extract the items to their suitable factors. ✓ The skewness and kurtosis were used to examine the distribution of the data	✓ The reliability coefficients (Cronbach's alpha) of the factors in the BLSE were .89, .89, .91, and .89, respectively and the overall alpha was .96.
***Study D:* Three experienced physics education experts (also expert in self-efficacy and related constructs)**	
Initial trial (EFA) ✓ The scree plot clearly indicated one factor only; factor rotation did not use and the factor explained 56% of the variance. ✓ All the scale (5 items) had factor loadings between .694 to .821. Confirmatory trial (CFA) ✓ Through Amos 7.0 software, the study provided χ2 = 2.127, p = .831 (p>.05). ✓ The output of CFA: RMSEA =.000; RMR = .009; GFI = .998; NFI=.994; and CFI = 1.000 mainly showed the best model fit. Final checks for stability and invariance ✓ Criteria; "A questionnaire is invariant if the factor structure for data from different samples from the population is consistent" (Lindstrøm & Sharma, 2011).	✓ Overall Cronbach's α=.796 represented sufficient reliability to assess the Physical Self-Efficacy of undergraduate student.
***Study E:* No information available for content validation**	
✓ All 40 items were ranked allowing to a five-point Likert scale (1 = "agree" to 5 = "strongly disagree"). ✓ The research didn't provide the information about the process of validation process. The authors performed the Mann-Whitney U-test subjected to statistical analysis for non-parametric data.	✓ The values of Cronbach alpha were between .76 and .86 with distribution of the Scale 1: (α = 0.76), Scale 2: (α = 0.86), Scale 3: (α = 0.77), Scale 4: (α = 0.80)
***Study F:* Adaptation from previous studies (Ishak, 2008)**	
✓ The KMO value was a high (0.93) and the Bartlett's Test was significant. ✓ EFA with PCA was utilised to examine the construct validity of the scale and it explained 54% of the variance. ✓ The factor loading values ranged between 0.59 and 0.82, (in the range of Stevens (2002)).	✓ The overall Cronbach's alpha coefficient was 0.96 with indicated a high reliability.

The Dimension of Self-Efficacy in Science Education

Table 4 articulates the possibility of dimensions relating to university student self-efficacy in science. The author adds two dimensions, namely self-assessment (SA) and self-learning strategy (SLS) as part of the new dimension of self-efficacy. An objective reasoning could be derived for this decision is many previous studies explored the relationships between pre-service teachers (student teachers) and their science achievement, science assessment, and cognitive and/or metacognitive abilities. This argument also in-lined with Mehdinezhad (2012), the dimensions of self-efficacy included subject matters, curriculum and instruction, communication competences, assessment, learning environment and implementation of technology. Turning to metacognitive beliefs, student teachers have self-learning strategy (SLS) and self-assessment (SA). Metacognition in SE is incorporated into research addressing the core aims of science instruction including learning strategy and assessment due to its' development and expansion (Zohar & Barzilai, 2013). It means learning strategy and assessment as part of the course of instruction.

On the other hand, the dimensions such as higher-order thinking skills, conceptual understanding, everyday application, practical work, and science communication are the derivation of self-efficacy dimensions through this systematic review as a routine dimension. Conceptual understanding in SE was found to be one of the key objectives of current metacognition research. We need to employ a wide range of instructional practices for fostering student teachers' metacognition based on those routine dimensions.

Table 4.
The Possibility of Dimensions Related to University Student Self-efficacy in Science Education

No	Dimension (based on the results of review)	Dimension (author's proposed)
1	Conceptual Understanding Knowledge/ comprehension-level skills Subject matters	Conceptual Understanding (CU)
2	Higher-order skills	Higher-order thinking skills (HOTs)
3	Practical work Psychomotor skills	Practical work (PW)
4	Everyday application Implementation of technology	Everyday application (EA)
5	Science communication Communication competences	Science communication (SComm)
6	Curriculum and instruction Learning environment	Self- Learning Strategy (SLS)
7	Assessment	Self-Assessment (SA)

Conclusion and Recommendations

Generally, the objectives of the factors analysis cover the following main points: (1) reducing the number of originating variables into fewer new variables (reducing data); (2) identifying the relationship between variables forming factors with the factors formed through EFA; (3) testing the instrument's validity and reliability with CFA; (4) test data validation to find out whether the results of factor analysis can be generalised to the population; and (5) the use of factor analysis in integration with other analysis techniques.

Based on the criteria in selection studies, the conclusion can be drawn from how researchers made sample selection, self-efficacy scale, and analysis of data and findings. First, the number of samples (participants) in corresponding to the relative stability should be considered by the researchers in conducting survey study. Second, seven factors or dimensions have been proposed in accordance with the self-efficacy scale in university science students as pre-service teachers, including: conceptual understanding (CS), higher-order thinking skills (HOTs), practical work (PW), everyday application (EA), science communication (SComm), self-learning strategy (SLS), and self-assessment (SA). Third, there were several criteria in accompanying with data analysis in self-efficacy scale by considering the source of parameter results of Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA) and descriptive analysis as described in discussions part above.

For further research, it is highly suggested to use the combination of EFA dan CFA simultaneously. EFA is used when the study is looking for a structure of a variable, or it is called the data reduction method. EFA can trace correlations based more on actual data than based on theory. Assumptions of doing EFA are there is multivariate normality, homoscedasticity, linearity, and data are continuous (Mindrila, 2017). EFA is used in conditions where the researcher does not have preliminary information, or the hypothesis must be grouped into whichever variable a set of indicators has been made (Fabrigar & Wegener, 2012). So, the researcher departs from the indicator (manifest) and then forms the variable or dimension. Meanwhile, at CFA, researchers have already an initial assumption that the indicators fall into certain latent variables or dimension (Brown, 2015). Thus, the purpose of CFA is to confirm or test a model, namely a measurement model whose formulation comes from the theory previously carried out through extraction via EFA as done by several authors in the sample selection in this study.

For the applicant, the author recommends to seven dimensions of self-efficacy in science education with its scale (see Appendix) should be used to research concern in the theme of self-efficacy of learning and self-efficacy of teaching. These set of dimensions has gone through the stages of gradual generalisation from similar research related to self-efficacy in science education. As we know the positivism paradigm, especially survey research, is still the favourite among researchers including science education, so the choice to use the support of tools such as statistics, in this case, the EFA and CFA are highly recommended for researchers.

Limitations of Study

This systematic review involved only 25 articles that met the criteria from the selection study method. This number is not sufficient to represent all ideas about scales related to self-efficacy in science education. Therefore, further research is needed on this topic. Besides, the surveying approach utilised article abstracts and keywords of these selected journals published from January 2008 to December 2017. It could be that in 2018 until now, research on self-efficacy in science education, primarily related to the questionnaire scale, is also developing. Thus, further study on this topic is still very much needed.

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[Note: * Articles were selected in the review process]

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Appendix
Self-efficacy Scale

Conceptual Understanding (CU)
1. "Learning science means understanding science-related knowledge".
2. "Learning science means understanding the connection between science concepts".
3. "Learning science is to realise the true meanings of science theories and formulae".
4. "Learning science enables me to understand science-related questions and phenomena".
5. "Learning science can expand my knowledge and vision".

Higher-order thinking skills (HOTs)
6. "I am able to design science experiment to verify my hypothesis".
7. "I am able to propose many solutions to solve a science problem".
8. "When I come across a science problem, I will actively think over it first and devise a strategy to solve it".
9. "I am able to make systematically observations and inquiry based on a specific science concept or scientific phenomenon".
10. "When I am exploring a science phenomenon, I am able to observe its changing process and think of possible reasons behind it".

Practical work (PW)
11. "I know how to carry out experimental procedures in the science laboratory".
12. "I know how to use equipment in the science laboratory".
13. "I know how to set-up equipment of laboratory experiments".
14. "I know how to collect data during the science activities".
15. "I can write a laboratory report to summarise main findings".

Everyday application (EA)
16. "I am able to explain everyday life by using science theories".
17. "I am able to propose solutions to everyday problems by using science".
18. "I am able to apply what I have learned in school science to daily life".
19. "I am able to use scientific methods to solve science problems in everyday life".
20. "I can understand and interpret social issues related to science in a scientific manner".

Science communication (SComm)
21. "Learning science supports me to express my own opinions".
22. "I always give comment on presentations made by my classmates in science class".
23. "I think it is important to communicate the science phenomena after learning science".
24. "I learn science so that I can clearly explain what I have learned to others".
25. "I feel comfortable to discuss science content with my classmates".

Self- Learning Strategy (SLS)
26. "Learning science enables me to understand the scientific approaches".
27. "Learning science enables me to understand the scientific models".
28. "Learning science enables me to choose varieties of learning strategies".
29. "Learning science enables me to choose varieties of learning methods".
30. "Learning science enables me to understand the scientific representations".

Self-Assessment (SA)
31. "Learning science means getting high scores on examinations".
32. "Learning science is to answer examination questions correctly".
33. "The major purpose of learning science is to get more familiar with test materials".
34. "I learn science so that I can do well on science-related tests".
35. "There is a close relationship between learning science and taking tests".