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Klews Chart's Contribution to Promoting Students' CreativityIn Stem Education with the Topic Optics

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This study demonstrates that the KLEWS teaching technique is effective in developing students' creative abilities in STEM education with the subject of Optics. The KLEWS chart allows students to practice logical and argumentative thinking based on scientific information and evidence. Furthermore, teaching according to KLEWS chart stimulates students' curiosity, imagination, creativity, and desire to learn more about science. The mixed methods research was carried out on 161 eleventh grade students in Vietnam (including 80 students in the control group and 81 students in the experimental group). The research evaluates students' creative abilities by observing students' creative expression in normal STEM's topics without KLEWS chart in each group. Then, for the experimental group, organize teaching STEM topics using the KLEWS chart, and for the control group, organize teaching the topics of normal STEM. The results showed that the experimental group reached a high level of creativity (7.77/10 points), while the control group had a medium level of creativity (4.81/10 points). In addition, the research found that students were excited and active in STEM activities; applied the KLEWS chart to explore knowledge of STEM topics; confidently made a presentation and had the ability to use the keywords and scientific terms listed in the KLEWS chart and link them together. The findings of this study will help to clarify the effectiveness of developing students' creative capacity in STEM education using the KLEWS chart.

Keywords: creativity, STEM education, KLEWS chart, Optics, competency.

Faced with the requirement of accelerating industrialization, modernization, and international economic integration, countries around the world's education systems must pay special attention to the issue of educational innovation in order to train a qualified workforce. It is necessary to have high-quality knowledge that includes not only specialized knowledge but also interdisciplinary understanding (Tsupros et al., 2009; Li & Wang, 2021). Furthermore, skills such as using knowledge to solve problems, creating innovative products,

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and working in groups are becoming more valued. STEM education is widely regarded as a game-changing educational reform with the goal of firmly establishing a country's position in economy, science, and technology, as well as training a qualified workforce. STEM jobs are expected to grow rapidly in the United States, where STEM education originated (Carnevale et al., 2013; Li et al., 2020; Sharma & Hudson, 2022). Not only that, but this prediction is shared by other developed countries such as Australia, the United Kingdom, France, Canada, Singapore, and Thailand.

STEM is an acronym for Science, Technology, Engineering, and Mathematics. STEM was originally used to refer to science, technology, engineering, and mathematics development policies in the United States. The National Science Foundation (NSF) coined the term STEM in 2001, and it is now used as a catch-all term for any event, policy, program, or practice involving one or more STEM principles (Bybee, 2010).

According to the U.S. National Academy of Sciences study in 2007, more than 80% of careers growing in this country depended on the proficiency in knowledge and skills in mathematics, technique, science, and technology that STEM Education gave. The background of STEM is the integration in the context of worldwide challenges and problems in education. Orientation of STEM Education helps students have a unified view of science based on their knowledge of the world around them (Carla et al., 2016).

STEM education in high schools is a teaching approach that focuses on developing students' competencies in the fields of Science, Technology, Engineering, and Mathematics. In which students can engage in STEM activities, primarily practice and experiential activities to create products, serve as living and learning tools, or solve practical problems.

Theoretical Framework and Literature Review

Constructivism is one of the most effective educational teaching theories. This theory encourages students to develop their own knowledge based on personal experiences and apply it directly to their learning environment (Marone, 2016). Each individual student is at the center of the teaching process, while the teacher acts as an arbiter to institutionalize new knowledge of the lesson as a controlling organization and a representative of orthodox scientific knowledge. The central concept of constructivism is that knowledge emerges from the learner's self-structured perception into his or her internal system, and that knowledge is subjective. Constructivism is a subject theory that emphasizes the role of the perceiver in the interpretation and construction of knowledge (Nurpatri,et al., 2021). It is necessary to organize the interaction between learners and learning objects in order to assist learners in incorporating new information into their own subject-adjusted thinking structure. Learning encompasses not only discovery but also the interpretation and organization of knowledge. Constructivist teaching entails teachers guiding students to discover knowledge for themselves, perform learning tasks, and develop individual research methods, thereby creating knowledge for themselves.

Existing Knowledge - Predict - Test - Fail - Adapt - New Knowledge is the process by which students acquire new knowledge (Piaget, 1997). According to this process, teaching a new knowledge does not begin with the teacher announcing that knowledge, but rather with discovering the knowledge to be acquired from existing knowledge. Students can be creative, express themselves, make predictions, test their predictions, listen to your point of view, repeat the experiment if necessary, then debate and agree. new ideas and knowledge. Teachers will discover many unexpected or unusual factors by listening to and monitoring students' opinions and creativity. Teachers will respect students' opinions and encourage students to choose the right path to continue. access to information As a result of that activity, students obtain a knowledge system that meets the requirements while also discovering a way to occupy knowledge. This process is reflected in the creativity that results from the students' thinking process, which is clearly reflected in the STEM teaching process activities. As a result, STEM education is regarded as a teaching model that effectively applies constructivist theory while encouraging students' creative abilities.

Howard Gardner's book "Frames of Mind: The Theory of Multiple Intelligences" was the first to officially publish the theory of multiple intelligences in 1983. The recognition of the many components of human intelligence is at the heart of this psychological theory. Multiple intelligences refers to eight distinct intelligences: linguistic, logical-mathematical, musical, spatial, bodily-kinesthetic, communicative, introspective, and naturalistic intelligences.

However, there are intelligences that are superior to the rest for each individual (Gardner, 2003).The most valuable aspect of Howard Garder's theory is a new perspective on the diverse human potential and the need to exploit and promote those potentials in teaching. According to the theory of multiple intelligences, each individual almost reaches some level in each of the various "intelligence categories". This level, in particular, is not "constant" throughout a person's life, but may change depending on the individual's cultivation. Based on eight different human intelligences, multiple intelligences theory "provides" eight different potential learning pathways. Gardner (2012), on the other hand, claims that most people only have three of the eight intelligences. This is determined not only by each individual's capacity, but also by their interest in learning. As a result, in addition to focusing on developing learners' strengths, it is also necessary to develop learners' weaknesses. It is also necessary to use appropriate teaching methods to stimulate interest and promote the learner's intellect.

This theory has provided a correct perspective not only for psychological researchers, but also for educators working to develop diverse intelligence in humans. As a result, in education, the spirit of respecting students' individual abilities and potentials must be promoted. As a result, teaching that seeks to comprehensively develop learners must create conditions for the development of multiple intelligences for learners in a variety of fields, rather than focusing solely on the development of logic - mathematics and language, as traditional teaching does.

The overview study of Yildirim (2016) analyzed 34 different studies to show the impact of STEM education on enhancing interest and motivation in STEM fields, developing problem-solving ability, scientific capacity as well as student's learning outcomes (Yildirim, 2016). The positive effects of STEM education on students are manifested specifically in creating learning motivation, increasing positivity, sense of meaning, and enthusiasm for learning (Tillman et al., 2014). This is a key factor which makes learners keep career orientation and persistence in STEM areas (Fortus & Vedder, 2014). STEM education is also considered to have a great influence on academic success and students' attitudes at school (Hurley, 2001). For the impact on career orientation, studies also show that STEM education plays an important role. From the age of 15, students in many developed countries reluctantly choose STEM subjects, although many of these subjects are prerequisites to be promoted in their universities. Students who do not choose to study STEM subjects have fewer opportunities to contribute to society as STEM experts (Ainley et al., 2008).

Positive experiences in the secondary school years are very important, making favorable conditions for learners to choose STEM subjects in the future. Research shows that most learners recognize the importance of STEM in society, but they do not see the importance of STEM to themselves. Many students choose to study some STEM subjects in high school to support their studies at university, as they get good grades in STEM subjects, they will have the advantage for university admission (Bøe et al., 2011). Developing learners' necessary competencies to engage in STEM fields effectively takes a long time (English & King, 2015). Therefore, high schools need to create a supportive teaching and learning environment to develop students' STEM competencies and create favorable conditions for them to develop later in higher education (Blank, 2013).

In addition to studies that show a positive impact, a number of studies show that STEM education is ineffective at developing creative abilities or improving students' academic knowledge (Yildirim, 2016). As a result, the effectiveness of the way to organize the STEM education model and support teaching techniques in high schools must be carefully studied.

In Vietnam, the Overall program of the new general education program issued in 2018 (Vietnam MOET, 2018) described: STEM education is an educational model based on an interdisciplinary approach, helping students to apply scientific, technological, technical, and mathematical knowledge to solve lots of practical problems in a specific context:
- Mathematical education creates a connection among mathematical ideas, between mathematics and practice; between mathematics and other subjects & educational activities, especially for science subjects, Natural sciences, Physics, Chemistry, Biology, Technology, and Informatics to implement STEM education;

- Natural science education helps students gradually form and develop natural science competencies through observation and experimentation, applying synthesis of knowledge and skills to solve problems in their life simultaneously with Mathematics, Physics, Chemistry, Biology, Technology, and Informatics to implement STEM;
- Technology education is implemented through a variety of subjects and educational activities, of which the core is Technology part in Informatics and Technology subject at primary school level and Technology subject at secondary and high school level. Along with Mathematics, Science, Natural Sciences, Physics, Chemistry, Biology, and Informatics, Technology plays an important role in the implementation of STEM education;

- Informatics education plays a key role in preparing students for the ability to seek, receive, expand knowledge and be creative in the era of the fourth industrial revolution and globalization; effectively supports students' self-studying; creating a stable base to apply digital technology, serving the development of new knowledge content, deploying new and modern educational methods for all subjects and educational activities; Along with Mathematics, Science, Natural Sciences, Physics, Chemistry, Biology, Technology contribute to implement the STEM education.

Thus, according to student-centric teaching orientation in STEM education, it needs to link the fields of science, technology, and society based on the foundation of mathematical language to unite the three environments: natural, social, and artificial to meet the needs of humans in real society, as proposed in Figure 1 (Bien & Hai, 2019).

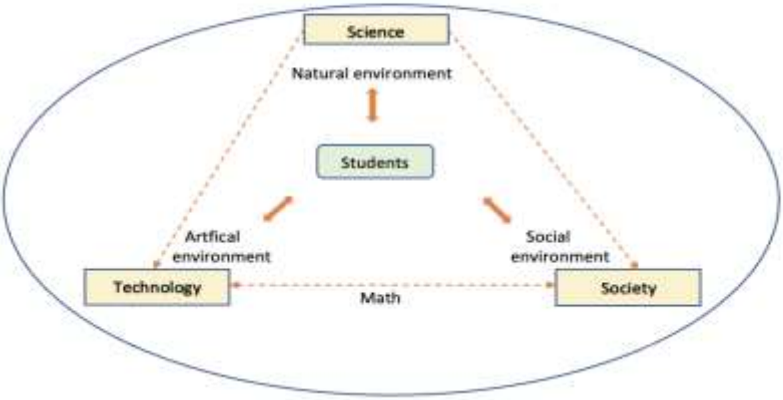

Figure 1. The connection of natural environment, social environment and artfical environment in STEM education

Using the KWL chart in teaching was introduced by Donna Ogle in 1986, which is a kind of organization to teach comprehension activities. The KWL charts support teachers to activate students' prior knowledge of a subject or topic and encourage them to actively learn, read, and research. The KWL chart is particularly useful as a reading strategy when reading texts and it can also be used to assess what students have learned in a unit of study. The KWL chart includes the following elements: *K – What we Know; W – What we want to Learn; L – What we have Learnt*. Students begin by brainstorming everything they already know about the topic of the text. This information will be recorded in column K of the table. Students then make a list of questions about what they would like to know more about in this topic. Those questions will be recorded in column W of the table. During or after reading, they will answer the questions in column W. This information will be recorded in column L (Ogle, 1986).

The term KLEW was firstly introduced by Hershberger et al. in 2006, as a revised and updated version of the KWL teaching technique to meet the requirements of the new education system (Hershberger *et al.*, 2006). There are two obvious differences between the traditional KWL format and the KLEW approach (Max, 2013):
Firstly, traditional KWL charts provide no opportunity for students to demonstrate how their collective evidence has supported students to deeply understand the content. Evidence is essential to teach science today. Therefore, the KLEW chart has devoted an entire column "E" to relevant evidence, so that students not only realize the overall importance but also create the habits in scientific research.

Secondly, the KLEW format shows that learning is never-ending. This idea is at the heart of the scientific research process. While the traditional KWL chart ends the cycle with an "L" – from something learned. This closed-minded approach does not accurately represent the idea of the research process through exploring, discovering, and expecting new problems. Meanwhile, the KLEW chart allows the teacher to state this expectation. When students fill out the "W" column with additional questions, they are demonstrating that new knowledge always leads to new questions, the notion that learning is never-ending.

By 2015, the two authors mentioned above continued to introduce a new update, which is KLEWS, by adding the element "S – what Scientific principles or vocabulary help explain the phenomena?" (Hershberger & Zembal-Saul, 2015). In this column, the teacher explains the concept behind what the students have learned. It is important that based on this final step, students are able to connect with a common concept from their own personal experience in the process. In addition, the addition of scientific terms and principles, can provide a starting point for a more complete scientific explanation. The learning process with the KLEWS chart is based on constructivism, and theory of multipe intelligences, which are two of many important theories to build educational programs (Posner et al., 1982). The elements of the KLEWS chart are described in Table 1.

Table 1
The elements of KLEWS chart

K	L	E	W	S
what do we think we ***Know***?	what are we ***Learning***?	what is our ***Evidence***?	what do we still ***Wonder*** about?	what ***Scientific*** principles or vocabulary help explain the phenomena?

Creativity is one of the competencies that students need to have in the 21st century when they have to face the strong development of technology and prepare for their future career. Based on the interviews, it was found that students lack skills, especially creative skills, and teachers have not trained students' creative capacity, although the curriculum has been developed and emphasized more on the creative aspect (Hanif et al., 2019). Creativity refers to the creation of a new and appropriate process, product or solution for an ongoing task (Amabile, 2012). If creativity is related to learning and technology, it will produce high-quality work. Recent research has shown that technology allows students to build a number of means that can help them create high-quality work in a creative context (Loveless, 2002). Therefore, creativity is one of the important competencies that need to be developed for students (Dawes & Wegerif, 2004).

Objectives of the Study

This study aims to answer the following two questions:

- How effective is the use of KLEWS chart in organizing STEM educational activities?
- How are students' creative abilities developed when they take part in STEM educational activities using the KLEWS chart?

Significance of the Study

STEM education fosters creativity in students by teaching them about the scientific nature of things and phenomena, researching knowledge, discovering, practicing, and motivating them to participate in learning activities related to future professions (Hsu & Yeh, 2019), assisting in the formation and development of students' creative skills and abilities to solve interdisciplinary situations in life.

Furthermore, the KLEWS chart encourages students' higher-order thinking by assisting them in developing information gathering skills and scientific evidence to support the process of discovery, discovery, and creativity. As a result, using the KLEWS chart in STEM education is a mutually beneficial combination that promotes the optimal development of students' creative capacity. Simultaneously, Optics knowledge has many common applications in science and technology, piqueing students' interest in learning and exploring. The Optics section's knowledge circuit is based on what students already know to develop new knowledge based on phenomena and data collected from experiments. This is very compatible with the KLEWS chart's teaching process, and is consistent with the constructivism and multiple intelligences theories mentioned above, helping to stimulate students' curiosity, imagination, creativity, and desire to explore deep science. As a result, using the chart to design STEM topics in Optics in the direction of STEM education is extremely effective in developing students' creative capacity.

Method

Research Method

The study was carried out by mixed methods research. Data was collected through observing the process of students' STEM education activities on the subject of Optics.

Sampling Strategy and Sample

The participants, selected through convenience sampling, were the grade 11 students at An Bien high school in Vietnam. They were categorized into two groups: control and experimental, based on similar criteria such as the number of students, age, and academic ability. The experimental and control groups are in charge of the same teacher. The charateristics of participants is shown in Table 2. This method of sampling is used to eliminate unnecessary variables and ensure that the research results are due to the impact of the research topic and not by chance.

Table 2

Characteristics of participants of the study

Info.	**Control group**		**Experimental group**	
	11A3	11A4	11A5	11A6
Number	40	41	40	40
Percentage of student with average-above mark	85%	89%	90%	85%

Research Instrument

Based on some creative capacity scales proposed by other authors: Barbot et al., (2011), Nga et al., (2017), and Vietnam MOET (2018), we propose a creative capacity structure that can be used to teach STEM topics as shown in Table 3.

Table 3

An observational instrument for measuring students' creativity

No.	**Creative Dimension**	**Score**			
		0	**1**	**2**	**3**
1	Find out new issues, new situations in practice and propose the right and effective solution.				
2	Design diagrams, drawings showing the principle of structure and operation of the technical system and show its novelty and effectiveness compared to the known ones.				
3	Find a new survey and measurement solution, ensure efficiency but easily to implement, ensure accuracy.				
4	Find out new equipment and materials to replace old equipment and materials but still ensure high efficiency and savings.				

5	Propose new design solutions for the existing technical system, changing some design details to improve efficiency.
6	Carry out the implementation of solutions, construction, manufacturing, ... technical systems to bring benefits and social significance.
7	Apply learned knowledge to solve new problems, new situations in practice.
8	Combining mindset manipulations (comparison, analysis, evaluation) and methods of judgment, hypothesis modeling, hypothesis testing, thereby making accurate conclusions for the problem.
9	Create lots of solutions to a real problem and bring optimal efficiency.

The scoring convention is as follows: The maximum score for each expression is 3 points, which are integer points corresponding to the level of each expression in the creative capacity scale, the maximum score of each group in the scale is 27. In order to facilitate the calculation of points in the learning process of students, we proceed to convert the scale score of 27 to a scale of 10 according to the formula:

[Scale score of 10] = [Scale score of 27] x 10/27

The category of creative capacity is shown in Figure 2.

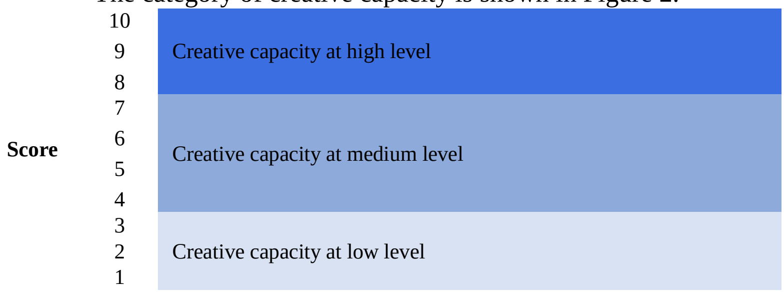

Figure 2. The category of creativity capability

Research Procedure

Based on the process of organizing STEM topics (Vietnam MOET, 2018), we apply the KLEWS chart to STEM educational activities in the direction of developing students' creative capacity in the sequence described in Table 4.

Table 4

The procedure of STEM education using KLEWS chart

No.	Name of activity	Content
1	Identify the problem	Students have the task to complete a learning product or solve a specific problem with criteria that requires students to use new knowledge in the lesson to propose and build solutions.
2	Research the background knowledge and propose solutions	Students discuss and state knowledge related to the topic and fill in column K on the KLEWS chart. Students work on experiments or use simulations to research related problems, note in column L all the problems realized during the implementation attached with proofs for those problems in column E. Columns L and E are performed in parallel, each statement in column L will be followed by one or more evidences in column E, symbols and lines can be used to show the combination.
3	Choose a solution	Organize for students to present, explain and defend the design with

		explanations (using knowledge that has just been learned and existing).
4	Manufacture, experiment, and evaluation	Organize for students to make samples according to the design, in combination with testing during the manufacturing process. Students evaluate the samples and adjust the original design to ensure that the sample is viable. Students add noted information in columns L and E of the general KLEWS chart (if any).
5	Sharing, discussing, and adjusting	Organize for students to present learning products that have been completed; exchange, discuss and evaluate for further adjustment and improvement. Students fill in questions and issues that need further research and improvement in column W. Students state the principles and scientific keywords that were withdrawn in the implementation process.

The pedagogical experiment was conducted over 8 weeks (from the beginning of Febuary to the ending of March, 2022), and had the permission of the Board of Directors and the professional council of An Bien High School, Kien Giang Province, Vietnam. The research assessed students' creative ability by observing the expressions of students' creative capacity in normal STEM lessons without using KLEWS chart in each group. After that, the research organized teaching STEM topics using KLEWS chart for experimental group, but taught normal STEM topics for control group. The groups were held twice a week, and the duration of each group was 90 minutes.
The proccess of pedagogical experiment is carried out through the following stages:

(1) Stage 1: Proposing the lesson plan;
(2) Stage 2: Evaluating students' creativity through observating the creative dimensions in STEM-based traditional education in pre-test stage (that is not the STEM topic the researchers proposed);
(3) Stage 3: Educating following the lesson plan of STEM education using KLEWS chart for experimental group, and the traditional lesson plan for control group;
(4) Stage 4: Using the observation instrument mentioned in Table 3, evaluating students' creativity.

Teaching Design

We research and build the process of teaching STEM education with the topic *"Design of optical experiments for visually impaired students"*, the specific process is as follows:

Activity 1: Identify research issues about optical experiments for visually impaired students

- Receive learning resources, listen to situations of topic.
- Discuss in groups and analyze the data of the situation.
- State the topic that needs to be implemented.
- Record the task on the KLEWS chart.

Activity 2: Research the knowledge base and propose the solutions to design optical experiments for visually impaired students

- Students discuss in groups and state the knowledge they have learned related to the topic. Write the content in column K in the KLEWS chart.

Figure 3. Students noted the content in the appropriate columns L - E in the KLEWS chart

- Students perform a light refraction experiment with a glass semi-cylindrical and comment on the path of light rays through the experiment. After that, they state the problems that were realized after going through the activities with proof of those problems. They noted the content in the appropriate columns L - E in the KLEWS chart.
- Students observe light-dependent resistors and its module, and add relevant knowledge that has been learned in column K in the KLEWS chart. After that, they do research on the structure and principle of light-dependent resistors and their modules through learning resources from the Internet, keep adding the obtained contents with the proofs and write them in columns L - E respectively in the KLEWS chart.
- Students rely on the KLEWS chart and discuss in groups to propose some options for using materials, technology, and drawings design of products.

Figure 4. Students working in groups

Activity 3: Selecting a solution for an optical experiment kit for visually impaired students

- The groups get the task of presentation, explaining the principles, and introducing the product design that the group has implemented.
- Students report, teake notes, and answer critical questions about the design of optical experiment kits for visually impaired students; self-assess, predict the advantages and disadvantages in the process of product implementation.

Activity 4: Manufacturing, testing and evaluating optical experiment kits for visually impaired students

- Step 1: Receive materials and tools.
- Step 2: Calculate the size of the product, measure, and cut the product. Students can look up the information by themselves or ask for help from teachers if necessary.
- Step 3: Test the product. Adjust the design if necessary.
- Step 4: Finish the product. Prepare the presentations of products. Add noted information to columns L and E of the KLEWS chart (if any).

Activity 5: Sharing, discussing, and adjusting the design of optical experiment kits for visually impaired students

- Groups exhibit the products, make presentations, introduce products and give feedback to protect their products.
- Students fill questions and issues that need further research and improvement in column W. Students state the principles and scientific keywords that were withdrawn in the implementation process.
- Teachers standardize knowledge for students, write down scientific phrases and terms related to product improvement in column S.

Results

RQ1: How does KLEWS chart affect to STEM education?

Through the method of observing the experimental process of organizing STEM education activities mentioned above, we obtained the following comments between the control group and the experimental group as shown in Table 5.

Table 5

Comparing the effects of STEM education on control and experimental group

No.	Control group	Experimental group
1	Students are interested in participating, but still carries out the task that the teacher passively transfers;	Students are excited and actively participate in getting knowledge;
2	Teachers spend a lot of time on research on knowledge base, teachers mainly repeat knowledge. Students answer fragmentary questions and do not know how to link knowledge together;	Students actively give relevant keywords to help the research of knowledge base become more vivid and logical, mobilizing students' existing knowledge;
3	Students have the expression of forgetting the knowledge that has been repeated in the research of a knowledge base that is not associated with proposing the solutions, the teacher needs to explain it again to the students. Students have not provided data and evidence for the above-mentioned contents yet;	Students voluntarily apply the contents filled in the KLEWS table to propose possible solutions that may match the scientific knowledge in a grounded manner, voluntarily collect scientific evidences in the experimental process to fill in the KLEWS chart with aim to support the hypothesis;
4	Students come up with solutions, but they are not innovative and creative, and they can't explain the basis of that solution, and the solutions are emotional;	Students are active and proactive in carrying out the tasks, know how to find information from the mentioned keywords and have breakthroughs and creativity in applying knowledge;
5	Students make a presentation of products that do not use many relevant technical terms, the frequency of mentioning the target knowledge is still low;	Students confidently make the presentation, they are able to use the keywords and terms mentioned in the KLEWS chart, know how to link knowledge together and present logically;
6	Teachers have difficulty condensing and expanding knowledge for students; The class took place as usual, without lots of creative and breakthrough elements. The duration of activities is often not guaranteed as planned in the lesson plan.	Teachers easily finalize the important knowledge and orient to expand research on other optimal solutions through the KLEWS chart stored on the large board, ensuring that the period of activities goes according to the lesson plan as expected.

Based on data from the qualitative analysis, it shows that using the KLEWS chart to organize STEM educational activities helps students to be excited and active, and they can apply the KLEWS chart to discover knowledge of STEM topics; Students confidently present and are able to use keywords and scientific terms listed in the KLEWS chart and link them together; Teachers easily finalize their knowledge and orientation to expand the topic through the KLEWS chart that has been saved throughout the implementation process. At the same time, ensure that the period of activities takes place exactly as the lesson plan of the STEM topics.

RQ2: How is students' creativity developed in STEM education using KLEWS chart?

Using the research tools listed in Table 3, we assessed students' creative capacity by observing the students' creative dimensions before and after the experiment. The result is shown in Table 6.

Table 6

The assessing result of students' creativity

Stage	Group	Score of dimensions									Average Score	Category
		1	2	3	4	5	6	7	8	9		
Pre-test	Control	0	2	0	1	1	1	2	0	0	2.96	Low
	Experimental	0	2	0	2	1	1	1	0	0	2.59	Low
Post-test	Control	2	2	1	2	1	2	1	1	1	4.81	Medium
	Experimental	2	3	2	3	2	3	3	1	2	7.77	High

The pre-test results showed that the creative capacity of students in the control group and experimental group before the experiment was similar and both had a low level of creativity. In particular, the expression of numbers (1), (3), (8), and (9) are all unsatisfactory.

From the post-test results, we found that: the experimental group has a high creative capacity, and the control group has a medium creative capacity; The creative capacity of students in the experimental group (7.77/10 points) is much higher than that in the control group (4.81/10 points). The expressions of (1), (3), (8), and (9) are all at a satisfactory level or higher in the experimental group, while in the control group, there are still some unsatisfactory expressions in STEM topics.

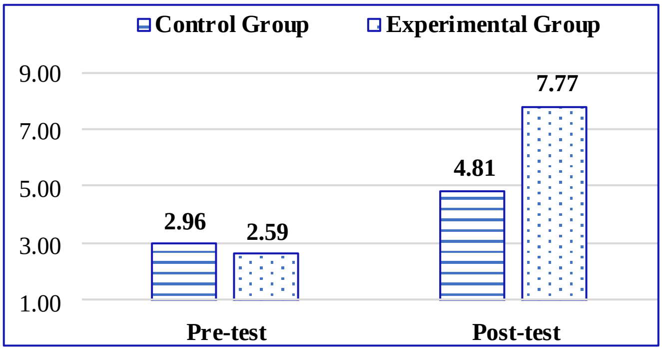

Figure 5. Comparing the creativity capability of control group and experimental group

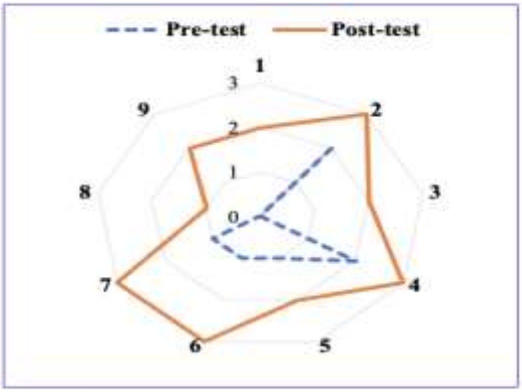

Figure 6. Students' creativity of experimental group for each creative dimension

For the experimental group using the KLEWS chart in the process of organizing STEM educational activities, the researchers found that creative expression (2), (4), (6), and (7) reached the maximum level. The expressions of (1), (3), (8), and (9) are from unsatisfactory to satisfactory after applying the research topics. This shows that the KLEWS chart is very effective to develop students' creative capacity.

Discussion

STEM education combined with the KLEWS chart is a type of teaching that can help students develop their competencies, form, and develop many skills, so it is very important to promote development in high schools. High schools need to continue to facilitate the organization of STEM topics using the KLEWS chart in schools to improve creativity for learners. The use of the KLEWS chart in organizing STEM educational activities needs to be done methodically as stated in the research, however, based on the capacity of the students, it can be applied flexibly. Teachers need to be proactive and spend much time investing and building lesson plans on STEM topics that are interesting for students to participate in. At the same time, deploying the teaching techniques with the KLEWS chart appropriately in many various learning situations. Students need to have a positive attitude towards study, discover new knowledge, and keep a serious attitude to study, constantly striving, improving knowledge, and developing their own capabilities. Moreover, when the students work in group to complete a mission, this will improve their cooperative behavior which is very important for human lives, works and society in 21st century (Chatathicoon et al., 2022). The training and organizing training courses for teachers to improve awareness, understanding, and skills to organize STEM topics and apply the KLEWS chart to teaching should be enhanced to promote students' creativity.

In the session of researching and proposing solutions, students are allowed to discuss in groups, exchange and state their learned knowledge related to the research issue and note the content in column K. Students' brain function will be affected by their increased attention (Makmee, 2022). Listing the mentioned knowledge in column K increases the student's attention to the problems. This activity helps them link knowledge to support the creative process in the following activities. Rustaman et al., (2003) said that the process of discussion creates many advantages with aim to stimulate students' creativity to express their own point of view, students are responsible for the results of group activities. At the same time, students can experience real or simulated experiments, record the problems realized during the implementation in column L attached with evidences for those problems in column E. Munandar (2004) stated that creative thinking can be developed through experiments and discussions among students. The KLEWS chart saves the main content, orients the creative thinking process for students, helps them propose multiple solutions and choose effective solutions. Based on columns K, L and E, teachers can easily see and evaluate students' ability to apply knowledge to solve creative problems. Creative expressions (1), (2), (3), (4), and (5) are clearly expressed.

The collected information is continuously added to column L and column E of the KLEWS chart in making samples, testing, and evaluation. This requires students to try to think of problems and shortcomings, events that occur in the process of manufacturing, testing products and explain to them by specific data. This process helps to train students to collect information and scientific evidence while students observe in reality or on experiment, which creates a scientific basis for their creative process. Creative expressions (6), (8), and (9) are effectively promoted.

In the session of sharing, discussions, and adjustments, students have the opportunity to discuss, ask questions, express their thinking, and issues that need to be researched, improved, and then they fill in the key contents in column W after groups of students make presentations about their completed learning products. The teacher guides students to state the principles and important scientific keywords to use in the research and fill in column S briefly. In this case, students' creative capacity plays an important role in creating new effective solutions to improve and fix students' products (Capraro & Morgan, 2013). Column W and column S in the KLEWS chart stimulate curiosity and be used as a premise to keep developing students' creativity after the end of STEM educational activities, helping students apply their acquired knowledge to solve new problems, new situations in practice - creative expression (Besemer & Treffinger, 1981; Royston & Reiter-Palmon, 2019).

Conclusion

The KLEWS chart plays an important role in developing students' creative capacity in activities of STEM topics. The KLEWS chart focuses on the evidence factor based on experimental observations. It is an important characteristic in the field of science (Max, 2013). For KLEWS-based teaching, students have the opportunity to practice creativity, logical thinking, and argumentative thinking based on evidence and scientific information (although not all observation results are scientific information). In addition, the process of learning according to the KLEWS chart also helps to stimulate students' curiosity, imagination, creativity, and desire to explore deeper science by helping them to set their own next wonder. At the end of the KLEWS chart are scientific concepts or scientific principles and even scientific explanations. This helps students update important keywords to support further research and develop their creativity at a higher level.

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