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HANOI NATIONAL UNIVERSITY OF EDUCATION

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CONSTRUCTION AND USE OF EXPERIMENTAL EQUIPMENT IN TEACHING SECTION "THERMOLOGY"- PHYSICS GRADE 8 TO DEVELOP EXPERIMENTAL COMPETENCE OF STUDENTS IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

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LIST OF THE AUTHOR'S PUBLISHED WORKS
RELATINGTO THE DISSERTATION

1. Xaypaseuth Vylaychit (2016), Construction of learning tasks to form the practical competence in students, Journal of Science, HNUE, vol 61, page 242-248.
2. Xaypaseuth , Nguyen Van Bien, NguyenAnh Thuan (2017), Design and fabrication of quatitative experimental equipmentof energy co
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6. XaypaseuthVylaychit, Nguyen Van Bien, Nguyen AnhThuan (2019), The process of building and using experimental equipment in teaching Physics "Thermal Studies" in grade 8, in order to develop the experimental competence of students in Lao People's Democratic Republic, Journal of Science, HNUE, vol 1/2019, page 157 - 164.

INTRODUCTION

1. Rationale

Lao PDR is currently in a period of industrialization and modernization to keep up with the development of science and technology and integrate with the world economy of knowledge. By 2020 the aim of Lao PDR is to escape the poverty and underdevelopment.

For achieving this goal, Laos Ministry of Education has set up an educational model by 2020, in order to educate students with thermodynamic section in jurnior high school, teachers currently teach almost by lecturing theory and not using experiment. This is partly because teacher still are fraid of using experiment in teaching. In their thought, demonstration experiment is not effective in teaching physice. For example when the teachers teach the concept of heat and temperaturesufficient knowledge, intellectual competence and good moral qualities.

For , they lust explains the thermal phenomena in daily life, or use simple experiments to help students understand the concept. The experiments about heat , heattrasfer and heating value are simple and not scientific, so that they are not effective in teaching to develop the experimental competence for student in the classroom. The cause of this that the available laboratory equipment used to teach these concept is still limited, with or without sufficient facilities needed to meet the teaching requirement. Especially the lack of the experimental equipment about technical applications is of great concerm here.

To combat the problem and improve quality of Physics teaching in juniir high school, we choose our research topic as “construction and useof experimental equipment in teaching section “thermology”- physics grade 8 to develop experimental competence of students in lao people’s democratic republic”.

2. Limitations

The dissertation is to design some experimental devices on the basis of analyzing the experimental competence structure and using these experimental devices in teaching section"thermology" - Grade 8 physics in secondary schools in Lao PDR according to teaching solutions problem solving to to enhance students’ experimentl competence.

3. Delimitations

+ Objects

- Knowledge content of Thermal Physics, 8th grade junior high school.
- Practical competence in problem-based learnning using physical experiment.

+ Scope of the research

The teaching process of thermal physics for 8th grade students in the secondary school, Salavan High School, Salavan district, Salavan province, Laos.

4. Scicentific hypothesis

If the construction and use of experimental equipment based on analyzing the experimental capacity and using these experimental devices in teaching section"thermology" - Grade 8 physics in secondary schools in Lao PDR according to teaching solutions problem solving will develop experimental competence.

5. Research goal

- To study the theoretical basis of teaching toward the development of the experimental competence

of students, especially, theories on the construction and use of laboratory equipment in physics teaching (8th grade)

- To study textbook content to determine the knowledge about thermal physics that 8th grade students have to acquire, then identify the experiment necessarily conducted.

- To survey the teaching status ofthermal physics in 8th grade, in order to understand the current teaching and learning method, the' difficultiesof teacher and the common mistakes of students about thermal physics, the current stateo of laboratory apparatus as well as the usage of those facilitesin secondary school.

6. Research method

- Study referentce: books, articles, theses, dissertation, Physics 8 textbooks, this is to build the theoretical basis and procedure using the experiment.

- Research in the laboratory: design, manufacture and test the experimental apparatus

- Do survey: observation, lesson plan review, discussion with teachers and students.

- Pedagogical practice: apply the lesson portgolio in the secondary school..

7. New contribution

In terms of theory:

- Proposed experimental competence structure in physics teaching.

- Proposed some suggestionsin teaching Thermology – greade – 8thphysice to develop the student's experimental competence.

In terms of reality:

- Construcct experimental competence equipment to carry out 18 experiments in teaching "Thermology"- greade 8th Physice.

- Build learning activitive (formation and use of knowledge) associated with constructes experiments.

- Compile 7 lesson portfolios, using designed learning activites and constructed experimental equipment.

- Evaluate the experimentce competence of students in the study thermologygreade – 8th Physics.

CHAPTER 1: LITERATUREREVIEW

There are many researches in the world about active learning methods and problem - solving skill implementation in teaching physics in junior and senior high school. Organizing activities, constructing experimental equipment, and using these facilities are important parts of the learning procedure. The experimental equipment is a means of teaching to promote the active learning for the student, there by enhancing their excitement and learning outcome, especially in the development of the experimental competence of student.

For the purpose of constructing and using laboratory equipment in teaching physics to develop student's experimental competence, we have studied the overview of the following issues:

- Review on competence and experimental competence..

- Review on the construction and use of laboratory equipment in teachingphysics to develop

experimental competence.

- Review on the study of the construction and use of laboratory equipment in the field of thermodynamics.

1. 1. Competence and experimental competence

+ Competence

- Competencerefers to the ability of an individual in a certain field - which help her toaccomplish work effectively as expected..

- The concept of competencecomes from the Latin word "competentia" which means "to respond". Today, this concept is understood in many different way. So far there have beenmany researchers on competence.

+ According to P.A. Rudich, competence is the psychological nature of a person who governs the acquisition of knowledge, skills and technique as well as the effect of performing an activity.

+ Gerard and Roegiers (1993) examine competence as an integration of skills that allow one to recognize a situation and respond to it in a natural and integrated manner.De Ketele (1995) argues that competence is a set of skills that affect a particular situation in a given situation in order to solve problems posed by the situation.

+ Experimental competence

In our research on experimmenttal competence, we have consulted on the conceptual contents of some theses or concepts in some articles and books:

- According to Josephy (1986), evaluation of experimental activity in physics through the OCEA includes four processes planning (experimental design, enhancement and clarification), implementation (observation, manipulation , data collection, interpretation (data processing, reasoning, prediction and explanation), communication (reporting, receiving information), no hierarchy or sequence is implied By presenting the processes and skills in this particular order.

- Millar (2004) has identified that practical work includes all activities related to the observation and manipulation of the objects that we study. Thr practical activities include both laboratory and home activities. Practical activities help students think and act like a scientist.

- The experiment competence is one of the specific competenes that are formed through the physics teaching. When solving practical problems, students have to apply knowledge the combination of mental activities and the pratical knowledge of the physics, techniques and their own life experience. Therefore, it is possible that these experimental exercises will enhance students’experimental competence.

1. 2. The studies about constructing and applying experimental equipment in teaching Physics

We have read and studies theses dissertations related to the topic of "Constructing and using experimental equipment of Thermal Physics":

Recentlythere has been a great deal of studies done by graduate students, master and bachelor students in Physics Department about the construction and use of experiment in teaching in secondary schools, high schools and universities, such as Dang Minh Chuong, Duong Xuan Quy, Nguyen Anh Thuan, Tran Hung Dung, Pham Van Nam, Nguyen Thi Thanh Huong, Ha Duyen Tung.

The authors have raised topics on the construction and use of physics experiments. The purpose of these studies to study the construction of experimental factilities (eg: new experiments, construction old experiment supplelement and experiments set up in the physics of teaching process) and research on experimental uses (eg, using experimental equipment to develop the processes in problem-solving teaching and developing the scientific process in theoretical and practical ways.

1. 3. The studies about constructing and applying experimental equipments in teaching Thermal Physics

There are also many studies about teaching thermal physics, particularly, the thesis and dissertation of the following authors:

- The author Nguyen Thi Thuy mentioned "Fostering student problem solving ability in teaching under LAMAP thermodynamics - junior high school".

- The author Pham Thi Ngoc Thang mentiones "Active self-reliance, physical knowledge awareness in thermodynamic teaching for 8th grade student in ethnic high schools.

- The author Nguyen Van Giang referre to "Active learning, self-reliance, and creativity of students in the teaching of the chapter: Preservation and Transformation of Energy in Physics 9".

- The author Vu Thi Thanh Mai mentiones "Studying the organization of cognitive activities of students in teaching some knowledge of thermodynamics in 8th grade in secondary schools towards the development of students in creative search activities. problem solving to improve teaching effectiveness ".

1. 4. The studies in Lao People's Democratic Republic

In Laos, there are dissertations, journals that involve the organization of teaching to develop students' competence such as: Houngsavang Keomixay, Vorlada Khoutphachan, Chanthasin Onkeo, Phouthkt Silapa, Phaylavanh Chittavong, Bouta Souliya.

The contents of each author's research are referred to the construction and use of laboratory equipment to develop active and creative activities of the students, while the research on experimental competence is not available. Many and if any are just simple (building simple laboratory equipment, no learning tasks and worksheet and laboratory exercises to assess students' learning outcomes as well as the Empowering Experiences), no in-depth study of the methodology of teaching organization. Particularly, the study of physics teaching in the construction and use of thermodynamic laboratory equipment to develop the experimental competence of students has not yet been applied in high school and junior high schools in Laos. Based on the above-mentioned overview, we see that is necessary to study how to construct and use experiments in physics teaching in secondary schools in Lao PDR to develop the experimental competence.

CHAPTER 2: THEREOTICAL BACKGROUND OF CONSTRUCTING AND PRACTICAL BASIS EXPERIMENTAL EQUIPMENTS IN TEACHING PHYSICS TO DEVELOP STUDENTS' EXPERIMENTAL COMPETENCE

2. 1. Experimental competence

2. 1. 1. Definition of Competence

In our opinion, competence is a complex psychological intrinsic which converges many factors such

as knowledge, skills, skills, attitudes, willingness to act and responsibility. The concept of competence linksto the ability to act. Action competenc is just onw kind of competence, but when competency development, we also imply the development of action competency.

2. 1. 2. Definition of experimental competence

We can summarize the experimental competence as the ability to combine knowledge and skills with psychological attributes such as excitement, belief, and will to accomplish the task. Experimental competence includes the identification of experimental purposes, experimental design (including the selection of experimental instruments, and data collection during the experiment), implementation (assembly, experimnet conduction, data record and processing, and evaluation of the results).

2. 1. 3. Structure of experimental competence

The experimental competence's structure includes 4 factors:

- Identyfy the purpose of the experiment
- Design experiment
- Carry out the designed experiment
- Analyze the results and evaluate the experiment

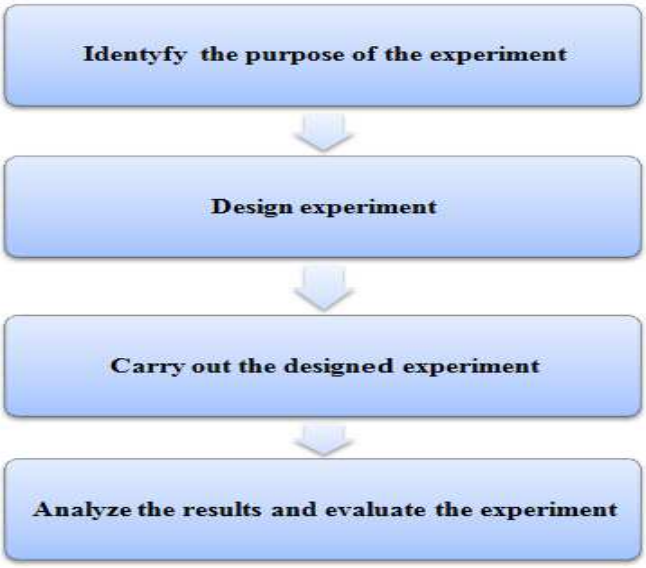

Figure 2.1: Practical competence structure

Identyfy the purpose of the experiment:

- Perform logical reasoning in order to identify the hypothesis to test
- Determine the conclusions that should be drawn from the experiment.

❖ **Design the experiment:**

- Identify the necessary material
- Determine the experimental setup
- Propose experimental procedure
- Predict (data sheet).
- Propose method of data processing
- Select the optimal experiment plan

❖ **Carry out the experiment:**

- Study the parts of the real device
- Assemble, arrange and conduct experiment with equipment
- Conduct the experiment as the planned with real equipment
- Data collection (qualitative data)

❖ **Data analysis and evaluation**

- Data processing (qualitative data)
- Draw conclusions from the experiment results

- Evaluate the advantages and disadvantages of the experimental design

2. 2. Teaching physics toward experimental competence development

To develop the student's experimental competence, we use the following measures:

2.2.1. Develop learning tasks associated with practical work to develop student experimental competence

Based on the components and behavior parameters of experimental competence, the teacher should hold the learning activities in which the student has the opportunity to reveal his or her corresponding to the paramater.

Below we present some examples of specific activities in teachingthermology. Corresponding to each task, we list the behavior parameters of the experimentalcompetence that students are expected to reveal, thereby develope their experimental competence.

2.2.2. Develop and improve laboratory equipment to support experimental activities

On the basis of theoretical physics teaching, especially on the development of experimental competence of students, we focus mainly on theconstruction and use of demonstrationl equipment. of the teacher. meanwhile, we also propose a procedure of construcing experimental upon thecompetence of student.

a. General requirements for the construction of laboratory equipment for teaching physics

- Scientific-technicalrequirements
- Pedagogical requirements
- Economic requirements

b. Aesthetically pleasingProcess of building experimental devices in teaching physics

- Determine the purpose of the thermal learning knowledge, see the curriculum and textbooks, need to add more, what to reduce in the textbook.
- Refer to the textbook of Grade 8 Physics of Laos and Vietnam to compare the program content and select it to suit the students' knowledge.
- Analyzing experimental capacity structure from which to clarify the empirical tasks that need to be assigned to students to help students form and develop behavioral manifestations of experimental competence.
- Develop a process of knowledge building from which to determine how to use experiments in school days.

2.2.3. Organize learning problems- based learning for teaching new contentechnical application

2. 2. 2. Problem-basedlearning procedure in order to develop students' experimental competence

In order to apply the type of problem solving teaching in the process of teaching Physics knowledge in an effective way to develop experimental capacity, specifying each stage must be done in the teaching process.

A specific Physics knowledge is important. We build the process of building and using experiments in teaching problem solving organizations for assigners according to Figure 2.2.

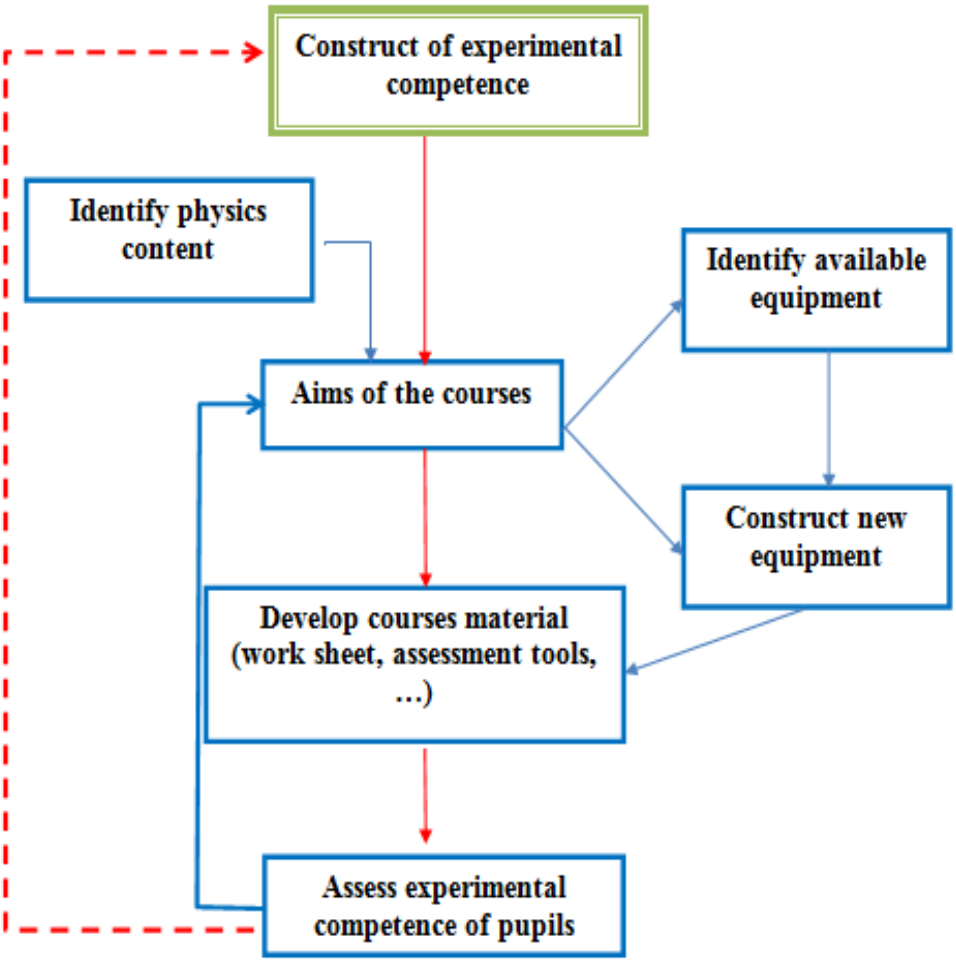

Figure 2.2: *Procedure of teaching and learning for development of stdentexperimental competence*

Derived from the analysis of the experimental competence structure, the teacher determines the corresponding teaching purpose based on the student's skill as well as the actual physical condition of the school. , the purpose of teaching must be specific, clear and measurable.

In order to determine the purpose of teaching with the development of the experimental competence of the student, the teacher develops experimental equipment on the basis of testing laboratory equipment, meeting the teaching purpose. teaching to develop empirical ability or not needing to make new or refine the experimental equipment to suit the content of the teaching.

Student performance assessment is based on behavior components of experimental competence, each knowledge content is evaluated according to different behavior indicators, depending on the suitability of experiments and the ability of students.

2. 2. 4. Constructing experiment exericesand using tasks associated with solving experiment exercises

Besides constructing experimental equipment for using in experiments in physics teaching to develop students' experimental competence in problem based learning, we have also developed a number of experiment exercises project or assignment for students to practice the ability to use experiments in practice

The content must be scientific, not identical to the experiments in the teaching process, mainly for students to conductexperiments familiar to daily life, the material must be easy to find and appropriate to the student. For example: let students select simple and easy-to-find tools in daily life such as firewood,

charcoal, plastic, water, pot thermometer for students to design experiment for measuring of each fuel. But this type of exercise is different for students to develop behavior that defines instruments or experiments such as: (assemble the experiment in steps, proceed well and get good results).

2. 5. Current status of constructing and using experimental equipment in teaching thermal physics in secondary schools in Laos.

2. 5. 1. Purposes of investigation

- Teaching status of teachers (teaching organization, teaching methods, construction and use laboratory equipment in teaching).
- Difficulties of the teacher when teaching thermodynamics and difficulties of students when studying thermology.
- Understand the necessity of the teacher for the laboratory equipment in general and for the thermodynamic laboratory in particular.

2. 5. 2. Investigating method

- Interview with the teacher, the teacher questionnaire, the student questionnaire, review the lesson plans of the heat unit lessons in junior high school.
- Attend classroom and learn the use of laboratory equipment.

CHAPTER 3: CONSTRUCTING AND USING EXPERIMENTAL EQUIPMENT IN THE PROCESS OF TEACHING KNOWLEDGE CONTENT OF PHYSIC THERMAL 8

3.1. Necessary experimentsin teaching "Thermal physics"

With this set of experiments, we can carry out 7 experiments corresponding to 7 knowledge, contents:

- Experiment 1: Feeling hot and cold
- Experiment 2: Measure temperature of the object
- Experiment 3: Measure water temperature
- Experiment 4: Measure body's temperature
- Experiment 5: Measure temperature at the classroom
- Experiment 6: Heat conduction of solids
- Experiment 7: Heat convection of gases
- Experiment 8: Heat radiation
- Experiment 9: Heat conduction depends on the nature and distance
- Experiment 10: Heat convection depends on the difference in temperature
- Experiment 11: Absorption of heat depends on the color
- Experiment 12: Factors influencing the temperature change
- Experiment 13: Experiment to varify the equation of heat equilibrium when mixing the same substance (hot and cold water)
- Experiment 14: Measuring the heating calorific value of fuels
- Experiment 15: Investigating the tranformation of mechanical energy into heat

- Experiment 16: Investigating the tranformation of heat into mechanical energy
- Experiment 17: Heat engine model
- Experiment 18: Simple heat engines

3. 2. Construcingexperimental equipment used in teaching "Thermal physics"

3. 2. 1. Experiment about heating calorific value of fuels

3. 2. 1. 1. The needs ofconstruction

In this knowledge, the activities and experimental designs have not been suitable with the contents of the knowledge. For example, the experimental equipment is not scientific, inaccurate, not interesting to students, and difficult to find some fuels in practice ...The content of this knowledge in texbooksis focuses on theoretical presentation or simply doing simple experiments. It not linked to the development of student experimental competence. Student just do as the model or as instructed by the teacher.

Thus, to develop the experimental competence of students, it is very crucial to have the accurate laboratory equipment with high scientific reliability. Therefore we have improved and built up the heat-exchanger productivity test equipment for students to conduct experiments. For example, let students do experiments to determine the heat value of fuels used in everyday life,tiindentify- which fuels has good heat and poor heat. These experiments help student have the skills of meansuring and determining the tools used in experiments, and collecting and processing data.

3. 2. 1. 2. Components of the experiment equipment

The equipment consists of the following components (Figure 3.1):

- Cylindrical milk cartridges (27) are perforated at the top and at the front, used to make the base stand. Alcoholic beads (28). Mini electronic scales (29). Rubber button with holes (30). 330ml Coca Cola can (31).

- Bottom base made of beer cans (32) used to place Coca Cola bottles and oil thermometers (22).

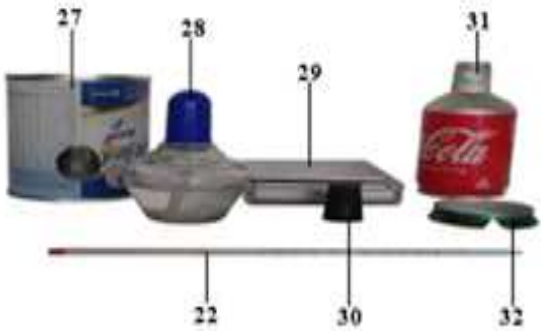

Figure 3.1: Equipment of calorific value of fuels

3. 2. 1. 3. Experiments conducted

Experiment 1: Measure the calorific value of three kinds of fuels: alcohol, candles and kerosen.

a. **Purposes ofexperiment**

- Identyfy the calorific value of three different fuels
- Know the calculated calorific value through the formula of water heat.

b. **Experimentsetupand conduction**

- Fill $300ml$ of water in to the Coca Cola can(31), use a rubber stopper to close the can(30) and then insert the thermometer into the rubber stopper (22).

- Place the Coca Cola can on the milk can (27) and use the cradle under the Coca Cola can (32).

- Take the same amount of alcohol, candles and kerosene, then burn the three fuels completely.

- Read the temperature value of water before boiling with alcohol, kerosene and candles.

- Use alcohol burner (28) to burn completely and measure the temperature of the water.

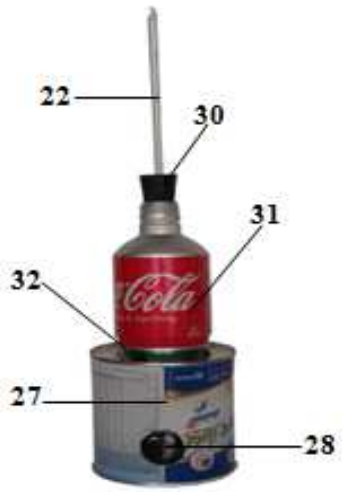

Figure 3.2: Alcohol, fire and candles

- Repeat the experiment with kerosene and candles correspondingly instead of school in order and measure the temperature rise, then use the formula to calculate the heat value of the fuel.

Table 3.1: Calorific value

NO.	Fuels	Water (g)	Increase of temperature (^{0}C)		Change in temperature (^{0}C)	Heat (J)	Calorific value (J/kg)
1	Kerosene(5g)	300g	t_1=26	t_2= 71	$\Delta t = 45$	Q= 56700	q= 11340.10^3
2	Alcohol(5g)	300g	t_1=26	t_2= 64	$\Delta t = 38$	Q= 47880	q= 9576.10^3
3	Candles(5g)	300g	t_1=26	t_2= 42	$\Delta t = 16$	Q= 20160	q= 4032.10^3

c. Experiment results

The calorific value of the kerosene is greater than the alcohol and the candle. (The longer the heat loss is in the environment, or the boiling water evaporates, the greater the error in boiling water.).

3. 3. Compile the detailed teaching processforthermal physics

3.3.1. The plan of teaching the heat value of the fuel

3.3.1.1. Learning Objectives

After learning this content, students can:

- Make logical assumptions to outline what to test: different fuels have different heat values.

- Determine the conclusionsneedes to draw from the experiment: which fuel among kerosene, alcohol and candles, give us more heat.

- Propose experimental steps: designeexperiments or experiments steps with measurements, observations and results ...

3.3.1.2. Diagram of scientific process for knowledge formation

Pose the problem
Situation:

- To boil 200 ml of water, burn the 150 g of candle or 100 g of oil.

↓

Problem statement

- What quantity represents for how well fule releases heat ?

↓

Problem solving

Propose hypothesis

+ $\frac{Q}{m}$ is a characteristic of heat value.

Verify the hypothesis

Hypothesis

Determine the heat value to as burning various fuels such as alcohol, kerosene and candles..

Design the experiment

+ Take the sameamount of three fuels by measuring the mass.

+ Use a thermometer to measure the temperature of the water when boiling by alcohol, candles and kerosene, respectively.

+ Calculate the heat generated when using different fuels and then record the results in the table.

+ Finally, calculate the calorific value.

Conduct theexperiment

Experiment results

NO.	Fuels	Water (g)	Increase of temperature (^{0}C)		Change in temperature (^{0}C)	Heat (J)	Calorific value (J/kg)
1	Kerosene(5g)	300g	t_1=26	t_2= 71	$\Delta t = 45$	Q= 56700	q= 11340.10^3
2	Alcohol(5g)	300g	t_1=26	t_2= 64	$\Delta t = 38$	Q= 47880	q= 9576.10^3
3	Candles(5g)	300g	t_1=26	t_2= 42	$\Delta t = 16$	Q= 20160	q= 4032.10^3

↓

Conclusions

- Q / m is the specific characteristic for the heat value, the higher the Q / m, the greater the heat output.

Figure 3.3: Diagram of scientific process of knowledge formation lesson "Calorific value"

3.2.1.3. Detailed teaching process

Objectives

Teacher's activities	Students' activities
Activity 1: Problematic situation and problem statement (work in class) (5 minutes)	
Teacherhas students to calculate and predict To boil 200 ml of water, burn the 150 g	- Students issues and predictions

of candle or 100 g of oil. **Problem statement:** - What quantity represents for how well fule releases heat ?	- Students issues
Activity 2: Propose solutions (work in class) and verify byexperiment (work in group) (60 minutes)	
Experiment 1: Measureleaseedheatofalcohol, candlesandkerosene. - Questions: when burning out different fuels such as alcohol, kerosene and candles, which fuel will releasethe most heat? - Teacher asks students to predict and let students design experiments according to those predictions - Teacher divide students into groups, students do experiments under the guidance of teachers - Calculate the calorific value of alcohol, candle and kerosene. - Use the obtained data to calculate the calorific value according to the formula: $q = \frac{Q}{m}$	- Students answer the questionnaire in the worksheet 5.01 - Students propose experiment plans and conduct experiments according to the worksheet 5.01 andSupportive sheett 5.02 + Pour water $300ml$ into a can of Coca Cola + Measure the initial water temperature Use water for a while, burn until the amount of fire burns out, and record the water temperature thermometer in the results table. + Repeat the experiment but replace the alcohol with candles and kerosene Council undertakes the following tasks: + Calculate thermal efficiency by formula $q = \frac{Q}{m} \Rightarrow Q = Cm\Delta t = Cm(t_2 - t_1)$
Activity 3: Present the results (15 minutes)	
- Teacher invite representatives of each groups to report the results of each experiment. - Teacher should: clarify conclusions when students report. - Teachers may rewrite the expression or concepts.	- The group reports to the class and draws conclusions: that the water temperature boiles as using kerosene increases faster than boiles using alcohol and candles. Thus, the haetvalue of kerosene is greater than that of alcohol and candles.
Activity 4: Inform, supplement and apply knowledge (5 minutes)	
- After the groups have reported the results, teacher have to comment, inform, supplement knowledge and emphasize the main knowledge content. - Teacher concludes for students the main contents of the lesson. - The water temperature boiledas using kerosene increases faster than boiledusing alcohol and	- Students take note the conclusions.

candles. Thus the heat value of kerosene is greater than that of alcohol and candles. - The heat value of alcohols, candles and oil obtained from the experiments deviated from the actual value due to the fact that the water did not receive completely the heat from the burne fuel..	

3.3.1.4. Assessement rubrics for experiments

Experiment 1: Measure heat value ofalcohol, kerosene andcandles

Table 3.2: Evaluation of behavioral expression in the experiment measuring heat value of alcohol, kerosene and candle

NO.	Behavior	Level of evaluation			
		Level 1	Level 2	Level 3	Level 4
1	Perform the logical reasoning to draw the verified consequence				
2	Determine the conclusions that need to be draw from the experiment				
3	Propose the experiment procedure				
4	Assemble and set up the experiment with real device				
5	Conduct the experiment				
6	Collect data				

Table 3.3: Specify the evaluation of practical competence

Behavioral expression	Level	Criteria
Lesson 5: Heat value of fuels **Experiment 1: Measure heat valueofalcohol, candlesandkerosene**		
Execute logical reasoning in order to identify the things to test	M1. 1. 1	Students describe logical reasoning and make inaccurate assumption that: all fuels release the same heat.
	M2. 1. 1	Students execute logical reasoning and make the assumption to verify under the teacher's guidance that: kerosene releases more heat than alcohol and candles do.
	M3. 1. 1	Students execute logical reasoning and make right assumption to varify under the teacher's guidance that: fuels such as kerosene, alcohol and candles release heat when they burn out and the kerosene emits more heat than alcohol and candles do.
	M4. 1. 1	Students state conclusions that need to be drawn but not sufficient that the

		purpose of the experiment isto find out that the kerosene releases more heat than alcohol and candles
Determine the conclusions that need drawing from the experiment	M1. 1.2	Student describe conclusions that need to be drawn but not sufficient: The purpose of the experiment was to find out that the kerosene releases more heat than alcohol and candles.
	M2. 1.2	Students describe conclusions that need to be drawn under the teacher's guidancethat the purpose of the experiment is to determine the heat value of fuels such askerosene, alcohol, and candles.
	M3. 1.2	Students identify sufficient conclusions by themselves thatthe purpose of the experiment is to determine the heat value of fuels such askerosene, alcohol, and candles.
	M4. 1.2	Students determine their own conclusions sufficiently and analyze the basis of purposes thatthe purpose of the experiment is to apply the formula Q= Cm ($t_2 - t_1$)and q = Q/m to calculate the calorific value offuels such askerosene, alcohol and candles.
Propose the experiment procedure	M1. 2.3	Students describe experiment plan inaccurately thatboiling water by alcohol, kerosene and candles, then observe the thermometer.
	M2. 2.3	Students describe experiment plan inadequately thatmeasuringmass of water to boil, measuring the same mass of the three fuels and burning out each fuel to investigate the temperature increase.
	M3. 2.3	Students propose experiment plan accuratelyand adequately under the teacher's guidance that measure mass of water to boil, measure the same mass of the three fuels and burn out each fuel to investigate the temperature increase of water, then use the formula to calculate the heat value of each fuel.
	M4. 2.3	Students propose experimental plan accuratelyand adequately by themselves thatmeasuremass of water to boil, measure the same mass of the three fuels and burn out each fuel to investigate the temperature increase of water, then use the formula to calculate the calorific value of each fuel
Assemble and set up the experiment with real device	M1. 3.2	Students assemble, set up the real experimental equipment inaccuratelylikeburningkerosene and then taking water on top for boiling, using the thermometer to measure the temperature increase.
	M2. 3.2	Students assemble, set up the real experimental equipment accurately but inadequatelylikeputtingthe water kettle on top of milk can to boil, using alcohol, candles and kerosene in order to boil water.
	M3. 3.2	Students assemble, set up the real experimental equipment accurately and adequately under the teacher's guidance likeputting the water kettle on top

		of milk can to boil, plugging the thermometer into the rubber stopper and seal, using alcohol, candles and kerosene in order to boil water.
	M4. 3.2	Students assemble, set up the real experimental equipment accurately and adequately by themselves likeput the water kettle on top of milk can to boil, plugging the thermometer into the rubber stopper and seal, using alcohol, candles and kerosene in order to boil water.
Conduct the experiment	M1. 3.3	Students conduct the experiments as plan but not exactly: students burn alcohol before taking water to boil and then plug the thermometer in.
	M2. 3.3	Students do the experiments as plan but not completely -Students plug the thermometer into the rubber button and seal the kettle by that button, thenboil water using alcohol, kerosene and candles.
	M3. 3.3	Students do the experiments as plan exactly and completely under the teacher's guidance - students plug the thermometer into the rubber button, seal the kettle by that button, place the kettle on top of milk can, then boil water using alcohol, kerosene and candles.
	M4. 3.3	Students do the experiments as plan exactly and completely by themselves- Students plug the thermometer into the rubber button,seal the kettle by that button, place the kettle on top of milk can, then boil water using alcohol, kerosene and candles.
Collect data	M1. 3.4	Students record some data: Record 1 in 3 fuel data.
	M2. 3.4	Students record complete data: Record 3 fuel data.
	M3. 3.4	Students record complete and accurate data under the guidance of teachers: Write the data out and follow the plan when using alcohol, candles and kerosene.
	M4. 3.4	Students can collect complete and accurate data: Write the data out and follow the plan when using alcohol, candles and kerosene.

3.4. Design some experimental exercises and project tasks

<u>Experimental exercise 1:</u>Measure calorific valueof fuels

Problem:

1. Heat valueof a fuel is determined by the formula $q = \frac{Q}{M} = \frac{Cm(t_2 - t_1)}{M}$

   In which:

   + q = Heatvalue with unit (J/Kg)

   + M= completely burned mass of fuel (Kg)

   + C = Specific heat of water 4200 (J/Kg^{0}C)

   + m= mass of water (Kg)

   + t1= Initial temperature (^{0}C)

+ t2= Final temperature (^{0}C)

Use the following equipment: thermometer, soil furnace, cooking pot, filter, charcoal, firewood and plastic sheet, to design and conduct experimentsto determine the heat value of charcoal, woodwood and plastic sheet.

Solution

- Experiment Design: Measuring the mass of charcoal, firewood and plastic sheet (chosen for equal mass).
- Pour water into the cooking pot (have equal volume of water in three cases).
- Place the pot on the ground and use charcoal, wait for it to burn completely and then measure the temperature of the water to record the results.
- Repeat the experiment using firewood and plastic sheet instead.
- Based on the above formula $q = \frac{Q}{M} = \frac{Cm(t_2 - t_1)}{M}$, Calculate theheatvalueof threefuels. Which one has the highest heat value.

Students

When students design experiment and measure the heatvalue of fuel, they have the opportunity to develop the following behaviorindices.

- Design of experiment, propose experimental plan (determine stepsto conduct experiment such as measuring mass of water and pouring water into the cooking pot, assembling and setting up the experiment)
- Conduct experiments (assembling the experiments properly in steps, carrying out the correct time, recording adequate data).
- Collect data (reading out the themometer indication, collecting standard data).
- Analyse data (Calculating the heat valueof charcoal, wood and plastic according to the principle of heatrelease of fuels).

CHAPTER 4: PEDAGOGICAL EXPERIMENT

4. 1. Purposes, objects và goals of pedagogical experiment

4. 1. 1. Purposes ofpedagogical experiment

- To test the feasibility of prepared teaching processes and laboratory equipment, thereby modifying teaching processes and improving thebuilt-up laboratory experiments to develop the student's experimental competence.
- To evaluate the experimentalcompetence of the students through the contents of seven lessons of the Thermal Physics8th grade in secondary schools in Laos

4. 1. 2. Objects andgoals of pedagogical experiment

❖ **Objects ofpedagogical experiment**

- Investigating objectsare 8th grade students in secondary level, Salavan High School, Salavan district, Salavan province, Laos.

❖ **Goals of pedagogical experiment**

- Investigate students and teachers' pedagogy through polls.

- Monitor and directly observe pupils during classtime.

- Analyze images, camera and worksheet during the experimental teaching hours.

4. 1. 4. Pedagogical experiment plan

The pedagogical experiment plan is compiled with 2 rounds.:

- The roundonewasconducted with 49 students from February to April 2017at Mr. Keo Junior High School, Salavan district, Salavan province,.

-The round two was conducted with 25 students at Salavan Secondary School, Salavan District, Salavan Province, , from September to November 2017.

4.2. Result

4.2.1.2. Results of student assessment in experimental round 1

After practicing the first round of pedagogy, we found that the experimental competencewas not developed at a high level, most of them only achieved level 2 and level 3 of behavioral expression for some excellent students in a class. The student's ability to conduct experiments is very low. For example, teacher helps students to determine thmateriasl and tools, to assemble the experiment, to conduct the experiment, to collect and process the data.

4.2.1.3. Difficulties in teaching students

The student's ability to perform experiments was weak andslow. The result of behavioral expression was low.

- Students have not been taught by the this kind method, so they do not know how to design the experiment, and how to record the results of the data. So the initial results were poor.- One teaching period is really little for students to complete the experiment.

- Some students write poorly, do not doexperimentactively.

- Students have not so many opportunities to approach the new. Therefore, they are not very good atthe new learning strategies, especially group work, stationlearing and project learning**.**

4.2.1.4. How to overcomethedificulties in round 2

- To combat the problem of poor student performance, we suggest to organize a tutorial on how to conduct an experiment, so students know the experiment steps and methods of conducting experiments before the lesson.

4.2.2. Result evaluation of round 2 in pedagogical experiment

4.2.2.1. Specific evaluation forteaching processin each content of knowledge

A. Quantitative evaluation:

In evaluating the learning process of each content we have evaluated according to the behavioral parameters of the practical competence as follows:

1) Perform logical reasoning to decide what to test.

2) Determine the conclusions that should be drawn from the experiment

3) Identify the laboratory equipment to be used

4) Determine the experimental setup

5) Propose steps for conducting the experiment

6) Get to know the real experimental parts

7) Assemble, arrange and conduct experiment with real equipment

8) Conduct the experiment

9) Data collection

10) Data processing

11) Draw conclusions from the experiment results

B. Assessment steps and assessment methods in evaluation the student's experimental competence

When evaluating students, we rely on worksheets, videos, images. Thanks to these tools we have set up our own rubrics to evaluate each lesson.

To evaluate the behavioral expression of experimentalcompetence in an experiment, we have chosen behaviors that are consistent with the content of learning.

Example: Evaluating a student to conduct experiments with the content about heating value of fuels in experiment 1 is that we are evaluated according to the following behavioral parameters.

Example: Experiment 1: Measure the heatingvalue ofalcohol, kerosene andcandles

Table 4.1: Behavioral levels collected from the worksheet 1

Problem: - If we use the three fuels (alcohol, kerosene and candles) to boil the same amounts of water in the same period, which fuel will releasethe most heat ascompletely burned?		
Question	**Student's answers**	**Level**
Question 1: Which fuel among alcohol, kerosene and candles release the mostheat?	Kerosene produces the most heat among the three fuels.	**3**
Question 2: What is the purpose of the experiment?	The purpose of the experiment is to measure the heating value of alcohol, kerosene and candles.	**4**
Question 3: Design an experiment	Pour water into the Coca Cola bottle and plug the thermometer into the rubber button, use alcohol to burn the Coca Cola bottle and then see how the thermometer indication changes compared to the value before burning.	**3**
Question 4: Assemble, experiment with real equipment	- Directly observe and watch the video: The direct observation showed that students 1 assembly right as designed experiment plan such as measuring the amount of water, plugging the thermometer into the rubber stopper, burning alcohol, he/she need teacher's help in some steps.	**3**
Question 5: Conduct the experiment	- Direct observation and recorded video	

	showthat students exactly followed the plan, using fuel in order as alcohol, kerosene and candles but it is not enough time for students to finish the experiment	**3**
Question 6: Data collection	- Students record data into the notebook but inadequately.: They record data of a fuel such as alcohol: initial temperature t_1=25, t_2=100 and $\Delta t = 75$, Q=4144,1, A=31390.	**2**

Through the answers of students 1, from 1, 3, 4, 5 we can collect data well for the purpose, the design of the test is quite standard so it reached level 3, while in the question 2, students responded correctly so they reached a high level, 4. Finally, in the question 6, they did not collect enough data due totime constraints and were not able tocalculate, hence theymay reach level 2.

4.2.2.3. Evaluation of students'experimentalcompetence throughbehaviorsin eachexperiment.

A. Evaluation results of student 1

Here is an example of a summary table that collects behaviorindices for student 1 through experiments in pedagogical experiment.

Table 4.2: Levelof behavior indices of student 1

EXP	**LEVEL OF QUALITY CRITERIA**										
	HV 1	HV 2	HV 3	HV 4	HV 5	HV 6	HV 7	HV 8	HV 9	HV 10	HV 11
EXP1	1	1	2								1
EXP2	2	1	2								1
EXP3	1	2	2					2			2
EXP4	2	2	2					2			2
EXP5	3	2	3					2			2
EXP6	4	2		3				3			2
EXP7	3	2		3				3			2
EXP8	3	2						4			3
EXP9	2	3	3				3	4			3
EXP10	3	2			3		2	3			2
EXP11	3		3		3		4	3	2		
EXP12	3	3							3		
EXP13		3				3			3	3	
EXP14	3					3					2
EXP15	3	3	3			3	3	3	3		

We present a number of graphs of behavior indices of student 1(AlavanhAthvylay). During the course of 15 experiments for 5 behaviors: 1, 2, 3, 8 and 11, we selected these five behaviors because they were performed in multiple experiments, other behaviorindices are presented in the appendix.

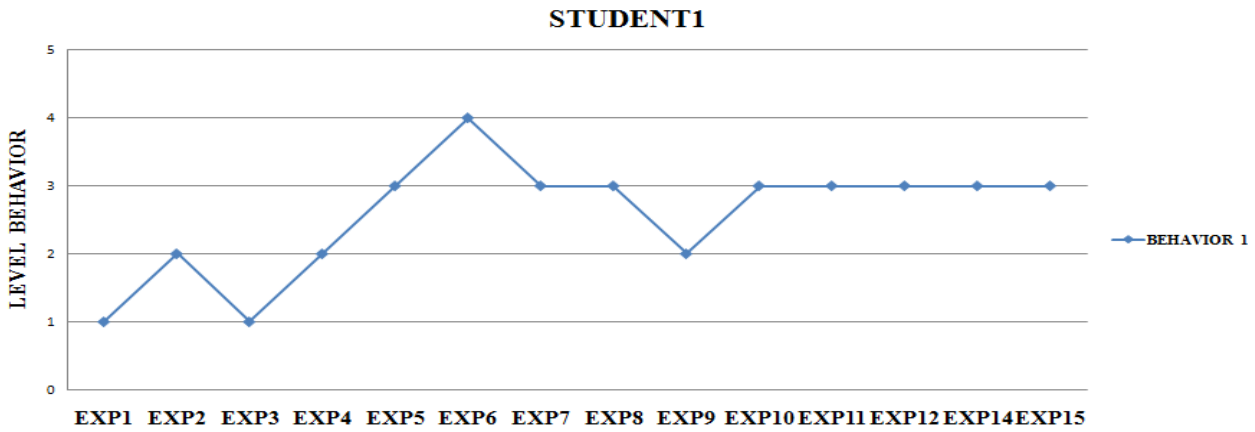

Figure 4.1. The graph illustrates the development of student 1 experimentalcompetence during the course of experiments based on the behavioral expression 1 (perform logical reasoning to decide what to test)

Through the graph demonstrating the competence of student 1 in the behavioral expression 1, it is clear that the development of this student's competence: From experiment 1 to experiment 3, the increase in behavioral expression was equal, and from experiment 4 to experiment 6, the behavioral expression increased gradually, and in experiment 6, the thermal conductivity test was dependent on the nature and distance students achieved. The highest level (level 4) followed by the 7 and 8 experiments, and the third was reduced to the 8, such as the temperature-dependent variation of the sample and the nature of the decrease to the level of 2. From experiment 10 to experiment 15, the level of increase of the behavioral expression is equal. Itcan be concluded that this student has a developmental regression good experimental force.

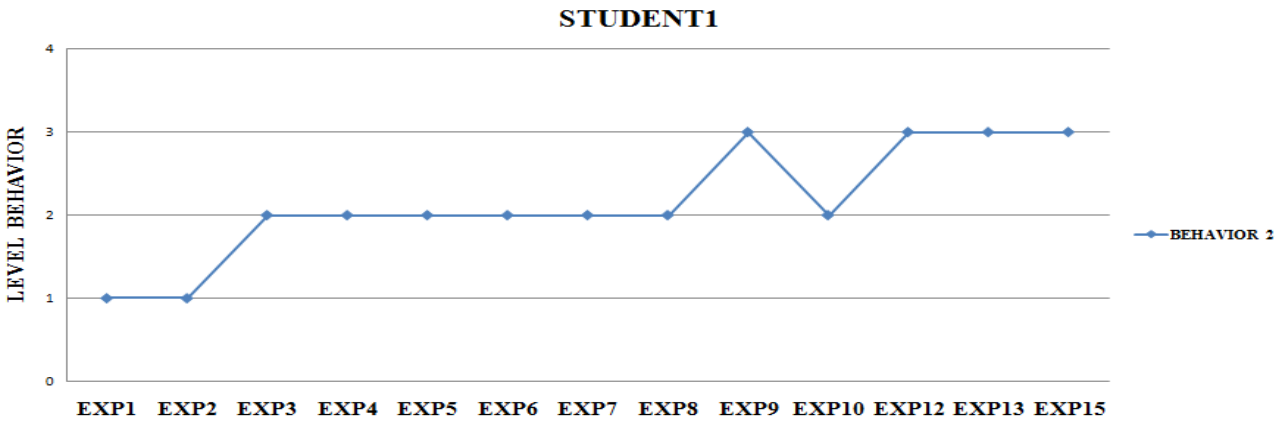

Figure 4.2. The graph illustrates the development of student 1 practical competence during the course of experiments based on the behavioral expression2 (identify the conclusions to be drawn from the experiment).

In the Behavior Indicator 2, student 1 demonstrated a clear increase in level of experimentallcompetence.Initially from experiment 1 to experiment 2 student 1 was stopped at a low level and in experiment 3, she was increased to the level 2. From experiment 3 to experiment 8 (experiments on heat conduction, heat convection and heat radiation), student 1 keeps steady at behavior level 2, from experiment 8 to experiment 15 to level 3 (only 10 experiments were used to test the equation for thermal

equation, students reduced the level down to Level 2). From here it can be concluded that this student has a good experimental development**.**

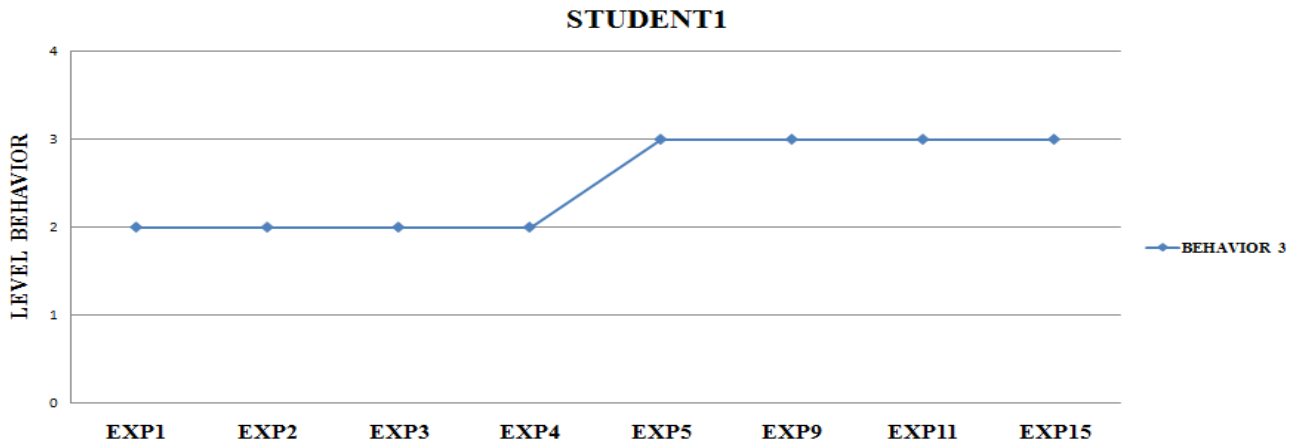

Figure 4.3. The graph illustrates the development of student 1 practical competence during the course of experiments based on the behavioral expression 3 (identify the necessary experimental equipment).

Behavioral expression 3 was conducted in eight experiments, which clearly illustrate the development of student experimental competence1: the level of development is divided into two regions, the first one from experiment 1 to The experiments of 4 students 1 kept the same level of development as Level 2 and gradually from Experiment 5 to Experiment 15 increased to Level 3. The empirical development of Student 1 for the Behavioral Indicator 3 good.

4. 3. Summary

After two rounds of pedagogic experiment, through the organization of teaching, supervision, monitoring and evaluation students' practical competence, we drawsomefollowing conclusions.

The teaching process has reached the goals of teaching. The construction and use of laboratory equipment for the 8th grade on therml physics has stimulated interest in learning, making students active, self-conscious and they have actively carried out the experimental procedures, arranged and assembled the experimental equipment during the experiment, presented and participated in evaluating the results, and hence they improve theirpractical competence considerately.

The teaching process has met the requirement of implementation of new teaching objectives but still relevant with current and future progress in terms of time. Organization of learning through the use of worksheet andsurveys shows that students operate at a high level with a mix of individuals and groups. This clearly demonstrates the importance of laboratory equipment used in group teaching or in stations. The equipment is designed to meet the requirements of science, engineering, pedagogy and aesthetics, which are well-used to produce a wealth of experiments that yield good results in developing thepractical competence of students.