Chemistry student’s virtual laboratory self-efficacy: A scale development

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Abstract. Self-efficacy is described as an individual's beliefs about their abilities to complete an action. It is a part of the social cognitive theory in the chemistry learning process. Self-efficacy consists of six aspects, namely the choice of activities, effort, perseverance, learning, achievement and strategy or orientation. The objective of this study was to develop an instrument of chemistry student virtual Laboratory self-efficacy (CSVL-SE) in a virtual laboratory within the chemical equilibrium topic. This research used research and development (R&D) method. The data was obtained through a self-efficacy questionnaire. The expert confirmed the content validity with 26 items that had been administered to 60 students in senior high school. Rasch Model used to analyse the data that met the unidimensionality, item fit, difficulty or ability estimation, reliability, and information function. The findings showed that 26 items match into the Rasch Model with reliability person and reliability item of 0.84 and 0.97. So that, this instrument is appropriate to collect the data.

1. Introduction
Self-efficacy is something that humans must have to do something, as well as in the learning process. Self-efficacy is a person's belief about their ability to organize and execute an action in order to achieve the desired goal [1]. Based on cognitive social theory, self-efficacy will affect the choice of activities, effort, persistence, [2] achievement, learning and strategy-oriented [3]. Further, students who have higher level of self-efficacy will have more influence on education because of their high motivation [4]. Thus, low level of students’ self-efficacy tend to evade many tasks, especially difficult or challenging ones [3].

Chemistry is a discipline of science that contains many abstract concepts that often cause problems in conceptual learning [5] so that practical activities are needed to prove the theory being studied. However, the fact is that there are still many schools that do not have adequate laboratory facilities. This is supported by other researcher which states that in the 2015/2016 academic year the percentage of high schools having adequate laboratories was only around 36.23% consisting of 44.33% for state schools and 28.11% for schools private [6]. The development of science and technology that continues to grow day by day can be a solution to the limited availability of laboratories. one of the learning media that can replace laboratory functions is a virtual laboratory. Students who used virtual chemistry lab both as a replacement and supplement of hands-on laboratory mostly had a better level of self-efficacy [7].

Self-efficacy value has a positive influence on academic performance of the students in chemistry lessons [8,9]. Furthermore, application of virtual laboratories works to increase self-efficacy [10]. Thus, the use of virtual laboratory media significantly improved the learning outcomes of the students [11].
However, learning outcomes cannot only be measured from the cognitive aspect. Mastery learning students are also influenced by low motivation and self-efficacy [12]. The cognitive and affective aspects assessment of learning outcomes should be done concurrently. Students who have a good affective aspect will also have good cognitive skills in learning process [13]. Thus, it is a necessary integrated instrument of chemistry student virtual laboratory self-efficacy that needs to be developed which aims to know student's self-efficacy when doing experimental use virtual laboratory. This study aims to measure the validity and the reliability of self-efficacy instrument and its development in the chemical equilibrium topic. Thus, to analyze the items quality using item response theory. In addition, this research would give information about its construct validity.

2. Method
There were 60 participants of 12th-grade students in the special region of Yogyakarta, Indonesia in this study. Procedural development research model which is descriptive research, provide the following steps to produce self-efficacy questionnaire as the final product. So that the result of this instrument will be applied in research and development (R&D) to know self-efficacy chemistry students using Virtual Laboratory in chemical Equilibrium. Thus, from the self-efficacy theory, the researchers arrange the validity of the content who confirmed to experts' judgment. The questionnaires used to know empirical validity value.

3. Result and Discussion

3.1 Unidimensionality
Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) approaches used to test the unidimensionality [14]. CFA is appropriate when the scale has known factor properties, while an EFA is more appropriate when the scale is relatively undetermined. The KMO-MSA value in this study is .631. This result indicates that the sample is qualified (.631 > .05) and the result test of Barlett Sphericity indicates that the variable of this study is correlated (.00 < .05). Thus, this study proper on unidimensionality or construct validity. If the KMO-MSA is higher than 0.6 and significant at α <0.05 for Bartlett Sphericity test, a factor of the correlation matrix is assumed [15]. The result presented in Table 1.

| Test | Student’s virtual laboratory self-efficacy | Conclusion for Factor Analysis |
|------|-------------------------------------------|--------------------------------|
| KMO-MSA test | .631 | Appropriate |
| The significance value of Barlett Sphericity test* | .00 | Appropriate |

*statistical significance level of .05

Based on KMO-MSA results obtained that the KMO value fulfilled. Hence, assumption of the unidimensionality can be analyzed by using the EFA. The results are presented in Table 2.

| Component | Initial Eigenvalues Total % of Variance | Component | Initial Eigenvalues Total % of Variance |
|-----------|----------------------------------------|-----------|----------------------------------------|
| 1         | 5.356 | 20.599 | 6 | 1.362 | 5.240 |
| 2         | 4.621 | 17.773 | 7 | 1.295 | 4.980 |
| 3         | 2.068 | 7.953 | 8 | .981 | 3.773 |
| 4         | 1.749 | 6.725 | 9 | .957 | 3.681 |
| 5         | 1.560 | 6.000 | … | .74 | .285 |
Table 2 shows that 7 eigenvalues have values greater than 1,000. Thus the variance of the 7 factors presented as the response of tested participants to the integrated assessment. Total variance of 7 factors can account is 69.27%. The unidimensionality assumption result can also be observed through the scree plot. Thus, scree plot illustrated the eigenvalues by the number of components that preserve the factors.

![Scree Plot](image)

**Figure 1.** CSVL-SE scree plot

Figure 1 confirms the integrated assessment instrument of seven factors. The percentage of a dominant factor was 20.599%. The output in exploratory factor analysis has a dominant factor with over 20% of the variance, it means that the unidimensionality assumption could be considered acceptable [16].

### 3.2 Items Fit

The Partial Credit Model 1 Parameter Logistic (PCM 1-PL) used in the Rasch Model appropriated for the polytomous data analysis. The fit index requires for measure item empirically in Rasch Model. As stated in Boone [17] the criteria used to know the appropriate item as it follows, (a) Outfit Mean Square (MNSQ) Value accepted: $0.5 < \text{MNSQ} < 1.5$; (b) Outfit Z-standard (ZSTD) value accepted: $-2.0 < \text{ZSTD} < +2.0$; and (c) Point Measure Correlation value (Pt Mean Corr) between: $0.4 < \text{Pt Mean Corr} < 0.85$. The list of the item fit results are presented in table 3 below.

### Table 3. Result of Item Fit analysis

| Item | Outfit MNSQ | Outfit ZSTD | Pt- Measure Correlation | Conclusion | Item | Outfit MNSQ | Outfit ZSTD | Pt- Measure Correlation | Conclusion |
|------|-------------|-------------|--------------------------|------------|------|-------------|-------------|--------------------------|------------|
| 25   | 1.49        | 2.5         | .22                      | Not fit    | 16   | .96         | -.1        | .36                  | Fit model  |
| 24   | 1.39        | 1.9         | .20                      | Fit model  | 19   | .95         | -.2        | .47                  | Fit model  |
| 3    | 1.24        | 1.2         | .35                      | Fit model  | 6    | .96         | -.2        | .36                  | Fit model  |
| 7    | 1.24        | 1.4         | .35                      | Fit model  | 5    | .97         | -.1        | .44                  | Fit model  |
| 2    | 1.21        | 1.1         | .22                      | Fit model  | 21   | .95         | -.3        | .51                  | Fit model  |
| 22   | 1.18        | 1.1         | .45                      | Fit model  | 14   | .93         | -.3        | .29                  | Fit model  |
| 9    | 1.16        | 1.0         | .46                      | Fit model  | 13   | .83         | -.9        | .40                  | Fit model  |
| 18   | 1.14        | .9          | .32                      | Fit model  | 20   | .82         | -1.0       | .36                  | Fit model  |
| 26   | 1.04        | .3          | .49                      | Fit model  | 11   | .82         | -1.2       | .46                  | Fit model  |
| 23   | 1.01        | .1          | .26                      | Fit model  | 10   | .74         | -1.4       | .47                  | Fit model  |
| 15   | 1.02        | .2          | .31                      | Fit model  | 1    | .72         | -1.6       | .37                  | Fit model  |
| 12   | 1.02        | .2          | .50                      | Fit model  | 17   | .68         | -2.2       | .61                  | Fit model  |
| 4    | 1.01        | .1          | .54                      | Fit model  | 8    | .64         | -2.6       | .66                  | Fit model  |

If the item fit statistic is acceptable, then the item can be considered as a valid item [18]. The analysis was used to detect whether the items have functioned properly in measuring or not. According to Table...
3, the item fit measurement output analysis were used Winstep program. 1 item is not a fit model, namely item 25 and rest of the item are fit model, so that the item can be considered as a valid item.

3.3 Difficulty/ability estimation
The item difficulty index was used to find out the proper answer at specific ability levels of the problem. The difficulty index was measured to get proportion of test takers responding to the item accurately. A good instrument item have difficulty value may range between -2.0 logit and +2.0 logit [19]. An item categorized as a very difficult item with difficulty index above +2.00 logit and considered as a very easy item if they have difficulty index below -2.0 logit. As a result, 26 items are obtained fit in the measurement. The list of the item difficulty are presented in Table 4 below.

**Table 4. Item difficulty of (CSVL-SE)**

| Item Number | Difficulty index | Category         | Item Number | Difficulty Index | Category |
|-------------|------------------|------------------|-------------|------------------|----------|
| 21          | 1.61             | Very difficulty  | 25          | -.05             | Medium   |
| 26          | 1.50             | Very difficulty  | 23          | -.65             | Easy     |
| 11          | 1.39             | Very difficulty  | 3           | -.76             | Easy     |
| 9           | 1.35             | Very difficulty  | 5           | -.84             | Easy     |
| 18          | 1.17             | Very difficulty  | 1           | -.88             | Easy     |
| 8           | 1.10             | Very difficulty  | 14          | -.88             | Easy     |
| 17          | 1.10             | Very difficulty  | 24          | -.88             | Easy     |
| 4           | 1.03             | Very difficulty  | 20          | -.03             | Very easy|
| 22          | .86              | Difficulty       | 10          | -1.07            | Very easy|
| 12          | .80              | Difficulty       | 15          | -1.15            | Very easy|
| 7           | .36              | Difficulty       | 2           | -1.19            | Very easy|
| 6           | .29              | Difficulty       | 16          | -1.48            | Very easy|
| 19          | .06              | Difficult        | 13          | -1.79            | Very easy|

3.4 Reliability
The measurements that can be replicated are defined as reliability. Before any measurement instruments or assessment tools can be used for research and applied, their reliability must be established. The result of Rash analyzed show Alpha Cronbach's value was found to be 0.80. This implies that there is an approximately 80% of the consistency in producing the similar results over and over again. Thus, the assessment of CSVL-SE has high reliability. The finding was supported by Ceniza and Cereno [21] the reliability was high reliability with coefficient range 0.81 - 1.0, range 0.61 - 0.80 indicates moderate reliability, range 0.41 - 0.60 means reasonable reliability, range 0.10 - 0.40 means low reliability, and lower than 0.10 means there is no reliability.

**Table 5. Person and Item reliability statistic result**

| Parameter (N) | MNSQ | ZSTD | MNSQ | ZSTD | Separation | Reliability | Category |
|---------------|------|------|------|------|------------|-------------|----------|
| Persons (60)  | .99  | -.4  | 1.00 | -.3  | 2.30       | .84         | High     |
| Items (26)    | .99  | -.1  | 1.00 | .0   | 5.43       | .97         | Excellent|

*Cronbach alpha (KR-20) Person Raw Score Test Reliability = .80

The reliability of the instrument was analyzed by the person and item analysis. The person's reliability is 0.84, indicates high reliability with 2.30 separation index. Further, the item reliability is 0.97, indicates excellent reliability with 5.43 separation index (Table 5). The person reliability indicates 84% consistency from all of the items instrument. Item reliability indicates 97% consistency items in acquire the similar result over and over again.

3.5 Information Function
The information function test is very useful feature of the item response theory. Capability levels estimated in the information function test [22]. The information function is the sum of the item information functions in the test [19]. Therefore, the higher the test information function is, the items in the test also have a high information function.

![Test Information Function](image)

**Figure 2.** Test Information for CSVL-SE

Figure 2 it can be concluded that 26 items tested on 60 students show that these items are suitable for knowing the level of ability of students in the low, medium and high categories. The final result of CSVL-SE has 25 items that fit with the Rasch Model. The reliability of person and item were categorized as high and excellent consecutively. The difficulty of the item was normally distributed on a five-category. Afterward, the information function test indicated the statement used is not too difficult and give good information of correspondent ability.

4. Conclusion
The study found that a scale development of the chemistry student's virtual laboratory self-efficacy (CSVL-SE) instrument has strong validity of construct and content. Unidimensionality, item fit, difficulty or ability estimation, reliability, and information function has good value. This shows that this instrument can be useful for chemistry teachers and researchers to measure the self-efficacy of students using a Virtual laboratory on Chemistry in the topic of chemical equilibrium.

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