Cypriot Journal of Educational Sciences

Volume 21, Issue 2, (2026) 152-161

www.cjes.eu

Development of learning independence instruments for senior high school students in grade XI on geometric transformation material

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Suggested Citation:

Cahyani, A., Hakim, L. E., Sovia, A., Hidajat, F. A., & Deniyanti, P. (2026). Development of learning independence instruments for senior high school students in grade XI on geometric transformation material. *Cypriot Journal of Educational Science*, *21*(2), 152-161. https://doi.org/10.18844/cjes.v21i2.9759

Received from September 20, 2025; revised from January 09, 2026; accepted from March 21, 2026.
Selection and peer review under the responsibility of Prof. Dr. Hafize Keser, Ankara University, Turkey (retired)

Abstract

Improving the quality of education can be done in various ways, one of which is through the use of instruments as measurement tools that serve an important role in enhancing students' learning experience. This study aims to produce a valid, reliable, and practical assessment instrument to measure learning independence in geometry transformation material. This instrument was developed through the following steps: (1) developing the initial draft of the instrument, (2) testing the content validity, (3) testing the construct validity and reliability. The results showed that the instrument developed was valid and reliable. Aiken's V value of 0.978 indicates high content validity. All items were empirically valid (r count > r table; sig. < 0.05), and Cronbach's Alpha value of 0.893 indicated high reliability. This instrument is suitable for measuring students' learning independence in geometry transformation material and meets the requirements for a valid, reliable, and practical test. The learning independence questionnaire plays an important role in identifying students' levels of independence in managing and organizing their learning processes and can be used across various educational institutions to evaluate the effectiveness of curricula and learning methods in shaping independent learners

Keywords: Instrument development, learning independence

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1. INTRODUCTION

Amid the rapid development of the digital era, the world of education must continue to adapt to equip future generations to face ever-evolving global changes and challenges (Purba et al., 2025; Wijaya et al., 2016). Rapid transformation in various fields, especially technology, demands responsive and innovative education (Nurhayati et al., 2024). Digital developments bring more interactive and inclusive learning methods, while, at the same time, digital skills are becoming increasingly essential in everyday life. Education needs to take a leading role in ensuring learners acquire developmentally appropriate skills to enable them to contribute significantly to the advancement of a changing global society (Hasibuan et al., 2024; Indy, 2019; Nur & Tamam, 2024).

Education is a process that aims to change the attitudes and behaviors of individuals or groups, shaping human maturity through teaching and training activities (Chusna et al., 2024; Rahman et al., 2022). Education is essentially a learning process that aims to maximize individual potential to achieve positive goals (Mendo-Lázaro et al., 2022; Schwartz et al., 2022; Wasitohadi, 2014). As part of efforts to develop society, education is a key strategy for improving the quality of Indonesia's human resources (Rasyid et al., 2024; Suryadi, 2022). Through the learning process, people are expected to maximize their potential and play an active role in the nation's and state's positive development.

Various factors play a role in improving student learning, one of which is fostering independence in learning. Learning independence includes students' ability to manage time, design learning strategies independently, and actively take steps to understand the material (Azizah & Prabowo, 2024; Qurbi et al., 2023; Tarigan et al., 2024). By fostering independence in learning, students can develop independent learning habits, strengthen intrinsic motivation, and hone their metacognitive skills. Students with high levels of learning independence are usually better able to face challenges in the learning process, so they have the potential to achieve better (Ma & She, 2024). The aspects of learning independence that are applied not only affect academic achievement but also helps a person able to face various changes and challenges in life (Fatmawati & Aziz, 2024; Lestari et al., 2024).

Efforts to improve the quality of education include various methods, one of which is the use of instruments as evaluation tools. This instrument plays a crucial role in improving the quality of students' learning experiences (Atikah, 2024; Sunaryati et al., 2024). Using instruments, educators can objectively measure and evaluate student learning achievement and development. Instruments such as tests, project assessments, and interactive teaching aids provide a more comprehensive picture of students' understanding of the subject matter. Instruments also assist educators in identifying areas for improvement and in designing more effective learning strategies (Nasution et al., 2024; Zahroh et al., 2025). Therefore, the use of instruments as a measurement tool can make a major contribution to improving the overall quality of education.

Learning independence instruments are tools or techniques used to evaluate students' ability to manage learning independently (Nurhidayati et al., 2024; Sintiawati et al., 2025). The utilization of learning independent instruments can provide an important picture of the extent to which students succeed in developing independent learning skills. The assessment allows educators to design learning methods that are more focused on developing the independence skills that need improvement. Learning independent instruments helps students reflect on their abilities and increase independence, thereby creating a learning environment conducive to personal development and academic achievement (Arini et al., 2020). Thus, the use of learning independence measurement tools plays an

important role in creating adaptive learning approaches that support the improvement of student independence.

The development of learning independent instruments has been a focus in studies across various fields. In Arini et al.'s research (2020), it was identified that, out of the statements tested, 1 was invalid, while 19 were valid. Therefore, invalid statements cannot be relied upon as an instrument for measuring student learning independence. Nevertheless, this instrument is considered to have high reliability, as its Cronbach's alpha is 0.77 (0.6> 0.6). Thus, this instrument is suitable for use as a reliable and effective measurement tool to assess students' learning independence in primary schools. From an interview with a high school teacher in Bogor Regency, it was revealed that the teacher had never assessed students' learning independence in his class. This finding is a reason for researchers to continue studying student learning independence.

Several studies have been conducted related to the development of learning instruments of independence. Andayana et al.'s research (2021) developed an instrument to measure the mathematics learning motivation of fifth-grade elementary school students. Putri et al. (2021) conducted research on the validity of the self-confidence questionnaire for secondary students in mathematics learning. This research was conducted in junior high schools, high schools, and vocational schools. Audhiha et al. (2022) conducted research on the development of instruments to assess learning independence in elementary school students. Abdal et al. (2023) conducted research on the development of self-efficacy instruments in mathematics: a validation study with exploratory factor analysis. Meanwhile, Belawati et al. (2023) conducted research on the development of tools to assess independent online learning readiness among high school students in Indonesia. Based on previous research, no instrument has been developed to assess learning independence among high school students in grade XI on geometric transformation material.

Based on the preliminary results, previous studies, and interviews conducted, researchers are interested in developing learning independence instruments at the senior high school level and testing their validity and reliability.

2. METHOD AND MATERIALS

This research design is a Research and Development study that aims to produce a valid and reliable learning independence instrument. This instrument was developed through several systematic stages adopted from Belawati et al.s' research, (2023), namely:

1) Develop an initial draft of the instrument, based on the results of theoretical studies on learning independence and indicators that are relevant to the context of mathematics learning, especially geometry transformation material.

2) Conducting content validity tests, involving experts (expert judgment). Content validity was analyzed using Aiken's V coefficient to determine the level of conformity of instrument items with the indicators measured.

3) Testing the construct validity and reliability, through trials with grade XI high school students. Construct validity was analyzed using item-total correlation (empirical validity), while reliability was analyzed using Cronbach's Alpha coefficient to measure the internal consistency of the instrument.

2.1. Participants

This research was conducted in one of the senior high schools in Bogor Regency. The test subjects in this study were 140 high school students. The determination of the number of participants refers to the opinion of McCoach et al., (2013), which suggests that the number of samples for testing the validity and reliability of the instrument is 5 to 10 times the number of items. Because the instrument developed consists of 20 statement items, the ideal sample size ranges from 100 to 200 respondents. Based on these considerations, the researcher took 140 students as the research sample.

2.2. Instrument

The instrument developed in this study is a questionnaire of student learning independence on geometric transformation material. The instrument is arranged in the form of a four-choice Likert scale (Strongly Agree, Agree, Disagree, and Strongly Disagree) and consists of 20 statement items that represent six indicators of learning independence adopted from Hidayati & Listyani (2010), namely: 1) non-dependence on others, 2) having self-confidence, 3) behaving in a disciplined manner, 4) having a sense of responsibility, 5) behaving based on one's own initiative, and 6) exercising self-control. Each item is designed to measure certain aspects of the predetermined indicators, based on relevant theoretical studies. The preparation of instrument items pays attention to the suitability of content, clarity of language, and readability by high school students. The instrument was validated by experts and empirically tested to determine its validity and reliability before being declared fit for use.

2.3. Data Analysis

The data obtained from the results of the instrument trials were analyzed to determine their validity and reliability. Data analysis was carried out with the following steps:

1) Content Validity:

Content validity was analyzed using Aiken's V coefficient based on the assessment of three experts. Aiken's V value is used to determine the extent to which the instrument items represent the indicators being measured. Aiken's V value is declared valid if > 0.80. The results of content validation were then calculated using Aiken's formula (1980) with the following formula:

$$V = \frac{\sum S}{[n(c-1)]}$$

Remarks:

$S = R - Lo$

V = Aiken Index

S = Score given by rater (assessor) minus the lowest score

R = Score given by rater

Lo = Lowest assessment score (1)

C = Lowest assessment score (4)

n = Total rate

2) Empirical (Construct) Validity:

Empirical validity or construct validity was analyzed using Pearson product-moment correlation between item scores and total scores. Items are declared valid if the

significance value (p) <0.05 and r count> r table.

3) Instrument Reliability:
Instrument reliability was analyzed using Cronbach's Alpha coefficient to determine internal consistency between items. The instrument is said to be reliable if the Alpha value is ≥ 0.60. This statistical analysis was carried out with the help of SPSS version 26 software.

3. RESULTS

This research produced a student learning independence instrument developed through three main stages: the development of the initial draft of the instrument, a content validity test, and a construct validity and reliability test.

3.1 Development of the Initial Draft of the Instrument

The initial draft of the instrument for developing student independence was prepared by referring to theories that emphasize aspects of student independence. This process involves identifying indicators of independence based on a review of relevant literature, such as learning initiative, self-confidence, responsibility, problem-solving, and self-control. The first step is to review the theory of independent learning. In this study, it refers to the indicators of learning independence from Hidayati & Listyani (2010):

Table1

Indicator of Learning Independence

No	Indicator	Number of items
1	Non-dependence on others	3
2	Have self-confidence	3
3	Behave in a disciplined manner	2
4	Have a sense of responsibility	4
5	Behave on their own initiative	4
6	Exercise self-control	4

Based on the indicators listed in Table 1, the next step is to compile items for each indicator. This study has 20 statement items, each with four answer options: Strongly Agree, Agree, Disagree, and Strongly Disagree.

3.2 Content Validity Test

The instrument design was evaluated by three experts (validators) through a content validation process. This process involved providing an assessment sheet to the validators to qualitatively assess the suitability of the instrument's content to the measured indicators. In addition, validators were asked to provide a quantitative assessment of each item using a validation sheet, which was analyzed using Aiken's V coefficient. After the expert judgment was conducted, the instrument was revised based on feedback to improve the clarity, readability, and accuracy of each item's substance.

Based on the validity analysis of the learning independence instrument using Aiken's index, all items demonstrated high content validity. A total of 20 items had Aiken's V values above 0.80,

indicating a very good level of conformity between the items' content and the indicators measured. These items cover six indicators of learning independence, namely: independence from others, self-confidence, discipline, responsibility, initiative, and self-control. The following table presents the results of the calculation of the overall Aiken's V coefficient.

Table2

Aiken's Coefficient Calculation Results

No	Rater 1	Rater 2	Rater 3	S1	S2	S3	$\sum s$	V
Item (1-20)	80	78	78	60	58	58	176	0,979

From the Aiken coefficient calculation, a value of 0.987 (> 0.8) was obtained, indicating that the items of the overall learning independence instrument have high validity. After the instrument is declared valid based on content validity, the next stage is testing by distributing questionnaires to respondents. After all respondents have completed the learning independence questionnaire, the researcher collects and evaluates the responses. The data were converted to numerical values and analyzed using SPSS version 26.

3.3 Construct Validity and Reliability Test

After the instrument is declared content valid, the next step is to test its construct validity and reliability using empirical data from 140 respondents. Construct validity was assessed using Pearson product-moment correlations between each item and the total score.

Table3

Construct Validity Test Calculation Results

Item	calculate R	Sig.(2 tailed)	interpretation	Item	calculate R	Sig.(2 tailed)	interpretation
Item 1	0,688	0,000	Valid	Item 11	0,681	0,000	Valid
Item 2	0,662	0,000	Valid	Item 12	0,705	0,000	Valid
Item 3	0,729	0,000	Valid	Item 13	0,609	0,000	Valid
Item 4	0,720	0,000	Valid	Item 14	0,688	0,000	Valid
Item 5	0,667	0,000	Valid	Item 15	0,732	0,000	Valid
Item 6	0,665	0,000	Valid	Item 16	0,684	0,000	Valid
Item 7	0,639	0,000	Valid	Item 17	0,672	0,000	Valid
Item 8	0,663	0,000	Valid	Item 18	0,705	0,000	Valid
Item 9	0,634	0,000	Valid	Item 19	0,721	0,000	Valid
Item 10	0,625	0,000	Valid	Item 20	0,682	0,000	Valid

The analysis results show that all items have a calculated r value greater than the r table value (0.165) and a significance value (p) < 0.05, indicating that all items are statistically significant. Thus, each item can represent the learning independence construct being measured.

Table4

Reliability Statistics

Cronbach's Alpha	N of Items
0,892	20

Reliability testing was conducted to assess the internal consistency of the instrument's items. Calculations using Cronbach's Alpha yielded a value of 0.893, which falls within the high-reliability range (above the minimum threshold of 0.60). These results indicate that the learning independent instrument has a good level of reliability and is suitable for use as a measurement tool in the context of mathematics learning on geometric transformation material.

This finding reinforces that the developed instrument is not only conceptually valid but also empirically consistent in measuring the intended construct. With its demonstrated validity and reliability, this instrument can be used to objectively and measurably detect and map students' levels of learning independence.

4. DISCUSSION

The results of the study indicate that the developed learning independence instrument meets the criteria for high validity and reliability. The content validity obtained from expert assessment indicates that all items are consistent with the learning independence indicators formulated on theoretical grounds, as stated by Hidayati & Listyani (2010). Aiken's V value of 0.987 indicates that experts have a high level of agreement regarding the relevance and clarity of each item in the instrument. Relevance refers to the extent to which the items in the instrument are directly related to the objectives, indicators, or constructs being measured. Clarity refers to the extent to which the items in the instrument are formulated in clear, unambiguous language that is easy for respondents to understand (Matondang, 2009; Saputri et al., 2023).

In addition, construct validity, as indicated by the item-total correlation analysis, shows that all items consistently measure the intended construction. This finding aligns with previous research indicating that indicators such as initiative, responsibility, and self-control are important dimensions for measuring student learning independence (Zimmerman, 2010). The instrument's high reliability, with Cronbach's Alpha of 0.893, indicates very good internal consistency. Excellent internal consistency means that each item supports the others in measuring the same construct cohesively, so the results can be relied upon for research and further measurement purposes (Adetya & Yuliana, 2025; Cohen & Swerdlik, 2009).

In practical terms, the existence of this instrument makes an important contribution to teachers and researchers in evaluating students' level of learning independence, particularly in the subject of geometric transformation, which is known to be highly challenging and to require independent learning skills. This instrument can also be used to design differentiated learning strategies and data-based learning interventions.

However, this study has limitations, namely that the pilot study was conducted in only one school and no further factor analysis was performed to test construct validity in greater depth. Therefore, further research is recommended to conduct construct validity testing using exploratory factor

analysis (EFA) or confirmatory factor analysis (CFA), and to expand the scope of subjects across different schools and regional contexts.

5. CONCLUSION

This study successfully developed a valid and reliable instrument for measuring student learning independence in geometric transformation material. Content validity, assessed through Aiken's V analysis, showed that all items in the instrument were aligned with the indicators being measured. Construct validity, assessed via item-total correlations, indicated that all items were statistically significant. Additionally, the reliability test results, with a Cronbach's Alpha of 0.893, indicate high internal consistency. Thus, this instrument is deemed suitable for use as a measurement tool to assess the level of learning independence among high school students and can be utilized in the planning, implementation, and evaluation of mathematics learning processes.

6. IMPLICATION

The results of this study have significant implications for education, particularly for mathematics learning at the secondary school level. The learning independence instrument, which has been validated both theoretically and empirically, can serve as a diagnostic tool for teachers to identify students' levels of learning independence. This information is useful for designing more adaptive and responsive learning strategies tailored to students' needs, in line with the principles of differentiated learning and character development in the Merdeka Curriculum.

Additionally, this instrument contributes to the development of data-based research and evaluation in learning. Researchers and education policymakers can use this instrument to develop learning models that strengthen independent learning skills. Indirectly, its use can also increase students' awareness of the learning process they are undergoing, thereby encouraging self-reflection and growth in intrinsic motivation for mathematics learning.

7. LIMITATION AND SUGGESTION FOR FURTHER RESEARCH

This study has limitations in its scope: the trial was conducted at a single school with a limited population, so the results cannot be generalized widely. In addition, construct validity was assessed solely through item-total correlations, without advanced statistical approaches such as factor analysis. Therefore, future research should involve a more diverse sample and employ exploratory factor analysis (EFA) or confirmatory factor analysis (CFA) to examine the construct structure in greater depth and strengthen the instrument's validity. In this section, the scientific results should be presented clearly. This section does not have to be separate from the discussion. However, if the discussion is long or complex, the conclusion can be written separately. In this section, the study's limitations can also be mentioned.

Conflict of Interest: The authors declare no conflict of interest.

Ethical Approval: The study adheres to the ethical guidelines for conducting research.
Funding: This research received no external funding.

Cahyani, A., Hakim, L. E., Sovia, A., Hidajat, F. A., & Deniyanti, P. (2026). Development of learning independence instruments for senior high school students in grade XI on geometric transformation material. *Cypriot Journal of Educational Science*, *21*(2), 152-161. https://doi.org/10.18844/cjes.v21i2.9759

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