

Development of a Mechanical Wave Creative Thinking Skills Assessment Instrument Based on Student Learning Styles

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Abstract: This research aims to develop and test creative thinking skills assessment instruments based on student learning styles, and is motivated by the importance of mastering 21st century skills, including creativity, for students in facing the demands of education at the tertiary level. The research method used is Research & Development (R&D) with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The pilot test subjects included 3 alumni and 15 3rd semester students of the Physics Department of Semarang State University who were taking the wave course. The instruments developed include creative thinking skills assessment instruments and learning style identification instruments (visual, auditorial, kinesthetic). The results of instrument validation showed "Very Feasible" criteria with a percentage of 90% for the KBK assessment instrument, and a score of 92% on the learning style identification instrument. Both instruments received positive responses from users with a KBK instrument score of 82% and a learning style instrument of 83%. The profile of students' creative thinking skills showed that all respondents were at the "Creative" or "Very Creative" level. The average KBK score for visual learning style is 81.875, auditorial is 81, and kinesthetic is 82.2. The instrument is feasible to use and able to measure the profile of creative thinking skills based on learning styles.

Keywords: Assessment, Learning Styles, Instrument, Creative Thinking Skills

Introduction

The Role of 21st Century Skills and Creativity in Higher Education

Indonesia is increasingly showing its role in the international arena, one of which is thanks to the mastery of 21st century skills (Learning and Innovation Skill) by its young generation (Zubaidah 2018). These competencies, known as the 4Cs, include Critical Thinking Skills, Creative Thinking Skills, Communication Skills, and Collaboration Skills (P21). Students as the next generation must master these four skills, especially since higher education requires them to solve problems effectively without the limitations of rigid methods, thus demanding creativity.

Creativity, from a cognitive perspective, is defined as a thinking skill that involves fluency, flexibility, originality, and detail (Lestari and Zakiah 2019, 2). This means that students must be able to find their own unique approaches, look at problems from multiple perspectives, generate original ideas, and elaborate details well. These demands arise from the paradigm shift in higher education from *lecturer-centered learning* (TCL) to *student-centered learning* (SCL). In SCL, the focus is on developing students' creativity, personality, and independence in seeking and finding knowledge (Sailah et al. 2014, 53).

The development of creative thinking skills in higher education is essential for students to become more flexible, adaptive, and able to find their own comfortable way of learning. When students are free to recognize their strengths and weaknesses, they can adjust their learning needs, feel comfortable, and motivated to explore knowledge from various sources, not just stick to the material provided by the lecturer. Ultimately, this will help achieve graduate learning. Thus, creative thinking skills play a vital role in the learning process in this era.

Learning Style as the Key to Creativity Development and Learning Optimization

One way to explore potential and identify weaknesses in developing creative thinking skills is through learning styles or modalities. Learning style is a person's consistent way of capturing, remembering, thinking, and solving problems (Supit et al. 2023). Each individual has a unique learning style; it can be single or multimodal (bimodal, trimodal, or dominant one of the three) (Octaria et al. 2020). This difference is not a disorder, but rather individual uniqueness.

Based on sensory perception, there are three types of learning styles:

1. Visual: Students tend to understand things better through the sense of sight (reading, pictures, diagrams, visual objects). They prioritize visual acuity and need visual evidence or data to understand.
2. Auditorial: Students understand more easily if they learn through the sense of hearing (listening to explanations, reading aloud, listening to recordings). Hearing is the main need for them to remember and understand information.
3. Kinesthetic: Students understand more easily through movement (touching, practicing, scribbling, drawing, gestures, hands-on experiments). Hands become their main key in absorbing information.

Learning style is very important to maximize the learning process because it is the most comfortable way for someone to think. There is a significant relationship between learning styles and academic achievement. Research by Bire, Geradus, and Bire (2014) in Kupang showed a significant effect of visual (26.4%), auditorial (24.2%), and kinesthetic (26.2%) learning styles on student learning achievement. However, unfortunately, the existence of learning styles is often ignored, even though it can be a benchmark for optimizing student potential.

Urgency of Creative Thinking Skills Assessment Instrument Based on Learning Style

The wave course in the Physics Department is an ideal example because it combines theory and practicum, which supports all learning styles: visual and auditory through theoretical learning in the classroom, and visual, auditory, and kinesthetic through practical activities in the laboratory. This course also demands creative thinking skills as problems, especially during the practicum, can be solved using various methods. The inquiry model used in the practicum encourages students to not only stick to the diktat, but also develop their own creative ideas.

In order for learning in this course to run optimally, an instrument is needed to analyze creative thinking skills based on learning styles. This instrument will be an important reference to optimize student potential. By knowing the level of creative thinking skills and dominant learning styles of students, lecturers will find it easier to determine the right teaching methods, and students can identify the most suitable learning methods for themselves. The synergy between lecturers and students supported by this instrument is expected to maximize the learning of wave courses.

Unfortunately, until now, there is no instrument available to measure creative thinking skills and learning styles simultaneously. Therefore, based on the background that has been described, the preparation of a creative thinking skills assessment instrument based on learning styles is needed.

The purpose of this research is to compile and test creative thinking skills assessment instruments based on student learning styles so that a product is produced in the form of a set of assessment instruments that are valid and acceptable to the community. So that this research can provide benefits to students in order to maximize learning outcomes, teaching lecturers have evaluation materials to optimize the learning process of wave courses in the next period, and researchers in the field of education get a deeper understanding of the preparation of creative thinking skills assessment instruments based on learning styles and become material for further research.

Methods

The research method applied in this study is research and development (Research & Development) with the ADDIE model (analysis, design, development, implementation, evaluation). According to Sugiyono, the R&D research method is a research method applied with the aim of producing a product and testing the effectiveness of the product (2013, 297).

Based on Branch's research (2009, 2), until now, the ADDIE model remains one of the most effective models in producing a product from development research because this model has a complex guiding framework and is very appropriate for developing educational products and other learning resources.

The test subjects in this study were 3 alumni of the UNNES Physics Department and 15 people who were still students in semester 3 and were taking wave courses.

Stages of Development Research

Analysis is the first stage that aims to identify gaps in the performance of products that have been created before, so that it can be a reason for another product to be made as a development of existing products. (Branch 2009, 23).

In this research, needs analysis was conducted by deepening previous studies and unstructured interviews with several students majoring in Physics semester 3 at UNNES.

In the design phase, the design of the product to be developed is based on the problems found in the analysis stage.

In this study, the design phase was carried out by: 1) designing a list of questions on the learning style identification questionnaire instrument based on existing indicators, 2) designing a set of assessment instruments based on creative thinking skills indicators.

Based on Maydiantoro's explanation, the development stage is the stage of realizing the product design that has been made. The conceptual design that has been prepared, in this phase begins to be developed into a product, then will be tested for feasibility. So that at the end of the development phase, the product is ready to be implemented (2021, 7).

The development phase was carried out with the realization of the instrument design followed by an instrument validation process carried out by two experts consisting of one instrument expert lecturer and one teacher with a S-2 (Master) Physics Education background.

The fourth stage is the implementation phase which is carried out by applying the product that has been prepared/developed to the respondents with the aim of obtaining preliminary feedback as material for evaluating the product.

The trial was carried out in two stages, namely a small-scale trial with three Physics alumni and a broad-scale trial with 15 Physics students who were taking the wave course.

The last stage in the implementation of this research is the evaluation phase which includes fixing errors, shortcomings, and some aspects that have not been inputted in the product. The evaluation process was adjusted to the results of the expert validation test and the combined final results of the user response questionnaire obtained in the implementation phase.

Validation and Testing Process

The instrument validation process is carried out by filling out a validation questionnaire sheet. The validation sheet contains several aspects, including: 1) Questionnaire format; 2) content; 3) Language; and 4) Writing (Susilawati et al. 2019). The format in the validation sheet was prepared using a Likert scale with categorization: 5 very good, 4 good, 3 quite good, 2 less good, 1 very less good.

The percentage of Instrument feasibility was calculated using the following equation:

$$P = \frac{Sp}{St} \times 100\%$$

P = Validity Percentage

Sp = Acquisition Score

St = Overall Score

Table 1. Instrument Validity Criteria

Value	Criteria
$20 \leq P \leq 40\%$	Not feasible
$41 < P \leq 55\%$	Not feasible
$56 < P \leq 70\%$	Feasible enough
$71 < P \leq 85\%$	Feasible
$86 < P \leq 100\%$	Very feasible

After going through the validation process and carrying out improvements based on input from the two validators, then the instrument was tested in two stages (small-scale and broad-scale trials). The results of the trial were obtained through a user response questionnaire prepared using a Likert scale with an assessment of the aspects: 1) Ease of use; 2) Language; 3) Relevance and usefulness.

The equation used to analyze user responses is as follows:

$$N = \frac{Sp}{St} \times 100\%$$

N = user response score

Sp = acquisition score

St = overall score

Table 2. User Response Criteria

Value	Criteria
$20 \leq P \leq 40\%$	Not good
$41 < P \leq 55\%$	Not good
$56 < P \leq 70\%$	Good enough
$71 < P \leq 85\%$	Good
$86 < P \leq 100\%$	Very good

The results of the user response questionnaire aim to find out whether the instrument prepared gets a positive or negative response. The response represents whether or not the instrument is accepted by the community.

Analysis Process of Creative Thinking Skills Profile Based on Learning Style

The process of analyzing creative thinking skills is carried out through document studies obtained from two data (story problems and practicum reports). The assessment sheet prepared is a set of story problems and practicum report assessment sheets along with the grids, rubrics, and scoring guidelines.

Both instruments were prepared based on mechanical wave material with an assessment based on indicators of creative thinking skills with the equation:

$$N = \frac{Sp}{St} \times 100\%$$

N = value of creative thinking skills

Sp = combined acquisition score (question assessment and practicum report)

St = overall score

Furthermore, the categorization of students' creative thinking skills is based on the table below:

Table 3. Criteria for Creative Thinking Skills

Value	Criteria
$25 \leq P \leq 40\%$	Level 0 (Not Creative)
$41 < P \leq 55\%$	Level 1 (Less Creative)
$56 < P \leq 70\%$	Level 2 (Moderately Creative)
$71 < P \leq 85\%$	Level 3 (Creative)
$86 < P \leq 100\%$	Level 4 (Very Creative)

The next step is to analyze the identification of student learning styles from the learning style identification instrument.

The instrument is a questionnaire divided into three learning style groups (visual, auditorial, kinesthetic), each group containing 10 statements. The questionnaire is structured using a Likert scale worth 4, 3, 2, 1 with positive and negative statements.

The results of the learning style identification are known through comparing the scores between the three learning style groups (visual, auditorial, kinesthetic), the highest score being used as a benchmark for the dominant learning style of the respondent.

In certain cases, scores between two or all three learning styles may be the same. This means that the student has two or three balanced dominant learning styles, which can be referred to as multimodal.

After knowing the level of creative thinking skills and the dominant learning style of students, the next step is to describe the profile of creative thinking skills based on learning styles in a qualitative descriptive manner.

Results and Discussion

This research provides three results which are the answers to the three problem formulations. The three results are: 1) the process of preparing the instrument; 2) the results of the validation; test and the instrument trial; 3) the profile of creative thinking skills based on the learning style of the instrument prepared. The preparation process, the results of the trial and validation test are grouped into two based on the type of instrument, namely the creative thinking skills assessment instrument and the learning style identification instrument.

Creative Thinking Skills Assessment Instrument

Instrument Preparation Process

The analysis process was carried out by studying previous studies and considering suggestions from lecturers as a needs analysis. Through the needs analysis, it was found that the wave course facilitates all indicators of creative thinking skills, not only through practicum learning, but also conventionally in the classroom. It's just that it has not been maximized in its implementation.

Furthermore, the instrument is arranged in the form of a story problem from a phenomenon that actually occurs. The inspiration in the preparation of the problem was from news on the internet, which was then correlated with the physics of mechanical wave material, and assessed from the point of view of creative thinking skills.

The initial design of the question is in the form of a description question with answers in the form of problem solving that can trigger students' creative thinking skills. Students are given the freedom to answer according to their creativity, but still based on physics science.

The second creative thinking skills assessment instrument is the practicum report assessment sheet as supporting data. The process of preparing this instrument is through deepening each indicator of creative thinking skills, then synergized with the components in the student practicum report.

In the development process, a validation test was carried out by two validators with the results listed in the table below:

Table 4. Results of the KBK Instrument Validation

Aspects Assessed	Percentage Average	Criteria
Conformity with KBK indicators	100%	Very Feasible
Clear and easy to understand	87,5%	Very Feasible
In accordance with the research objectives	87,5%	Very Feasible
Does not cause double meaning	100%	Very Feasible
The product describes the research objectives	75%	Feasible
Overall score	90%	Very Feasible

Based on the validation results in the table above, the overall validation percentage value is 90% so that the assessment instrument for the level of creative thinking skills can be categorized as "Very Feasible".

After going through the validation test, followed by trial/implementation. The results of the small-scale trial by three UNNES Physics alumni are as follows:

Table 5. Feedback on the Small-Scale Pilot Test of the KBK Instrument

Aspects Assessed	Percentage Average	Criteria
The instrument is easy to understand	93%	Very Good
In accordance with the material that has been covered	87%	Very Good
The questions are easy to read	93%	Very Good
The time allotted for the test is sufficient	80%	Good
Use standard Indonesian that follows the rules of the language	100%	Very Good
The statements in the questions are clear and easy to understand	93%	Very Good
Overall score	91%	Very Good

Subject A01 provided some input in the form of additional duration and language effectiveness. While subjects A02 and A03 did not provide input. Overall, the percentage of not provide input. Overall, the percentage of responses obtained is 91% which means very good.

Furthermore, a wide-scale trial was conducted with 15 respondents and the following results were obtained:

Table 6. Response to Broad Scale Trial of KBK Instrument

Aspects Assessed	Percentage Average	Criteria
The instructions for filling out the questions are easy to understand	89%	Very Good
Question items are in accordance with the material that has been studied	80%	Good
The display/layout on the questions is easy to read	85%	Very Good
The duration required for working on the questions is sufficient	68%	Cukup Good
Using standardized language and according to Indonesian rules	91%	Very Good
The statements in the questions are clear and easy to understand	80%	Good
Overall score	82%	Good

Based on these results, the student creative thinking skills assessment instrument received a response of 82% with good criteria.

This means that there is still something to be addressed from the duration required. The solution is to add the duration of the work from 30 minutes to 45 minutes.

Based on the results of the validation test, limited scale trial, and broad scale trial, improvements were made to the creative thinking skills assessment instrument by changing the grammar that was less effective, adding the duration of the work and tidying up the appearance of the questions to make it easier to read.

Profile of Creative Thinking Skills

The assessment of creative thinking skills is carried out through two methods, namely working on case questions which are notated as KBK 1 and assessing practicum report products with the notation KBK 2. The problem solving is carried out by the respondent, while the assessment of the practicum report is carried out by the researcher.

Based on these two data sources, the following results were obtained:

Table 7. KBK Assessment Results

Name	KBK Score 1	KBK Score 2	Combined KBK Score	KBK Level
S-01	93	85	89	Very Creative
S-02	73	85	79	Creative
S-03	87	70	78,5	Creative
S-04	93	60	76,5	Creative
S-05	80	80	80	Creative
S-06	87	85	86	Very Creative
S-07	100	75	87,5	Very Creative

Name	KBK Score 1	KBK Score 2	Combined KBK Score	KBK Level
S-08	80	90	85	Creative
S-09	73	75	74	Creative
S-10	87	75	81	Creative
S-11	87	85	86	Very Creative
S-12	80	85	82,5	Creative
S-13	87	85	86	Very Creative
S-14	80	85	82,5	Creative
S-15	73	85	79	Creative

Overall, respondents were at level 3 (creative) and level 4 (highly creative) creative thinking skills.

Learning Style Identification Tool

The Instrument Development Process

The analysis was carried out with literature studies and unstructured interviews with three respondents conducted outside of lecture hours.

Subject 1 expressed his dependence on the "overnight speeding system" method, i.e. studying only when going to an exam. Meanwhile, Subject 2 showed inconsistency in understanding the material; sometimes he was able to master the material with one reading, but often required intensive repetition of other material. On the other hand, Subject 3 showed a tendency towards practicum activities compared to theoretical learning in class.

The three interviewees stated that they had heard about the term learning style but had never carried out an identification test. Subject 2 stated that he would be happier if he could find out his dominant learning style, so that he could focus on that learning style to understand materials that are considered difficult.

Based on the results of these interviews, it was stated that it is necessary to develop an instrument that can be used to identify each dominant learning style.

The learning style identification instrument was prepared in the form of a questionnaire consisting of three groups based on visual, auditorial, and kinesthetic learning styles, each of which contained 10 positive and negative statement items. In its development, an expert validation test was carried out with the results in the table below:

Table 8. Results of Learning Style Instrument Validation

Aspect	Skor		Rata-rata	Percentage	Criteria
	V1	V2			
Material	12	12	12	100%	Very Good
Language	11	12	16,5	96%	Very Good
Construction	10	9	9,5	79%	Appropriate
Overall Score				92%	Very Feasible

Based on the validation results, the three aspects have met the criteria for feasibility of use. Taking into account the suggestions and input from the validators, improvements were made on the scale side (one scale was added) and provided a more even distribution of positive negative questions.

After improvements after the validation process, a small-scale trial was carried out with the results as in the table below:

Table 9. Response to Small Scale Trial of Learning Style Instrument

Aspects Assessed	Percentage Average	Criteria
Clarity and ease of use	93%	Very good
Language	83%	Good
Relevance and usefulness	83%	Good
Overall Score	87%	Very good

From the results of the limited scale trial, the results were obtained in the form of a score of 87% or a positive response from users.

Furthermore, a wide-scale trial on this instrument was carried out with fifteen respondents by filling out a student learning style identification questionnaire instrument, followed by filling out a user response questionnaire afterwards. The duration of filling out the student learning style identification questionnaire instrument is 30 minutes, and the user response questionnaire for 10 minutes.

The results of the broad-scale trial can be seen in the table below:

Table 10. Response to Wide Scale Trial of Learning Style Instrument

Rated Aspect	Percentage	Criteria
Clarity and ease of use	86%	Very good
Language	80%	Good
Relevance and usefulness	82%	Good
Overall Score	83%	Good

In the evaluation stage, comprehensive improvements are made based on the results of expert validation combined with the results of the user response questionnaire, so that the best version of the student learning style identification instrument is obtained and ready for widespread use.

Learning Style Identification Results

The results of learning style identification based on the instrument are listed in the table below:

Table 9. Learning Style Identification Results

Name	Visual Score	Auditorial Score	Kinesthetic Score	Dominant Learning Style
S-01	29	29	28	VA
S-02	30	34	30	A
S-03	27	33	32	A
S-04	31	29	27	V
S-05	29	28	30	K
S-06	28	24	23	V
S-07	28	29	28	A
S-08	25	34	35	K
S-09	27	29	27	A
S-10	34	27	35	K
S-11	23	28	22	A
S-12	26	29	31	K
S-13	29	28	28	V
S-14	28	30	32	K

S-15	31	25	30	V
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Determination of the dominant learning style is carried out by comparing the highest score among the three learning styles. For example, in subject S-05, his visual learning style identification score was 29, auditorial 28, and kinesthetic 30. Then subject S-05 has a kinesthetic learning style.

Based on the table, the data shows that 4 students have a visual learning style, 5 people have an auditorial learning style, 5 people with a kinesthetic learning style, and one person has a combined visual and auditorial learning style.

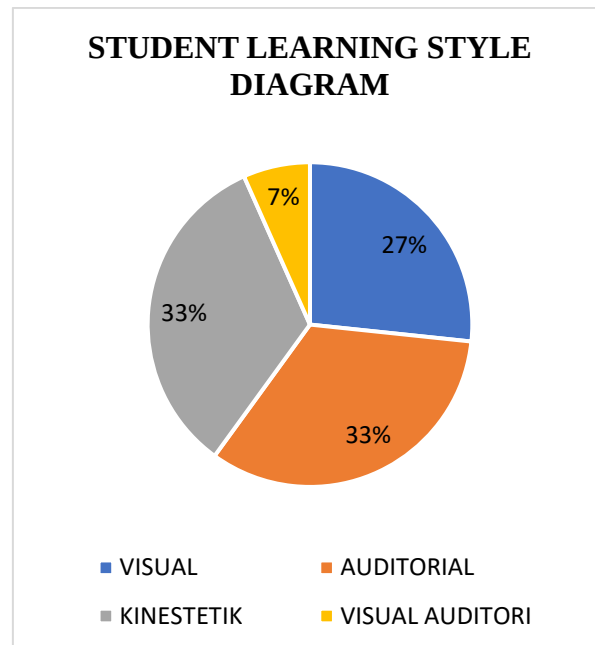


Chart 1 - Student Learning Style Diagram

Profile of Students' Creative Thinking Skills Based on Learning Style

Based on the acquisition of creative thinking skills assessment data and identification of learning styles, the results are listed in the table below:

Table 10. Results of Creative Thinking Skills Assessment Based on Learning Style

Name	KBK Score	KBK Level	Dominant Learning Style
S-01	89	Very Creative	Visual Auditorial
S-02	79	Creative	Auditorial
S-03	78,5	Creative	Auditorial
S-04	76,5	Creative	Visual
S-05	80	Creative	Kinesthetic
S-06	86	Very Creative	Visual
S-07	87,5	Very Creative	Auditorial
S-08	85	Creative	Kinesthetic
S-09	74	Creative	Auditorial
S-10	81	Creative	Kinesthetic
S-11	86	Very Creative	Auditorial

Name	KBK Score	KBK Level	Dominant Learning Style
S-12	82,5	Creative	Kinesthetic
S-13	86	Very Creative	Visual
S-14	82,5	Creative	Kinesthetic
S-15	79	Creative	Visual

Based on the instrument that has been prepared, the profile of creative thinking skills based on the learning styles of the fifteen trial subjects is that each learning style has its own features. However, when looking at the quantitative data obtained, the average score for each learning style is 81.875 for visual learning style, 81 for auditorial learning style, and 82.2 for kinesthetic learning style. In test subjects who have two dominant learning styles, namely visual and auditorial, the value of creative thinking skills stands alone.

Conclusion

Based on the research that has been conducted, several conclusions are obtained, namely:

1. The set of instruments prepared has gone through validation tests and trials with feasible results and positive responses. The overall instrument validation test results were 90.83% and the user response was 85.75%.
2. The profile of creative thinking skills can be measured through the creative thinking skills assessment instrument based on learning styles prepared with the results of 81.875 for visual learning styles, 81 for auditory learning styles, and 82 for kinesthetic learning styles. It should be noted that the three learning styles have their own uniqueness, including if someone has a dominant learning style in the form of a combination of two or more learning styles.
3. The three learning styles are included in the creative category with different scores from one another. The highest creative thinking skills score is in the kinesthetic learning style, then visual, and the lowest in the auditorial learning style.

Learning in wave courses that have practicum in them can activate the creative thinking skills and learning styles of each student. With the help of the assessment of creative thinking skills based on learning styles, learning in wave courses can be carried out more optimally.

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