



Proceeding of International Conference on Islamic Education and Science Development (4th ICONSIDE)

Vol. 4 No. 1 (2026) 104 – 110 | E-ISSN: 3064-2310

Mataram, 10th - 11th June 2026

Development and psychometric evaluation of a learning style instrument for chemistry learning

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Abstract. *This study aimed to develop a valid and reliable learning style instrument specifically designed for chemistry learning among senior high school students. Understanding students' learning styles is essential in chemistry education due to the abstract nature of chemical concepts and the need for effective instructional strategies that accommodate individual learning preferences. This research employed a Research and Development (R&D) approach with a descriptive quantitative design, adapting the ten-step non-test instrument development procedure proposed by Mardapi. The instrument was developed through the adaptation of the Solomon and Felder learning style instrument and validated by two chemistry education experts. Field testing was conducted with 63 eleventh-grade students at SMA Negeri 9 Bengkulu. Data were analyzed using Product Moment correlation for validity testing and Cronbach's Alpha for reliability testing. The results showed that out of 11 developed items, 10 items were valid with correlation coefficients exceeding the critical value ($r\text{-table} = 0.248$), while one item was found invalid and subsequently removed. Reliability analysis yielded a Cronbach's Alpha coefficient of 0.62, indicating a moderate level of reliability. These findings demonstrate that the developed instrument possesses acceptable validity and reliability for identifying students' learning styles in chemistry learning. Therefore, the instrument can be utilized as a practical tool to support teachers in designing more effective and student-centered chemistry learning strategies. Further refinement and broader-scale testing are recommended to improve the instrument's reliability and applicability.*

Keywords: Chemistry Learning; Learning Style Instrument; Instrument Development; Validity; Reliability.

INTRODUCTION

Chemistry learning is known as one of the challenging fields of study for many students at various levels of education. The complexity of concepts, the abstraction nature of the material, and the need to understand aspects of chemistry from both macroscopic, microscopic, and symbolic perspectives, make this subject require an effective learning approach that is tailored to the individual characteristics of students (Sukor et al., 2020; Rahmat et al., 2021). One important factor in achieving successful chemistry learning is understanding students' learning styles, which vary from individual to individual.

Learning style, defined as a person's way of receiving, processing and remembering information, plays a crucial role in determining the effectiveness of the learning process (Newton & Miah, 2017; Kharb et al., 2013). Various modern educational theories emphasize the importance of accommodating learning style variations to maximize students' learning potential (Awang et al., 2017; Rogowsky et al., 2015). In the context of chemistry learning, understanding differences in learning styles is increasingly important given the unique nature of chemical materials that include macroscopic, microscopic, and symbolic aspects (Petillion & McNeil, 2020; Treagust et al., 2018).

Several studies have explored learning styles and the instruments used in chemistry education. Mardikawati (2016) developed a software-based learning style questionnaire for chemistry preparation at the senior high school level and found that the reflector learning style

was most dominant. Alade et al. (2014) compared learning styles in public and private schools, and found that visual learning style was most dominant as well as a significant relationship between learning style preferences and student performance in chemistry subjects. Samudera et al. (2019) developed a chemistry learning instrument based on the Reading Questioning and Answering method combined with Creative Problem Solving, which proved effective in improving critical thinking skills. Meanwhile, Montenegro & Cascolan (2020) examined students' learning styles in organic chemistry courses, finding that collaborative and competitive learning styles were most dominant, while independent and participatory learning styles appeared least. They also noted some chemistry topics that were considered difficult by students.

Although many studies have been conducted on learning styles in general, instruments specifically designed to identify learning styles in chemistry learning are still very limited. The need for specific instruments arises due to the unique characteristics of chemistry learning that involve abstract understanding, molecular visualization, and interpretation of chemical symbols that require different approaches compared to other subjects (Gabel, 2015; Eilks et al., 2019). In addition, the diversity of chemistry learning methods, ranging from laboratory experiments to computer modeling, demands adjustments to specific learning styles (Tsapalis, 2020; Kousa et al., 2018). The challenges in understanding chemistry concepts also make the identification of learning styles important, as it can help educators design more effective strategies to overcome the difficulties that students often experience (Mutlu & Şeşen, 2016; Ramnarain & Ramaila, 2018). Understanding students' learning styles allows educators to create more engaging and relevant learning experiences, thus increasing students' motivation and interest in learning chemistry (Salta & Koulougliotis, 2015; Ardura & Pérez-Bitrián, 2018). Furthermore, tailoring teaching methods to students' learning styles has the potential to optimize learning outcomes through improved understanding and retention of chemical knowledge (Hussin et al., 2019; Anas et al., 2020).

The development of learning style instruments specific to chemistry learning is expected to provide deeper insights into students' learning preferences and needs. This instrument will assist educators in designing more effective learning strategies, developing appropriate teaching materials, and creating a learning environment that supports students' success in understanding chemistry concepts (Adnan et al., 2017; Cagande & Jugar, 2018). Given the importance of understanding learning styles in the context of chemistry learning and the limitations of existing instruments, the development of this instrument is an important step to improve the quality and effectiveness of chemistry education at various levels of education (Wardhani et al., 2019; Suyanti & Sormin, 2020).

METHOD

This research is a development research (Research and Development) with a descriptive quantitative approach, which aims to develop a valid and reliable chemistry learning style assessment instrument for high school students (Creswell & Creswell, 2018). The instrument development procedure adapts the 10 steps of non-test instrument development from Mardapi (2018), which include: determining instrument specifications, writing instruments, determining instrument scales, determining scoring systems, studying instruments, conducting trials, analyzing instruments, assembling instruments, measuring, and interpreting measurement results.

The instrument was developed by adopting the original version of Solomon and Felder (2005) which then went through a process of language transfer and adaptation of questions and answers in chemistry learning. The content validity of the instrument was determined through assessment by two experts, namely chemistry education lecturers, using the expert judgment method (Sireci & Faulkner-Bond, 2014). The instrument trial was conducted at SMA Negeri 9 Bengkulu, involving 63 grade XI students as research subjects, in accordance with the minimum sample size recommendation for instrument trials (Johanson & Brooks, 2010).

Data analysis includes validity and reliability tests. The validity test used the Product Moment Correlation formula with the help of SPSS for Windows (Widoyoko, 2012), where items were declared valid if $r_{\text{count}} \geq r_{\text{table}}$. Meanwhile, the reliability test used the Cronbach Alpha formula, also with the help of SPSS for Windows, with the criteria that the instrument was declared reliable if the Alpha value $> r_{\text{table}}$ (Taber, 2018).

The results of the validity and reliability analysis will be used to determine the feasibility of the developed chemistry learning style instrument. Items that meet the validity and reliability

criteria will be retained in the final instrument, while items that do not meet the criteria will be revised or eliminated, in accordance with good instrument development procedures (DeVellis, 2017). This process aims to produce an instrument that is not only valid and reliable, but also practical and effective for use in the context of chemistry learning at the high school level (Treagust et al., 2018).

RESULT AND DISCUSSION

Hasil juga mengemukakan tingkat ketercapaian target kegiatan atau atau luaran pengabdian untuk menjawab tujuan diadakannya pengabdian. (*Verdana 10 point, line spacing 1*). Pembahasan disampaikan secara berurutan sesuai dengan urutan tujuan yang telah dijelaskan pada bagian sebelumnya. Pembahasan disertai argumentasi yang logis dengan mengaitkan hasil PkM dengan teori,

Effective chemistry learning depends not only on the material presented, but also on understanding the various learning styles possessed by students. Each individual has different learning preferences, and the teacher's ability to recognize and adapt learning approaches to students' learning styles is an important factor in the success of the learning process. Therefore, the development of an instrument that can accurately identify students' learning styles in chemistry learning is a crucial step to improve teaching effectiveness. This instrument aims to assist teachers in adapting their teaching methods, so as to accommodate variations in learning styles and maximize student learning outcomes.

To ensure the quality of the instrument, researchers conducted expert validity as many as two expert judgment from the field of chemistry education at Yogyakarta State University. Based on their evaluation, it was found that some items, namely numbers 2, 3, 4, 6, 7, and 8, needed revision from the aspects of language, statement suitability, and construction. The experts assessed that some of the items were still linguistically unclear, not relevant enough to the concept of learning style being measured, and needed improvement in the drafting structure. After the revisions were made, the instrument was again consulted with both experts to ensure the changes had met the expected standards. This process was carried out until the instrument was considered suitable for use. In accordance with the opinion of Heynes et al. in Azwar (2012), content validity shows the extent to which the elements in the instrument are truly relevant and representative of the construct being measured, ensuring this instrument is in accordance with the purpose of measuring learning styles in chemistry learning.

After passing the expert validation stage, the learning style instrument developed and ready to be tested for validity and reliability consists of 11 statement items. Each statement includes auditorial, visual, and kinesthetic learning style options. Testing the validity of these instrument items is done to prove empirically that the items are valid, by meeting the instrument criteria through Product Moment correlation analysis. The results of the validity test in the second stage in the field, using the Product Moment correlation method, can be seen in Table 1.

Table 1. The results of the validity data test of learning style instruments with SPSS

Item Description	R _{count}	R _{table}	Result
P1	0.4	0.248	Valid
P2	0.502	0.248	Valid
P3	0.524	0.248	Valid
P4	0.67	0.248	Valid
P5	0.453	0.248	Valid
P6	0.39	0.248	Valid
P7	0.229	0.248	Invalid
P8	0.451	0.248	Valid
P9	0.503	0.248	Valid
P10	0.394	0.248	Valid
P11	0.424	0.248	Valid

Based on the results of the instrument item validity test using Product Moment correlation, the interpretation shows that of the 11 statement items, 10 items are declared valid, while 1 item is invalid. The R_{count} value of each item is compared with the R_{table} of 0.248, where

items that have R_{count} greater than R_{table} are declared valid. Items declared valid include P1, P2, P3, P4, P5, P6, P8, P9, P10, and P11, with R_{count} values ranging from 0.39 to 0.67. This indicates that the majority of statements in the instrument have good validity and can be used to measure students' learning styles. However, item P7 had an R_{count} value of 0.229, which was lower than R_{table} , so this item was declared invalid. Therefore, item P7 was removed from the instrument.

After reducing invalid items, 11 items were obtained as shown in table 2.

Table 2. Valid Instrument Item Statements

Indicator	Answer Option	Learning Style	Statement	Item No.
Detail-oriented	A	Visual	I am a person who...	1
Likes to discuss and explain	B	Auditory		
Likes to engage in many activities	C	Kinesthetic		
Remembers what is seen better than what is heard	A	Visual	I find it easier to remember something that...	2
Learns by listening and recalling discussions	B	Auditory		
Physically oriented and active	C	Kinesthetic		
Detail-oriented	A	Visual	When learning chemistry, I prefer to...	3
Likes reading aloud	B	Auditory		
Learns by practicing	C	Kinesthetic		
Organized and structured	A	Visual	I find it easier to remember chemistry material that...	4
Learns by listening and recalling discussions	B	Auditory		
Physically oriented and active	C	Kinesthetic		
Prefers reading rather than being read to	A	Visual	I find it easier to understand chemistry material through...	5
Learns by listening and recalling discussions	B	Auditory		
Learns by practicing	C	Kinesthetic		
Organized and structured	A	Visual	When discussing chemistry lessons, I tend to.....	6
Learns by listening and recalling discussions	B	Auditory		
Physically oriented and active	C	Kinesthetic		
Remembers what is seen better than what is heard	A	Visual	I prefer a chemistry teacher who...	7
Learns by listening and recalling discussions	B	Auditory		
Learns by practicing	C	Kinesthetic		
Good long-term planner	A	Visual	When I have free time, I usually fill it with...	8
Likes music and things with rhythm	B	Auditory		
Likes engaging games	C	Kinesthetic		
Detail-oriented	A	Visual	When the teacher explains in front of the class, I will...	9
Likes to discuss and explain	B	Auditory		
Physically oriented and active	C	Kinesthetic		
Organized and structured	A	Visual	When meeting new people, I tend to pay attention to...	10
Likes music and things with rhythm	B	Auditory		
Physically oriented and active	C	Kinesthetic		

Reliability measures the extent to which student results or scores remain consistent when assessments are repeated (Nitko & Brookhart, 2011: 64), and is an important stage after the validity test. After the instrument is declared valid, the next step is to conduct a reliability test to ensure the consistency of the measurement results. For this reason, valid instrument items were grouped in a table before calculating reliability using the Cronbach's Alpha formula with the help of the SPSS program. The results of this calculation will determine the extent to which the instrument is consistent in measuring students' learning styles. According to Guilford (1956), the reliability coefficient is interpreted as very high if ($1.0 \geq \alpha > 0.8$), high ($0.8 \geq \alpha > 0.7$), medium ($0.7 \geq \alpha > 0.4$), low ($0.4 \geq \alpha > 0.2$), and very low if ($0.2 \geq \alpha \leq 0.0$). This interpretation helps in evaluating how well the instrument can be relied upon in consistent measurements. The following reliability test results can be seen in table 3 below.

Table 3. Test results of learning style instrument reliability data

Cronbach's Alpha	N of items
0.62	10

Based on the reliability test using Cronbach's Alpha, a value of 0.62 was obtained for 10 items, which indicates that the reliability of the instrument is in the medium category. This is in accordance with Guilford's (1956) interpretation, which states that reliability values between $0.4 < \alpha \leq 0.7$ fall into the moderate category. This result indicates that the instrument has sufficient consistency, although improvements still need to be made to increase its reliability. In the measurement of learning styles, this value indicates that the instrument can be used, but it needs to be considered for further development to improve its consistency. This finding is also consistent with Azwar's (2012) research, which states that instruments with moderate reliability can still be used, but should be interpreted with caution. Further support comes from Felder and Spurlin's (2005) research, which found reliability values between 0.55 to 0.77 on the Index of Learning Styles (ILS). In addition, this result is also reinforced by the research of Astuti et al. (2023), which states that the learning style instrument has a fairly good level of reliability with a value of $r_{11} = 0.6497$.

CONCLUSION

Based on the research results, the learning style instrument developed for chemistry learning consists of 11 statement items, with 10 items declared valid and 1 item declared invalid. The reliability test results using Cronbach's Alpha showed a value of 0.62, which puts the reliability of this instrument in the medium category. This shows that the instrument is quite consistent in measuring students' learning styles, although there is still room for improvement to make the measurement results more reliable. Overall, this instrument can be used to identify students' learning styles in chemistry learning, with a note that improvement in terms of reliability is still needed. For further development, this instrument should be reviewed, especially on the aspects of language and the relevance of statement items, in order to improve its reliability. It is also recommended to test this instrument on a wider population so that the results are more representative and can be applied in various lessons.

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