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INQUIRY-BASED ELECTRONIC STUDENT WORKSHEETS ASSISTED WITH LIVE WORKSHEETS TO ENHANCE VISUAL-SPATIAL

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Abstract: This study aims to determine the feasibility of inquiry-based electronic student worksheets assisted with worksheets to train visual-spatial on molecular geometry topics. The 4-D development research type according to Thiagarajan, Define, Design, Develop, dan Disseminate was applied in the study. However, it was adapted into 3-D because it was only at the development stage. The results showed that the developed e-worksheets obtained 85.92% for content validity and 86.67% for construct validity with a very feasible category. The practicality of electronic worksheets in student activities was 97.98%, and student responses obtained a percentage of 93% with a very decent category. The N-Gain calculated the effectiveness of e-worksheets obtained 0.94 in the high category. The inquiry-based e-worksheets are feasible for training visual-spatial on molecular geometry materials.

Keywords: *Inquiry, Liveworksheets, Visual-Spatial, Molecular geometry.*

INTRODUCTION

Chemistry is a science that studies various materials about substances or compounds, including changes in structure, properties, and energy changes [1]. Chemistry is the study of an engineering material with a combination of two or more materials so that materials with new properties or characteristics are obtained. Chemistry involves an active role in improving the reasoning skills of each student. Product is obtained in the form of a concept from the results of that thought [2]. Chemistry subjects are often considered difficult. A total of 70.4% of high school students agreed with statements about chemistry that were difficult to understand because there was too much memorization, nothing to do with everyday life, lack of understanding of chemistry, interpret the material, and is abstract. The field of chemistry has several studies, including those considered to have abstract properties in understanding the material, namely the material on chemical bonds, which discusses further ionic bonds, covalent bonds, molecular geometry, and intermolecular forces [1].

In the molecular geometry sub-material, students are asked to understand how to determine the shape of a molecule according to the valence electron pair theory (VSEPR) with the electron domain theory. Students' success in understanding the concept of molecular geometry is seen from the way they understand the theory used to assist in describing the shape of a molecule. According to some students, there are difficulties experienced in understanding the theory because they can only observe in 2-dimensional form. In the molecular geometry material, students are asked to be able to visualize images of molecules in their concept in 3 dimensions [2].

High school students in class XI experience difficulties understanding the molecule's geometry. According to the results of the pre-research in the form of a questionnaire filled out by students, information was obtained that they had difficulty describing the geometry of the molecule even though the teacher had provided learning with PowerPoint media. This difficulty may be related to the ability of the students' to have low visual-spatial intelligence. Visual-spatial is the ability of students to understand images and project the dimensions of space even though they only see visuals in the 2-dimensional form[3]. Visual-spatial intelligence can describe information and integrate data and concepts into visual objects [4]. Every individual needs visual-spatial skills because to learn the concepts of molecular geometry, which are considered abstract, reasoning is needed in the form of the ability to describe an object and observe the objects provided [5].

Through the learning process to understand the concept of molecular geometry, the teacher has a role in helping in the formation of concepts by being a facilitator. By adjusting the objectives and learning models that are of interest to students, learning will be very easy to convey and accept by students[6]. The strategy that can be done is to use the inquiry learning model because it refers to curriculum 13, which suggests that students can actively participate in the learning process. Students can easily formulate concepts with confidence because inquiry learning involves the ability of students to investigate systematically, critically, logically, and analytically[6]. Building concrete knowledge formed from understanding concepts in each student will make them have long-term memory related to understanding the material

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compared to only receiving knowledge from the teacher [7].

The use of PowerPoint media by teachers was still carried out for learning in the class. At the same time, students preferred using teaching materials in the form of textbooks, worksheets, practical instructions. And as many as 74.1% of students choose to use electronic worksheets in helping the learning process because it is quite effective and helps to understand molecular geometry material. Therefore, the authors choose to use teaching materials in the form of electronic student worksheets with the help of the liveworksheets.com website. The selection of the website as an aid for creating e-worksheets because as many as 92.6% of students prefer to submit assignments online. From this statement, it can be seen that the liveworksheets.com website can support it by facilitating it. The worksheets used with the help of the liveworksheets.com website is a website that can create interactive worksheets for students. The form of questions that can be made varies to make students more interested in using these teaching materials. Answers that have been done can be sent directly via email to the intended teacher so that teachers can correct students' answers directly through the website of liveworksheet.com [8]. With learning in schools, carrying out face-to-face learning is limited due to the recent pandemic conditions that have decreased so that there are students who take part in face-to-face learning in class and face-to-face in their respective residences. So with these conditions, the use of electronic worksheets assisted by the liveworksheets.com website is considered very suitable to support the achievement of chemistry learning in schools. The study focus on developing an inquiry-based Electronic Student Worksheet assisted by live worksheets to train spatial visuals on molecular geometry topic.

RESEARCH METHOD

The study uses the 4D development research: define, design, develop and disseminate[9]. Data analysis was carried out by quantitative testing with eligibility criteria, namely having a valid, practical, and effective percentage of ≥61%[10]

The research instruments used were validation sheets, student response questionnaires, student activity sheets, and pretest-posttest sheets to measure students' visual-spatial abilities.

The feasibility of the validity aspect can be seen from the results of the content and construct validity instruments given to two university chemistry lecturers and one chemistry teacher[11]. The data were then analyzed by referring to Table 1 on the Likert scale. The data results are then calculated and interpreted into the validity criteria in table 2. Based on table 2, e-worksheets are declared valid for content and construct validity if they meet the percentage ≥ 61%[[10]. The following is the formula for calculating the obtained validation score:

$$P\% = \frac{Score\ that\ Obtained}{Maximum\ Score\ X\ Total\ Aspect\ x\ Total\ Respondent}\ x\ 100$$

Table 1. Likert Rating Scale

Evaluation	Score
Very Less	1
Not Enough	2
Enough	3
Well	4
Very Good	5

Table 2. Student Worksheets Validity Criteria

Percentage (%)	Category
0-20	Very Invalid
21-40	Less Invalid
41-60	Quite Invalid
61-80	Valid
81-100	Very Valid

The feasibility of electronic worksheets in the practical aspect is seen from the instruments in the form of response questionnaires and observations of student activities. The response questionnaire was given to students while three observers carried out the activity observation sheet. The student response sheet contains several questions with a score of 1-5 concerning table 1 on the Likert scale. The data results are then calculated using the same formula as validation and adjusted into the criteria for student response scores and student activities, as shown in table 3.

Table 3. Interpretation of Student Response and Activity Scores

Percentage (%)	Category
0-20	Very Less
21-40	Not Enough
41-60	Enough
61-80	Practical
81-100	Very Practical

As for the observation of student activity data, data processing is carried out by paying attention to positive answers (yes) and negative answers (no). Each answer has a different score. A score of one for the answer "yes" and a score of 0 for the answer "no". Then calculated using the formula:

$$\%\ Activity = \frac{\sum Answer\ score\ "yes"}{\sum\ maximum\ score} x100\%$$

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After that, the percentage results are interpreted in table 2. It can be said to be practical if the percentages of both ≥ 61%[10].

The feasibility of e-worksheets on the aspect of effectiveness is seen from the results of cognitive tests of visual-spatial abilities in pretest and posttest. In measuring this cognitive test, the first thing to do before getting learning using e-worksheets is to do a pretest to find out the students' initial abilities. The implementation of e-worksheets is carried out so that after the treatment, students re-test for a posttest containing the same questions to know the students' ability after learning using e-worksheets. The results of the two tests were then analyzed to determine the increase in results using e-worksheets.

The pretest and posttest were used to measure the level of students' visual-spatial skills, the data results in the form of scores obtained from the implementation of each test. The visual-spatial skills can be calculated based on the following formula:

$$Test\ scores = \frac{\sum Score\ that\ Obtained}{\sum Maximum\ Score}\ x\ 100$$

The results of the visual-spatial skill test scores are then interpreted for completeness following the minimum completeness score that the school has determined. Students who are classified as complete if they get a scorer≥75.

The data from the pretest and posttest results were then calculated to obtain the N-Gain score, which functions to determine the improvement in visual-spatial learning outcomes using e-worksheets. The formula for calculating N-Gain can be seen as follows [13]:

$$(g) = \frac{\%\ [G]}{\%\ [G\ maks]} = \frac{[\%(S_f) - \%(S_i)]}{[100\% - \%(S_i)]}$$

where (g): N-gain score; (S_f): Final test score average; (S_i): Initial test score average

Based on the results of the calculation of the value (g) that has been carried out to determine the improvement of students' visual-spatial skills before and after the use of e-worksheets. E-Worksheets are declared effective if the results of improving the visual-spatial skill test get an N-Gain score ≥ 0.3 refer to table 4 [12]. It shows that there is a significant increase between the test questions carried out before the use of e-worksheets and after the use of e-worksheet.

Table 4. Interpretation of Gains Score

Score (g)	Category
(g) ≥ 0.7	High
0.7 > (g) ≥ 0.3	Medium
(g) < 0.3	Low

RESULT AND DISCUSSION

This study uses Thiagarajan's 4D development model with modifications to 3D, which is limited to the development stage.

Define Stage

At the definition stage, the function is to determine the prerequisites regarding learning in molecular geometry material by looking at the existing problems so that they can be adapted to the e-worksheets that will be developed. The steps at this stage include initial analysis, student analysis, task analysis, concept analysis, and learning objectives.

The initial analysis aims to see how the existing conditions in chemistry learning have been carried out in schools so that they can be adjusted to develop the e-worksheets product that will be developed. The initial analysis was carried out by taking into account the curriculum used. The current use of the 2013 curriculum is more centered on student activities. Developing this e-worksheets product is very by existing learning conditions[13]. The implementation of chemistry learning on molecular geometry material in the 2013 curriculum uses basic competence "KD" 3.6, which discusses determining molecular geometry by applying VSEPR theory and electron domains.

The students' analysis aims to determine the suitability between students and the teaching materials developed, which can be viewed from their characteristics. The characteristics possessed can be known from the age range. According to research conducted by Piaget, it is said that children aged 15-16 have high thinking power so that they have arrived at the aspect of reasoning, visualizing the abstraction of material, and being able to conclude [1]. In the form of molecular geometry material, the average age of students is in that range. It is considered very appropriate to the thinking abilities of students of senior high school grade ten participants.

The task analysis was carried out to obtain a match between the indicators of spatial-visual skills that support the achievement of the learning process with the inquiry learning model used. In this case, it is useful to obtain an e-worksheets product that is under the use of molecular geometry materials. Concept analysis is carried out so that there is continuity between the content of the material and the model and skills used. This conformity is expected to make the developed e-worksheets able to contain a systematic outline of the material in molecular form. The concepts used in molecular shapes refer to basic competencies 3.6.

The formulation of learning objectives is based on the analysis that has been done previously. Then conclusions are drawn using operational verbs to form a learning goal to be achieved. In this case, it is hoped that students can achieve the learning objectives.

Design Stage

This stage is carried out by referring to the results of the definition obtained. Creating the e-worksheets framework is determined in advance by compiling a storyboard. At this stage, the researcher also worked on the material first so that the material used could be easily understood by students and did not forget to pay attention to the format used to prepare the material by referring to the POGIL syntax. At this stage, the learning design of the e-worksheets is also made with the liveworksheets.com website. The initial design of the device is carried out by making the front cover along with the appearance of the e-worksheets that will be developed—making the initial design using the Canva application with the help of Microsoft Word. The use of software assistance on the computer/laptop can make it easier for researchers to make designs because various kinds of features can be used and are very interesting. With this assistance, the appearance of the developed e-worksheets appeals to students.

Development Stage

This stage is carried out to produce e-worksheets teaching materials developed. By taking the steps carried out previously, the creation of e-worksheets is based on this. Everything is done at the development stage, starting from connecting the material with the syntax you want to use to present the e-worksheets form.

The e-worksheets must meet the aspects that have been analyzed previously. Adjustments to the live worksheets platform are also needed to simultaneously get input after a review/revision of the e-worksheets. The e-worksheets feasibility test is carried out based on the results of the previously designed teaching materials. Review and revisions, validation and revisions, limited trials, and data analysis are carried out at this stage. It can be viewed from valid, practical, and effective criteria to get proper teaching materials. If all stages have been carried out, it is ready to carry out a limited trial of the e-worksheets.

Validity

This development stage aims to obtain an e-worksheets product that is feasible in terms of content validity and constructs validity. At this stage, a revision is also carried out if there is input from the three chemists during the validation process, which in the end is obtained an e-worksheets that can be used. Content validity takes validated aspects related to material and visual-spatial intelligence, while construct validity includes discussions about presentation aspects and linguistic elements used.

It is very necessary to determine the suitability of e-worksheets so that when applied to students, e-worksheets can be used as teaching materials that are suitable for use in the learning process. After getting a response from the validator, an analysis of the results is carried out. It then can be continued by performing calculations to get the percentage and criteria for the aspects that have been validated. Figure 2 shows the validation results by three chemists with explaining the percentages obtained from the calculation results.

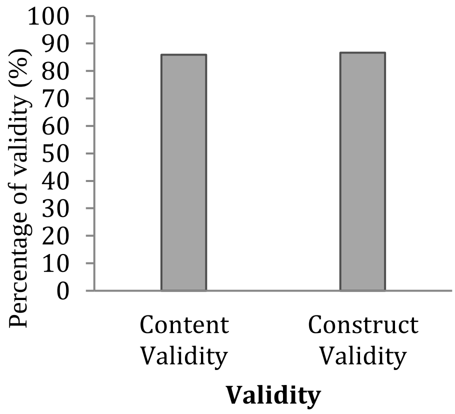

Figure 2. E-Worksheets Validation Results

Figure 2 shows that the validity results are obtained with a percentage of 85.92% in the aspect of content validity. For construct validity, it has a percentage of 86.67%. Both are in the very valid category if referring to table 2. According to Arsyad's research [14], on the aspect of overall validity, it functions so that students and teachers have teaching materials that can train students' understanding regarding interaction and motivation for learning in class. The validation result is depicted in Table 5.

Table 5. Validity Results in Each Aspect

Assessment Aspect		Percentage (%)	Category
Contents	Visual-Spatial	84.4	Very valid
	Material	86.6	Very valid
Construct	Language	84.4	Very valid
	Presentation	88.6	Very valid

In content validity, two main aspects are discussed: the suitability of the contents of the e-worksheets with the spatial visual intelligence to be developed and the material of the molecular geometry discussed. The resulting data is then adjusted to the validation criteria so that the results for the aspect of spatial-visual intelligence get a percentage of 84.4% and for the suitability of molecular form materials with a percentage of 86.6%. So from the data, it can be concluded that

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both are in the very valid category because this e-worksheets teaching material has a score of ≥61% each criterion on content validity. Adjustment between content and language is very important because it is related to distributing knowledge between teachers and students [15]. The material in the geometry of molecules is the most feared by students because of the difficulty of being understood. So it is necessary to increase visual-spatial abilities that can be implemented through the help of live worksheets [16]. By using the inquiry syntax in e-worksheets, students can construct understanding individually. It follows the constructivism learning theory, which emphasizes the activities of students in building knowledge concepts for themselves[7].

For construct validity, two main aspects are discussed: the linguistic elements used and aspects of the presentation of e-worksheets with the help of the liveworksheets.com website. The data results are then adjusted to the validation criteria so that the results for the language aspect get a percentage of 84%. The e-worksheets presentation aspect, with the help of the liveworksheets.com web, gets 88.6%. It can be concluded that both are in the very valid category because this e-worksheets teaching material has a score of ≥61% of each criterion in construct validation. In presenting the e-worksheets, the Liveworksheets.com website is used. This web has the advantage that everyone can use it without registering or logging in. As long as there is a link to access the developed e-worksheets, everyone can operate the e-worksheets. However, if you don't have an access link, you can search with the help of the search field and enter the keyword molecular shape on the live worksheets website. Collecting answers can be done by sending an email after the processing. So that students can simultaneously collect answers after working on the developed e-worksheets. The results of student answers can be sent directly to the teacher's account on the live worksheets website. E-worksheets can be used if you have entered the web via a link. On the initial display, there is a cover, then proceed with the content of the material based on the inquiry syntax. The inquiry syntax is used because it is by learning that involves students' activeness in finding knowledge[7]. The implementation of the molecular shape can be assisted by using the video contained in these e-worksheets. Explanations using videos can help students visualize molecular geometry [1]. Video media can communicate information and knowledge that describes an ongoing process or procedure. Learning videos are expected to help students understand the concept of learning well to improve learning outcomes[[17].

Live worksheets can improve student learning outcomes, this is evidenced by a previous study saying that there is an increase in student learning outcomes after using the Liveworksheets.com website[8].

Furthermore, a limited trial of e-worksheets teaching materials was carried out on 20 high school students. This trial aims to determine the feasibility of e-worksheets in terms of practicality and effectiveness. The practical review used instruments in the form of student response questionnaires and student activities. In contrast, the effectiveness review can be used instruments in the form of pretest-posttest to see the improvement of students' visual-spatial abilities[18].

Practicality

The feasibility can be seen from the practicality of the e-worksheets by conducting a limited trial of 20 students at the high school level. The use of response questionnaires and student activity observation sheets were used to determine the practicality of the e-worksheets. The method used is observations made by three people to observe the implementation of student activities in learning using e-worksheets, and the questionnaire response filling is carried out by each student based on experience when using e-worksheets[18]. Data from observations of student activities and student responses during learning can be seen in table 6.

Table 6. Results of Student Activity Data and Student Responses

No	Rated Aspect	Percentage (%)	Category
1.	Student Activities	97.98%	Very Practical
2.	Student Response	95.00%	Very Practical

Table 6 shows that the activity of students is at a percentage of 97.98% concerning the interpretation of scores in table 3, so it is in the very practical category. All activities have been carried out well by students, as seen from the data results that almost all aspects have a perfect percentage of implementation. The presence of visual-spatial intelligence can improve students' learning progress so that they are more enthusiastic in learning chemistry[5]. The use of electronic worksheets and increasing student interest also has the advantage of being easy to operate and easy to collect answers. The e-worksheets can provide curiosity in understanding the material because they interact in finding concepts individually[19]. Video on live web worksheets has the advantage that it can be re-observed when the duration has been completed. Students have a good understanding of the video material [20]. The aspect with the statement "students ask about material that has not been understood" has the lowest score among other aspects, which is

77.78%. It can be related to the statement by Haqiqi and Syarifah (2021) that by using the Liveworksheets.com website, students have the opportunity to solve problems by finding the right solution[19]. Problem-solving can be interpreted as students' effort to face difficulties when they have not been able to find the concepts being studied [21].

The practicality of e-worksheets can also be seen from the response questionnaires given to students. This aims to discover their responses to learning using inquiry-based e-worksheets on molecular shape material. The response can be in the form of a positive or negative response with a range of conformity categories, namely 1-5. Students choose point 5 if they agree with the statement given and vice versa. It can be seen from Table 6 that each aspect has a good percentage and the value that often appears as a percentage of 95% with a very practical category according to the score interpretation table in table 2. The positive response given to students can be achieved because there is a relationship between the suitability of the content, presentation, linguistic aspects, material suitability, e-worksheets design, and ease of operating e-worksheets. It needs to be considered to support students' cognitive stimulation of visual-spatial abilities because it is related to images of molecular shapes that are presented with a combination of color, resolution, rotation, and optical illusions [22]. Because, in general, in the form of molecules, there are various kinds of difficulties experienced by students, for this reason, it requires visual skills to represent images of abstract molecular geometry [16]. In the feasibility analysis of e-worksheets in terms of practicality, if the percentage exceeds 61%, it can be practical. So with this statement, it can be said that the inquiry-based electronic student worksheet assisted by liveworksheets.com to train visual-spatial on molecular geometry material is feasible to use.

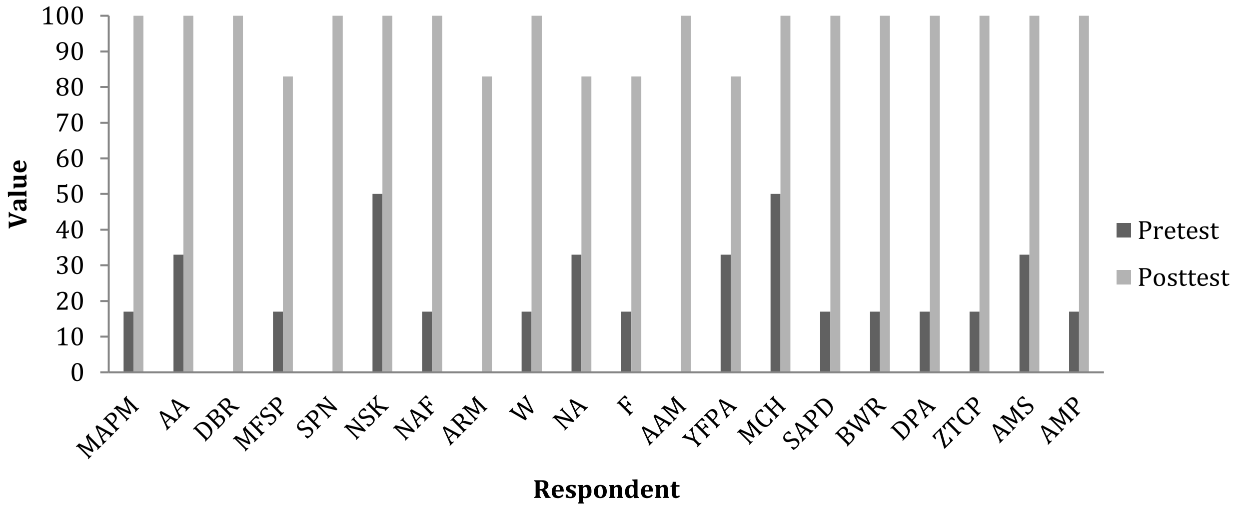

Figure 3. Pretest and Posttest Results

Effectiveness

The effectiveness of the e-worksheets is known from the test results with indicators of special visual abilities. Using research instruments in the form of pretest and posttest aims to determine the feasibility of the developed e-worksheets in terms of the N-gain score obtained. These acquisitions come from the calculation of students' scores during the pretest and posttest. In the study to determine the effectiveness of the e-worksheets, two stages were carried out, namely giving questions on the visual-spatial ability test before learning with e-worksheets and giving questions after learning using e-worksheets[13]. In addition to looking at the N-gain score, students' learning mastery must also be considered both during the pretest and posttest. So it can be said to be complete if there is a test score of ≥75 on the results of the visual-spatial ability test[18].

Students have given a multiple-choice test in the visual-spatial ability test with six questions and answer options a, b, c, d, and e. Questions are given through the google form on the link provided by the teacher. Each question has different indicators by paying attention to the visual-spatial aspect to be achieved. Table 7 presents the relationship between the topic of molecular geometry with the main dimensions of visual spatial indicators and the number of questions. The test is carried out individually according to the abilities possessed by students.

The test is carried out individually according to the abilities possessed by students. Then the pretest and posttest data obtained from the trial results were limited to 20 high school students and were recapitulated as shown in Figure 3.

Figure 3 shows a very significant difference between the pretest and posttest values. It is seen

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from the completeness experienced by students all students at the time of the pretest had a score in the unfinished category. Then after learning using e-worksheets and doing a posttest, all students have a score in the complete category. It shows that there is an increase before and after the e-worksheets trial. From the overall calculation, it can be seen that the completeness of the assessment possessed by 20 students reached a percentage of 100% with an average score of 95%, so both aspects were in the very good category. Increased understanding of molecular shape material occurs because students are accustomed to using e-worksheets teaching materials developed to represent molecular geometry in real problems. Students' cognitive learning outcomes are at a percentage of 100% with a very good category[18]. Inquiry-based chemistry worksheets can improve students' mastery of chemical concepts [6].

Table 7. The Relationship Between Visual Spatial Ability Indicators and Question Numbers

Topic	Visual Spatial Main Dimension Indicator	Question Number
Molecular Geometry	Able to correctly identify molecular formulas based on the visualization of known molecular geometries	1, 2
	Able to connect between known molecular geometry visualization data with the concept of molecular geometric shapes	3, 6
	Able to correctly determine molecular geometry in 2-dimensional form based on molecular geometry visualized in 3-dimensional form	4, 5

Table 8. Average Value of Overal N-Gain

No	Number of Students	Average N-Gain	Criteria
1	20	0.94	High

Then the pretest and posttest scores were calculated again to determine the N-Gain value obtained from the comparison between the difference in scores before and after the implementation of the e-worksheets with the total maximum score and the score before learning with e-worksheets. From the calculation, the N-Gain is 0.94 in the high category (table. 8).

Inquiry-based student worksheets assisted with the Liveworksheets.com website can provide a new atmosphere in learning at the school, with the content components provided using assistance from Liveworksheets.com, making student activities increase[8]. By constructivism learning theory that changes in student activities to become more active can make it easier for students to construct an existing problem so that they can automatically find solutions to these problems with each student's concept [13]. This learning follows the syntax of the inquiry learning model.

Implementing the development of inquiry-based electronic worksheets can support interactive learning and encourage students to work harder in solving the problems given. Problems need solutions so that students will think more about solving them[23].

CONCLUSION

It can be concluded that the inquiry-based electronic student worksheets assisted with Liveworksheets to train visual-spatial on molecular geometry topics are feasible in terms of validity, practicality, and effectiveness. It is considered with very valid, practical, and effective categories of electronic student worksheets.

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