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Original Article

Design and Teaching Process of Stem Project "Smart Night-Lamp" for High School Students

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Abstract: In Vietnam general education curriculum 2018, a learning model called STEM education is being interested in and encouraged in teaching and learning. Choosing a STEM topic will engage students to explore knowledge. The topics which selected need to be linked to reality and have a direct impact on human life. In the era of industry 4.0, besides data science, machine learning, artificial intelligence, etc., the role of automation is indispensable. The previously developed STEM topics are quite diverse, including topics on physics, chemistry, biology, informatics, etc. However, STEM topics about automatic control field are rarely exploited to increase students' awareness of the role of automation in life in the era of technology revolution 4.0, and also enrich the topics of learning and experience in the contents of smart home, warning system, etc. in the general education program issued in 2018. In this paper, therefore, we propose a new STEM project in the field of smart models, which is the smart night-lamp. Furthermore, we use the 6E teaching model to design the teaching process, which emphasis on two elements of technical design and practice in STEM-oriented teaching. After proposing a new STEM topic and designing a teaching process according to the 6E process, we also conducted a pedagogical experiment to ensure the feasibility of the proposed topic in STEM education.

Keywords: STEM education, 6E teaching model, automation, high school student.

1. Introduction

STEM education is a teaching model that is encouraged to implement in the new general education curriculum issued in 2018, at both the basic curriculum and the career-oriented education stage. There have been several documents from the government and the ministry of education and training (MOET) on STEM education in high schools [1-3]. As a result, there are many references for STEM topic proposals along with the design and teaching process on the basis of current education curriculum issued in 2006 [4-9].

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STEM topics in reference materials are quite diverse and covered in physics, chemistry, biology, informatics, etc. However, the exploitation of STEM topics associated with sensors and automatic control using transistor has not been strongly exploited. The construction of STEM topics in this trend increases the students' awareness about automatic control systems in the era of technology revolution 4.0. This exploitation is also more useful in building teaching contents for the new general education program issued in 2018 in physics and technology subjects that have many contents related to control circuits for smart home, warning system, etc.

The STEM project "Smart night-lamp" is designed to create opportunities for students to harness, learn and apply the knowledge of electricity and electronics learned in physics and technology subjects in the current general education curriculum, combining with photoresistance sensor to design smart night lamps, which used in a room that can automatically bright up when it is dark and automatically turn off when it is light. The topic of smart night lamps related to the content of subjects such as Physics and Technology, and so on in the current general education curriculum. These knowledge contents in the curriculum Physics (grades 11 and 12), Technology (grade 12), Sciences issued in 2018 have a very good level of response. Therefore, smart night lamp is a topic that is practical in both academic curriculum and extracurricular experience activities. Moreover, this project is also designed according to the 6E teaching model to harness the ability to explore knowledge and design techniques for students.

2. 6E Teaching Model

The 6E teaching model is an expanded 5E teaching model. In 1980, the 5E model was launched to help students hone the necessary skills of the 21st century, such as environmental adaptability, social skills, problem-solving skills, self-management, thinking abilities. The 5E teaching model consists of 5 phases (stages) applied to the teaching process design of a particular lesson/topic, including: i) Engage; ii) Explore; iii) Explain; iv) Enrich; and v) Evaluate [10].

From the 5E model, the technical practice element (ENGINEER) was added, and became the 6E model. The 6E is student-centered teaching model, and specifically emphasizes the combination of design and discovery. The use of 6E model in teaching has also been researched and developed in [11]. With the 6E process, in the Engage phase, students will be connected to a real-life situation through the proposed STEM topic. During the Explore, Exphain, and Enrich phases, students will access the science of physics and technology they have learned. In the Engineering phase, students will be able to design a control circuit, design a body for a smart night light. In the process of perfecting the product, students will have access to technology components and devices such as resistors, transistors, leds, and glue guns, soldering irons, and so on. Mathematical knowledge is integrated in the process of designing, perfecting and optimizing products.

3. Questions and Research Methods

We conduct research to address the following two questions:

- How does the STEM project "Smart Night Lamp" associates with the contents of education curriculum issued in 2006?
- How is the teaching process for STEM project "Smart Night Lamp" for high school students according to the 6E process?

We carried out research and analysis documents by qualitative approach to find out the connection of subject content and related subject content in the current high school education curriculum. On the theoretical basis of the 6E teaching model, we design the teaching process suitably.

4. Results and Discussions

4.1. Smart Night Lamp Project

4.1.1. Project Description

In the 4.0 technology revolution, the role of sensors is indispensable in intelligent control systems in modern life. Photoresistance sensor is low-cost, easy-to-use, and it can be used to automatically control electrical equipment (in this paper, equipment is a simple led light) based on light on the day and night. That means during the day there is light shining on the sensor, and at night there is barely light on the sensor. Based on the presence/absence of light on the photoresistance sensor, the sensor's internal resistance will change, that will be converted into an electrical signal, through the amplifier element to control the electrical equipment. The project helps students to solve problems about design and automatically control their night lamps by using the photoresistance sensor. By utilize some simple electronic components such as photoresistance sensors, transistors, LEDs, resistors, and battery sources, students can learn about the structure, working principles, and assembly of smart night lamp. Through learning activities, students can learn about the structure, working principles, and assembly of smart night lamp. Through learning activities, students can practice design skills and practice assemble basic electronic circuit.

4.1.2. Installation and Operation Process

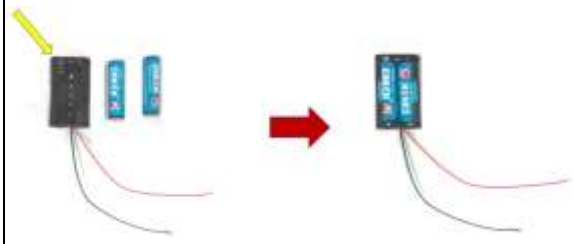
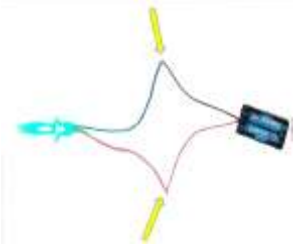
In this section, we build the assembly and operation process for the proposed STEM topic with the aim that after students state the design plan in groups, then the teacher will outline a common process to implement this STEM topic. In addition, since the students' background in electricity and electronics may not be the same, this section is also provided for students who have difficulty accessing the implementation of this STEM topic.

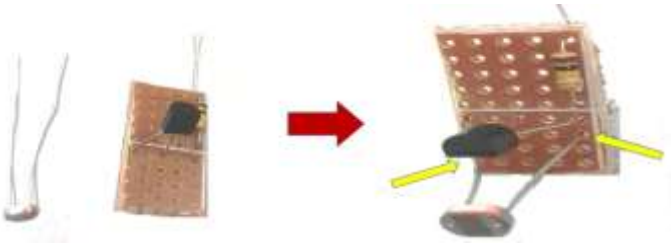
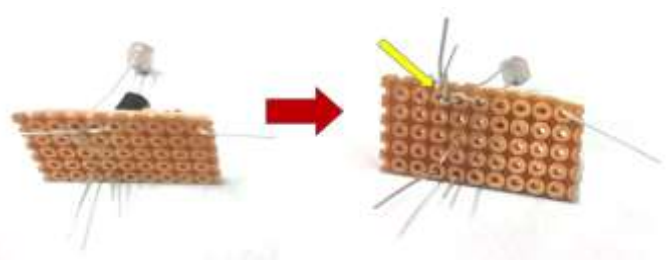
Table 1. Phases/stages in the 6E teaching model [12]

Phase/Stage	**Purpose**
Engage	Teacher evokes students' interest in the lesson, combined with students' known knowledge of the topic.
Explore	Students learn necessary knowledge related to the problem of the lesson. Students perform discovery by many different methods.
Explain	Students explain and choose what they have learned to assist in solving major problems. This is the period when students begin to present what they have learned by exchanging with each other and teachers.
Engineering	Students apply their knowledge to come up with solutions. Students present creative solutions through designs, information systems, models, and resources. After that, students can perform experiments manufacturing operation for their solution.
Enrich	Students explore further and lead to new situations, new applications, or improvements to make the better product.
Evaluate	Students and teachers evaluate and review the learning and working process. Although, this phase is stated in the end, but the evaluation process was non-stop and continuous throughout the implementation process.

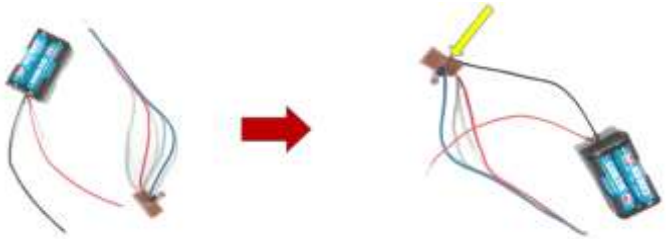
Table 2. List of equiment for smart night lamp" project

Equipment (quantity)	Notes	Tools (quantity)	Notes	Tools (quantity)	Notes
Reverse Transistor C828 (01)		Perforated copper (01)		Lampshade (01)	
1.5V Battery (02)		Battery Base (01)		Led (01)	
Wire (0.5 m)		Photoresistance Sensor (01)		100KΩ (01)	

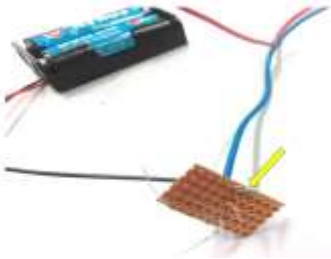
Operation	Illustrations
1. Assemble two batteries into the battery base (negative pole is the flat end of battery to place into the battery base where there is a spring, positive battery is the other end).	
2. Extend the wire for the night lamp (two red, blue wires 5cm long; red wire to the long pin of the Led, blue wire to the short pin of the Led). 	3. Check the night lamp to see if it is on? (the red end of the pin at the base of the battery is connected to the red end of the lamp, the black end of the battery is connected to the green end of the lamp). 

4. Assemble the electronic switch C828 (6th row, look down the text, from left to right corresponding to pins 1, 2, 3). The pins 1, 2, 3 are respectively the poles E, C, B of the transistor.	
5. Assemble the resistor R=100K (one1 end in first row on the circuit board and other end near the pin 3).	
6. Assemble the photoresistance sensor Cds (one end near the pin 3, other end near the pin 1).	
7. Twist three wires close together (the 3rd pin of C828, one pin of R, one pin of sensor).	
8. Assemble the night lamp (red wire end in first row near the end of the conductor, the blue wire end near the 2nd pin).	
9. Twist two wire close together (2nd pin of C828 and blue wire end of night lamp).	

10. Supply the negative voltage (put the black wire end at the base of the battery near the 1st pin).



11. Twist three wire close together (1st pin of C828, one black wire end of battery, one end of sensor).



12. Supply the positive voltage (put the red wire end at the battery base near the red wire end of the night lamp).

13. Twist three wire heads together (one red wire end of battery, one red wire end of lamp, one end of the resistor).

15. Welding the contact points (wire twisting places).

14. Check the night lamp operation (cover the photoresistance sensor with your hand, the light is on, if you take off your hand, the light turns off).

16. Use pliers to cut the excess wire at the weld places.

17. Design the base, body, and lampshade. Fix the position of the battery base, electronic circuit, night lamp by using a glue gun, or double-sided tape.

4.2. Analyse the Content of Knowledge in the Topic Corresponding to the Current Educational Program Issued in 2006

Currently, some high schools have organized STEM teaching for high school students, while students are learning the general education program issued in 2006. Therefore, in this section, to be able to implement STEM education for current students, we analyze the contents of the proposed STEM topic with the corresponding contents in the ongoing education program promulgated in 2006.

Subjects	Grade	Lesson	Content	
Physics	11	Lesson 7: Constant current. Power supply	Content 1. Providing current for electrical devices operate by the power supply. Content 2. The battery is a power supply.	Learned knowledge and applied students
		Lesson 13. Current in metal	Content 3. Conductor made of metal capable of conducting electricity.	Learned knowledge and applied students
		Lesson 17. Current in semiconductors	Content 4. The P-N junction in light-emitting diodes (LED) and transistors is made of semiconductor.	Learned knowledge and applied students
		Lesson 18. Practice: Examining the rectification properties of semiconductor diodes and transistor amplification properties	Content 5. Transistor can be used as an electronic lock.	Skills trained
	12	Lesson 31. Photoresistanceity phenomenon	Content 6. Photoresistance sensors are composed of semiconductors. Content 7. Photoresistance sensor works based on the photoresistance phenomenon.	Learned knowledge and applied students
Technology	12	Lesson 2. Resistors - Capacitors – Inductors	Content 8. The resistors are used to limit and adjust the current; dividing voltage in electrical circuits.	Learned knowledge and applied students
		Lesson 3. Practice - Resistors - Capacitors - Inductors	Content 9. Determine the value of the resistance by the color code on the resistor.	Skills trained
		Lesson 4. Semiconductor components and IC	Content 10. LED is a light-emitting diode, consisting of a P-N junction, used as a signal light in power supplies, equipments, etc. when power is on. Content 11. Transistor is composed of 2 P-N junctions assembled together, used as amplifying element or electronic lock.	Learned knowledge and applied students

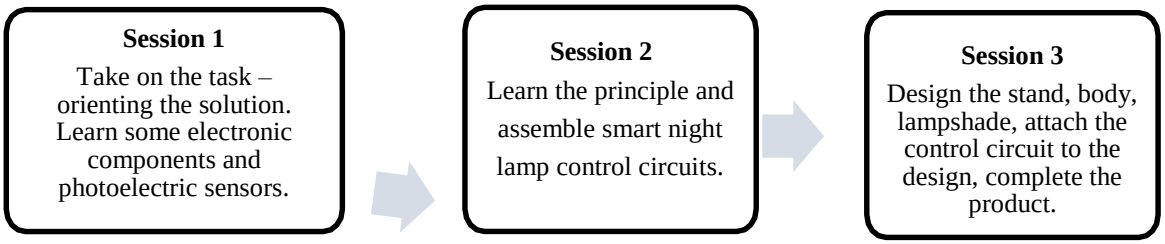
		Lesson 5. Practice – Diode – Thyristor – Triac.	Content 12. Electrode A, K of diodes is identified.	Skills trained
		Lesson 6. Practice - Transistor	Content 13. Identify electrodes A, K of diodes.	Skills trained
		Lesson 13. The concept of electronic control circuits	Content 14. Automate the machinery by Electronic control circuit	Learned knowledge and applied students
		Lesson 14. Control signal circuit	Content 15. The smart night lamp works on the signal control circuit thanks to these blocks: Receive command -Process-Amplify-Execute. Content 16. Use a resistor and photoresistance sensor in series as an input divider for the B pin of Transistor.	Establish the new knowledge

Based on the above table, it can be seen that the content of knowledge that students have learned in physics and technology subjects can be fully exploited to serve the proposed STEM topic. Through this topic, students can re-create knowledge, design and practice some practical skills to create new products that can be applied in life. Based on the content of the practical exercises in the main educational program, students can accept it well and the practice conditions are appropriate.

4.3. Designing the Teaching Process "Smart Night Lamp" Project

4.3.1. General Process

The topic is conducted in 3 sessions, specifically as follows:



4.3.2. Student Activity Suspends 6E Teaching Model

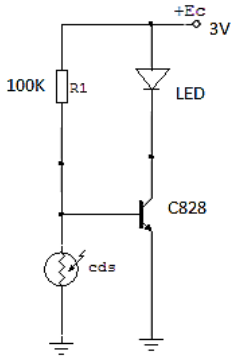
Phase	Student activities	Session
Engage	Students *emphasize* the important role of automation with home electrical equipment, and specifically, smart night lamp. Students think of some automatic control situations in real life that they have experienced. Students *propose* methods to automatically control electrical equipment without having to open and close the switch with the hands.	1
Explore	Students *explode* the principle of operation of photoresistance sensors, light emitting diodes, transistors, resistors, and direct current. Students *propose* experimental plans and do experiments in order to determine the output voltage of the photoresistance sensor in response to the case when there is and without light shining on the sensor. Students *explode* how to use electronic components and direct current.	1+ 2

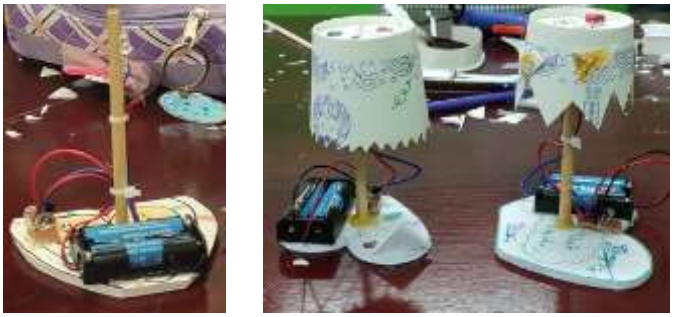
Explain	Students *explain* the basic principle of operation of the control circuit of smart night lamp. Students *presents* the roles and tasks of the main components of smart night lamp.	1+ 2
Engineering	Students *design* circuit diagrams from single electronic components such as light sensors, transistors, leds, resistors etc. to automatically control leds using light (when it's bright in the day, the led goes off; when it is dark at night, the led goes on). Students *determine* different electronic components and how to assemble them in place on a perforated copper board. Students *use* equipment to assemble the components. Students *operate* smart night lamp control circuit and reviews product efficiency. Students *design* the base, body, lampshade, attach the control circuit to the design and finishing of the product.	2+ 3
Enrich	Students *think* the plan for night lamp contains multiple of Led with different colors. Students *propose* improvements to products.	3
Evaluate	Students *present* their achieved results and *discuss* about their friends' achieved results. Students *discuss* the working process of themselves and their friends.	2+ 3

4.3.3. Teaching Process

Our idea in section 4.3.2 is that corresponding to the 6 phases of the 6E teaching process, the activities are listed for the whole STEM topic, i.e. all 3 lessons. In this part, we divide the series into 3 periods, and for each lesson, there will be activities corresponding (if any) to the above 6 phases. Inspired by the fact that automatic control systems for street lights, automatic garden/barn lights, etc., this work proposes a new STEM topic for the field of automation (students approach the discrete electronic components that they have learned such as sensors, transistors, resistors, leds etc.; then to the design of the total circuit that assembles from the above discrete components for automatic control by light; and finally to fabricate products), so the amount of work is quite large, therefore, we split into 3 lessons to can be flexible in implementing this STEM topic, this separation is effective when implementing STEM topics is not in 3 consecutive periods depending on the educational plan in particular high schools. The encrypted learning content (content 1, content 2, etc.) in section 4.2 is demonstrated in the student's learning activities according to the progress below:

Activities	Process contents	Contents
Session 1 – Direct circuit supply and some electronic components		
Activity 1. Start *[Engage]* *7 mins*	Each group of students in turn introduced about the selected sensor type in daily life: sensor name, specifications, its uses. Students commented that automation plays an important role for electrical equipment in the family, particularly night lamps. The teacher provides a list of commonly sensors used at home	Content 6 Content 7 Content 14 Content 15

<table>
<tr><td>Activity 2. Define the task [Engage]
5 mins</td><td>Problem to solve: How can I turn on and off the night lamp automatically, especially when it is used instead of the streetlight when it is bright (the light is off) and it is dark (the light is on)?
Students work in pairs to propose the first step.
Students define the task "Design and manufacture a signal control circuit for LEDs (night lamp) automatically"</td><td>Content 5
Content 7
Content 11
Content 14</td></tr>
<tr><td>Activity 3. Explore the photoresistance sensors [Explore]
10 mins</td><td>Teacher introduces the photoresistance sensor, and asks how to know how much the signal provided by the photoresistance corresponds to the value of the brightness intensity or illumination of the light shining on the sensor.
Student practice group mounting circuit to be able to measure the output voltage of the sensor corresponding to the values of illumination to different sensors</td><td>Content 4
Content 6
Content 7</td></tr>
<tr><td>Activity 4. Forming a design mindset
[Explore, Explain]
23-minute</td><td>Students formed the mindset about design smart night lamp control circuit under the guidance of teacher. Thereby, students determine the contents to learn to manufacture smart night lamp which turn on and off automatically through optical sensors when there is or no light shines on it.
In this activity, teachers need to present and discuss with students a simple, cost-effective smart night lamp control circuit, as shown in Fig. 1. Basically, the working principle of this circuit is as follows: In the nighttime, i.e., there are barely light shines on the photoresistance sensor (cds), the internal resistance of the cds (r_{cds}) is large, the combination between r_{cds} and R_1 forms the input voltage divider at pin B of transistor C828, so, the transistor works and has current through the C pin of the transistor, i.e. through the LED and makes the LED (night lamp) light. In the case of daytime, i.e., light is shining on the sensor, the sensor internal resistance is very small and is almost zero, so the transistor's B-pole is almost short-circuited to ground. Because of this, the transistor is not junction polarized to EB, hence, it is inactive, and the LED (lamp) turns off.
 
Figure 1. Control circuit.</td><td>Content 2
Content 3
Content 14
Content 15</td></tr>
<tr><td></td><td>Teacher summarizes session 1.</td><td></td></tr>
<tr><td colspan="3">Session 2 – Smart Night Lamp Control Circuit</td></tr>
<tr><td>Activity 1.
Find out the perforated copper circuit plate
[Explore] 5 mins</td><td>Students learn the structure of the perforated copper plate (copper plate) and locate and distribute the parts to be installed on the copper plate.</td><td>Practice</td></tr>
</table>

Activity 2. Assembly Engineer [*eNGINEER] 35 mins*	Students practice in 15 steps as in section 4.1.2. Assembly and operation process.	Practice
Activity 3. Operation [*eNGINEER]* *[Evaluate]* *5 mins*	Students test the product by covering the sensor with its hands (corresponding to the case that there is no light shining on the sensor), the lamp turns on, and take off the hand covered the sensor (in the condition that the lab is having light shining on the sensor), the lamp turns off. Students review and evaluate products and learning process	Practice
Secssion 3 – Design the base, body, and lampshades		
Activity 1. Learn about porous mica and paper cups. *[Explore] 5 mins*	Students learn about porous mica and solutions to cut and design the base and body of a smart night lamp using porous mica; and learn how to design and decorate a paper cup lampshade.	Practice
Activity 2. Assemble *[eNGINEER]* *20 mins*	Students practice cutting and designing the base, lamp body using foam mica; and practice cutting and decorating lampshades using paper cups.	Practice
Activity 3. Operation [*eNGINEER]* *[Evaluate]* *20 mins*	Students design, attach the base, body, lampshade together by using silicone candle spray gun. Students design and assemble smart night lamp control circuits on the body of the base. Students review and evaluate products and learning process.  Figure 2. Smart Night Lamps.	Practice
	Teacher summarizes 3rd session and the whole project. And then, teacher analyzes obtained student's results for each "E" out of a total of 6E as listed in the subsection "Student activity suspends 6E teaching model".	

4.4. Pedagogical Experiments

In this section, we carry out pedagogical experiments to answer the two research questions in section 2.2 "How is the STEM project "Smart Night Lamp" associated with the contents of current education curriculum issued in 2006?; How to teach STEM project "Smart Night Lamp" for high school students according to the 6E process?". Based on the knowledge learned in physics and technology in high school, if groups of students can do most of the content of this STEM topic, it proves that this STEM topic is suitable well with the current general education curriculum. In addition, the pedagogical experiment also aims

to verify the feasibility of the 6E teaching process built for this STEM topic.

4.4.1. Experimental Process

The process of pedagogical experiment was carried out with 24 high school students in Bac Ninh High School for the Gifted, Bac Ninh City with 3 consecutive lessons.

We perfom evaluation for students through classroom observations:

i) Monitor, observe, and take photos during the class;

ii) Observation and notes of student's implementation;

iii) Interview to get opinions of students after completing the topic.

4.4.2. Analysis of the Development of the Experimental Process

Session 1 – Direct current power supply and some electronic components

When teacher sets learning situations on how to automatically turn on and off the night lamp, students thought and came up with many different solutions, such as designing a timer circuit for a night lamp, using a light sensor (i.e. when there is or is not light shines on the lamp will turn off or on), using an infrared sensor (i.e. when there is a person in the room, the light will be on and there is no person in the room the light will turn off), etc. We see that students have mentioned automatic systems without the teacher's suggestion, showing that they are aware of the problem of automation in life. Currently, the automatic control of electrical appliances in the family is not too strange for students. However, the teacher emphasized the situation that only automatic control for a small LED light bulb that they had learned, how can they design and manufacture by themselves made students think and realize the study task. In the next activities, students will do worksheets and listen to teachers' discussion, and perform activities in accordance with the teacher's instructions. This shows that students focus and pay attention in the process of being instructed to perform the task.

Teacher asks the questions about the design of control circuit for night lamp. From there, the teacher asks students to perform the task of drawing out a sketch of the blocks that need to be able to automatically control the LED using the light sensor. Ending the activity, the teacher asks students to present their group's ideas for designing /diagraming of the control circuit block. At the end of the lesson, the teacher summarizes for the students to be able to design a circuit that controls the LED, we need to use the following blocks: Command receiving block (sensor); processing unit (voltage divider consisting of resistors in series with the sensor); amplifier and control unit (transistor); actuator block (LED light).

In addition, there are still some limitations such as, some students are not actively thinking and still passively, due to the class devided in 6 groups, teachers cannot throughly monitor each group's design step by step.

Session 2 - Smart Night lamp Control Circuit

In the activity of exploring the perforated copper plates and especially the assembly of control circuits for smart lamp, at first, the students in the group were quite confused because this is the stage of embarking on the assembly process, it requires the necessary techniques and skills to complete the product. However, after that, the groups exchanged a lot of excitement and came together on the idea of assembling each part before conduct assemble, and so on for the next components.

After the assembly stage, students test the product by covering the sensor with their hands (in case there is no light shining on the sensor), the light turns on, and takes off the hand, the light turns off. Students are very interested in observing this phenomenon. There are some students who do not use their hands to demonstrate that there is no intervention to turn the lights on and off by hand, but use a corner of the book, eraser, etc. to cover the sensor and the Led is also light, that increases excitement for students.

However, because the assembly process requires a lot of meticulous work, moreover, the electronic components are quite small, so a few students have shown signs of tired and boredom.

Session 3 - Design base, body, and lampshades

In this activity, students can use paper knives, scissors, glue guns, chopsticks, porous mica, plastic cups, crayons, etc. to design the base, body and lampshade. All students were very interested in participating in this stage because, students were completely creative and designed their own lamp model. As a result, the bases, lampshades are designed by the students are quite diverse, such as heart shapes, squares, circles, and other special shapes. Especially, students can use crayons to draw on the stand, the lampshade and the favorite drawings. After designing the base, body and lampshade, students use glue gun to attach the control circuit to the base.

At the end of session 3, 4/6 groups finished the product. The remaining groups have not yet completed the product due to reasons such as assemble inverted the battery poles, the welds are not in good contact, and especially students often confuse between the poles of the C828 transistor.

4.5. Experimental Results

To be able to confirm the feasibility of the pedagogical experiment for the research questions; to grasp the advantages and disadvantages of teaching STEM topic for this specific students; and can engage/develop this STEM topic for real-life applications. We conducted interviews to collect the opinions of three groups of students, which are groups 1, 3, 5.

i) The first question is about the activities they enjoy in the project. Representatives of all three groups liked the2 idea of designing a control circuit using sensors in session 1, assembling and especially testing the product in session 2. The reason that they like these activities is because they have only heard of electronic circuit boards, but had not the conditions to perform assembling directly, moreover, the test results of the light sensor make them very excited, the feeling it like a very interesting experiment. These comments show that they want to practice and develop design competencies, and practice is essential to students;

ii) The second question is about the difficulties they encountered in the process. The representative of group 5 has the idea that because electronic components are quite small, while the distance between teacher and group 5 is quite far, so it is difficult to observe and monitor. Group 1 and group 3 representatives also agreed with group 5's opinion and proposed to use a magnifying lens (if any) for easier observation;

iii) The third question about the desire to apply this product to real life. Representatives of 3 groups are very excited to use smart night lamps every day, because they only need to change batteries and decorate them better than having a smart product in their study corner;

iv) The fourth question is about applying this control circuit to a garden/or streetlight. The representative of group 5 answered that they just need to replace the LED with a larger, brighter one. The representative of group 1 replied that to control a garden light, it needs to have a much larger capacity than an LED and need an AC source, so it is necessary to have more components/parts to be able to work with alternating current. The representative of group 3 replied that instead of using one LED, we use a combination of many LEDs installed in series/parallel together and the power source needs to be larger.

v)The fifth question is about things that students have accumulated through the topic. The representative of group 1 said that this topic is very practical for students when they are in the era of technology 4.0, the field of automation is very necessary. Representatives of groups 3 and 6 all answered that this circuit principle can be applied to control a street light series.

After interviewing the representatives of three groups of students, we found that all three students were interested in practical activities,

identified tasks, and understood the general working principle of the smart night lamp control circuit, practice assembling, realize the benefits for reducing dependence of human interacting with electric-electronic equipment, and have good ideas for system development in other subjects. However, in terms of products, the components are quite small, making it difficult for students to assemble. After the pedagogical experiment, it can be seen that the proposed STEM topic is well suitable for high school students, specifically students in grades 11 and 12. The knowledge of physics and technology can be well exploited. to experience the STEM theme "Smart Night Light". This topic can be expanded to apply immediately in practice, such as automatic street light control, automatic pathfinder robot, automatic garden light, automatic pond barn light, control circuit for smart home, etc. using light sensors.

5. Conclusion

In this paper, we have proposed and built a new STEM topic “Smart night lamp”. This topic is suitable with one of the perspectives on building an overall general education program (the third perspective), which refers to focusing on practice, applying knowledge and skills learned to solve problems in learning and life. Furthermore, we continue to apply the 6E teaching process (a student-centered teaching model that helps students practice essential 21st century skills) to design a teaching process for this STEM topic. Based on the analysis of the knowledge content of the topic corresponding to the current general education curriculum in the subjects of physics (grades 11 and 12) and technology (grade 12), the proposed topic can be completely incorporated into the implementation of STEM teaching for upper-secondary school students. Through pedagogical experiments, we found that the topic of smart night lamp has created great excitement, and the teaching process built is feasible with the current education curriculum.

Reference

[1] Ministry of Education and Training, Official Dispatch 3089/BGDĐT-GDTrH Dated August 14, 2020 of the Minister of Education and Training on the Implementation of STEM Education in Secondary Education, 2020 (in Vietnamese).

[2] Directive No. 16/CT-TTg of the Prime Minister, 4/5/2017, On Strengthening Access to the Fourth Industrial Revolution, 2017 (in Vietnamese).

[3] Ministry of Education and Training, General Education Curriculum, 2018 (in Vietnamese).

[4] N. V. Bien, T. D. Hai (co-editors), T. M. Duc, N. V. Hanh, C. C. Tho, N. A. Thuan, D. V. Thuoc, T. B. Trinh, STEM Education in High Schools, Vietnam Education Publishing House, 2019 (in Vietnamese).

[5] N. T. Hai, STEM/STEAM Education from Hands-on Experience to Creative Thinking, Tre Publishing House, 2019 (in Vietnamese).

[6] N. T. Nga (editor), P. V. Hai, N. Q. Linh, H. P. Muoi, Design and Organize STEM Education Topics for Middle and High School Students, Ho Chi Minh City University of Education Publishing House, 2019 (in Vietnamese).

[7] T. N. Nguyen, Design and Organize STEM Education Topics for Middle and High School Students, HCMC University of Education, 2017 (in Vietnamese).

[8] Department of Secondary Education, Secondary Education Development Program 2 (Ministry of Education and Training), Training Materials for the Development and Implementation of STEM Education topics, 2019 (in Vietnamese).

[9] Department of Secondary Education, Secondary Education Development Program 2 (Ministry of Education and Training), STEM Education Orientation Workshop Materials in High School, 2019 (in Vietnamese).

[10] R. W. Bybee, J. A. Taylor, A. Gardner, P. Van Scotter, J. C. Powell, A. Westbrook, N. Landes, The BSCS 5E Instructional Model: Origins and Effectiveness, Colorado Springs, Co.: BSCS, 2006, Vol. 5, pp. 88-98.

[11] C. C. Chung, C. L. Lin, S. J. Lou, Analysis of the Learning Effectiveness of the STEAM-6E Special Course-A Case Study About the Creative Design of IoT Assistant Devices for the Elderly, Sustainability, 2018, Vol. 10, No. 9, pp. 3040.

[12] B. N. Burke, The ITEEA 6E Learning by Design (TM) Model Maximizing Informed Design and Inquiry in the Integrative STEM Classroom, Technology and Engineering Teacher, 2014, Vol. 73, No. 6, pp. 14-19.