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Instructing Third-Year Chemistry Pedagogical Students to Practice Extracting Eucalyptus Essential Oil by Approaching CDIO Teaching

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ABSTRACT: A basic CDIO (Conceive - Design - Implement - Operate) premise is that hands-on experience is a vital foundation on which to base theory and science. To address this, CDIO programs seek to improve the way engineering is taught and learned in four significant ways: (1) Increase active and hands-on learning; (2) Emphasize problem formulation and solution; (3) Thoroughly explore the underlying concepts of the tools and techniques of engineering; and (4) Institute innovative and exciting ways of gathering feedback. A significant challenge when applying the standards of CDIO to implement teaching practice contents for pedagogical students. We have applied the 12 CDIO standards to design learning activities for third-year chemistry pedagogical students to develop practical competences through the extraction of eucalyptus essential oil in the laboratory. Through the activities of the hands-on lesson, the chemistry pedagogical students developed the ability to teach a practical lesson, for example, eucalyptus essential oil extraction process.The paper has designed an experimental capacity framework for chemistry pedagogical students following the CDIO approach. Includes 9 competencies connected with 12 CDIO standards to evaluate the capacity of organizing practical teaching for third-year chemistry pedagogical students effectively.

Keywords: CDIO standards, eucalyptus essential oil, experimental practice competence, third-year chemistry pedagogical students, organic chemistry, teaching chemistry.

Abbreviations: CDIO, Conceive - Design - Implement – Operate; Ex**,** Experimental group; Co, Control group; ES, Effect Size.

I. INTRODUCTION

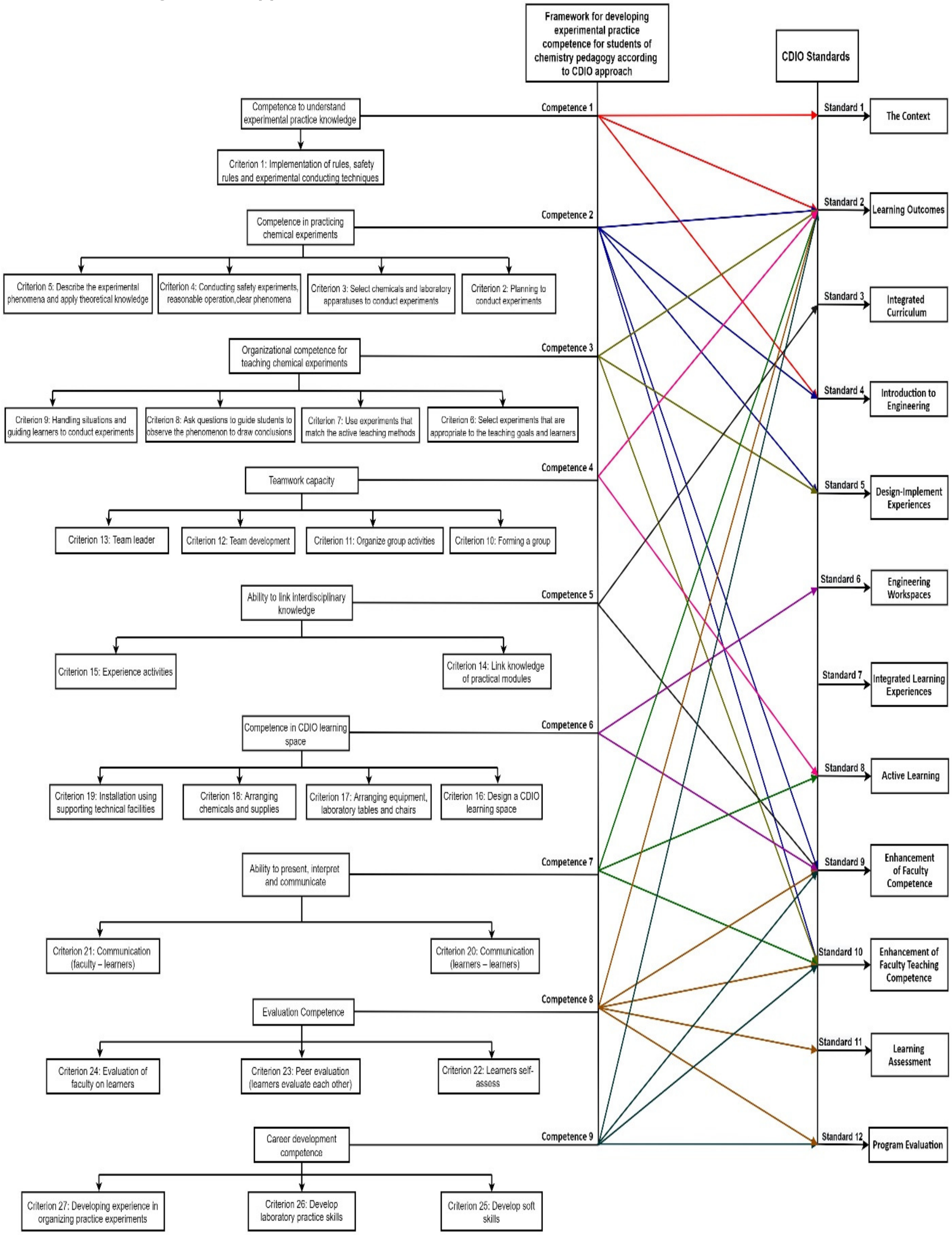
CDIO stands for the English phrase “Conceive - Design - Implement - Operate”, meaning: Conceptualization, conceptual design, implementation and operation. CDIO is an initiative of the engineering departments of the Massachusetts Institute of Technology (MIT), USA, in collaboration with Swedish universities. This is a solution to improve the quality of training to meet social requirements on the basis of determining output standards to design training programs and methods according to a scientific process [1, 2]. CDIO is based on a commonly shared premise that engineering graduates should be able to: Conceive - Design - Implement - Operate complex value-added engineering systems in a modern team-based engineering environment to create systems and products [3].

Up to now, the World CDIO Association has more than 100 members who are the leading prestigious Universities of Engineering Technology; in which, Asia CDIO Association currently has 28 members.

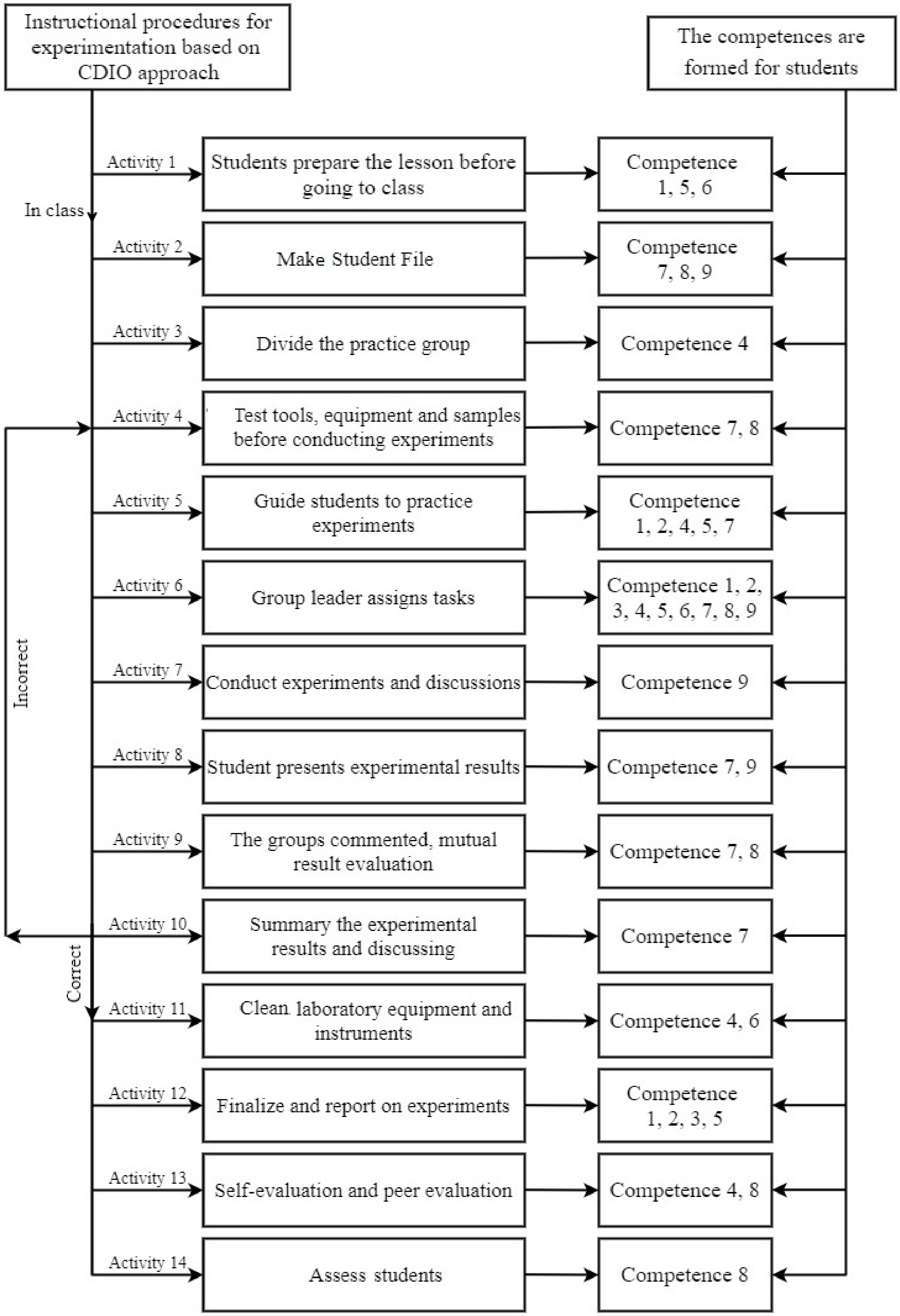
In Vietnam alone, 5 universities have been admitted as members of CDIO Association. Vinh University (Vietnam) has started applying CDIO teaching for all bachelor's disciplines since 2016. Studies on teaching CDIO approach mainly apply successfully to training programs of technical disciplines but very little research for pedagogy.

This paper focuses on the organization of activities for third-year chemistry pedagogical students in Vinh University to develop laboratory practical competencies through the implementation of a eucalyptus essential oils extraction process in the lab based on 12 CDIO standards (Scheme 1 and 2).

Scheme 1. Framework for developing experimental practice competence for third-year pedagogical chemistry students according to CDIO approach



Scheme 2. Instructional procedures for experimentation based on CDIO approach.



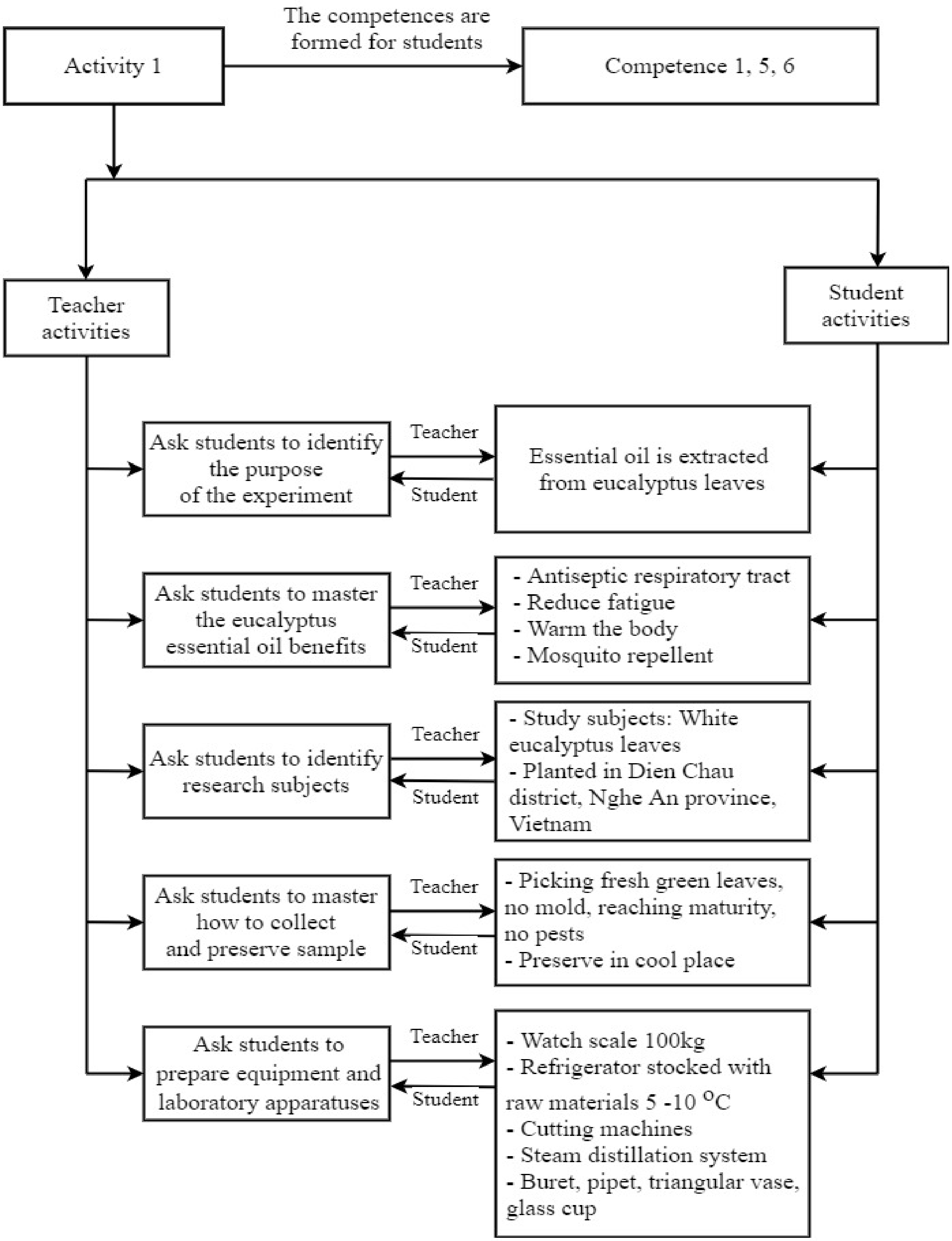
II. MATERIALS AND METHODS

Our research methodology and results are conducted through activities to shape and develop pedagogical chemistry students.

Activity Design

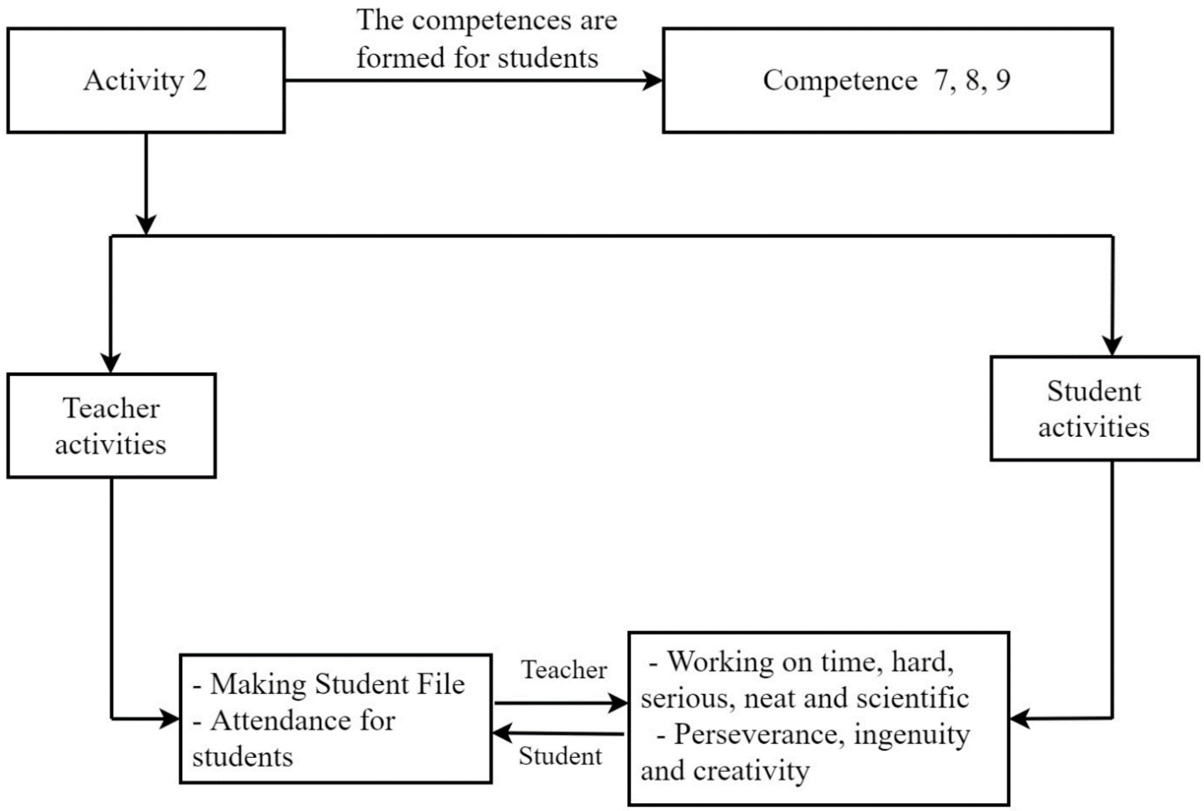
Activiry 1: Prepare the lesson of students before going to class (Scheme 3)

Scheme 3. Activity of students prepare the lesson before going to class.



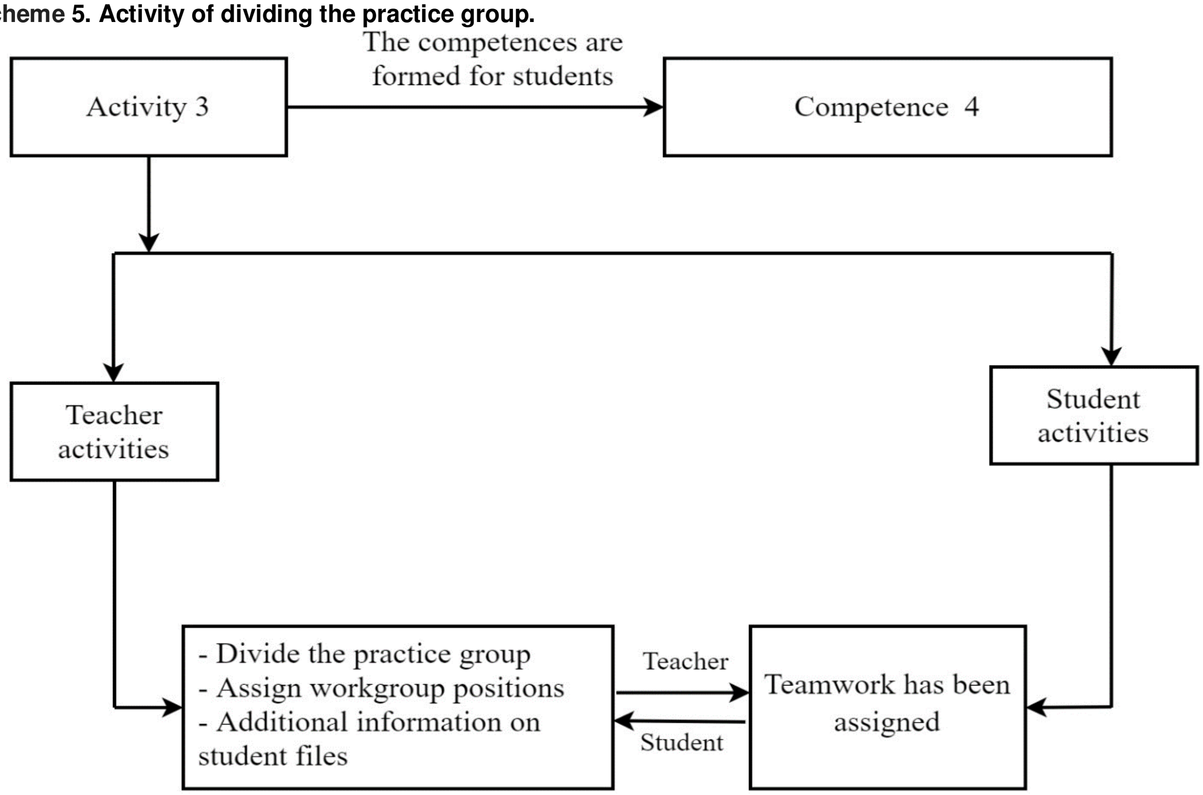
Activity 2: Make student file (Scheme 4)

Scheme 4. Activity of making student file



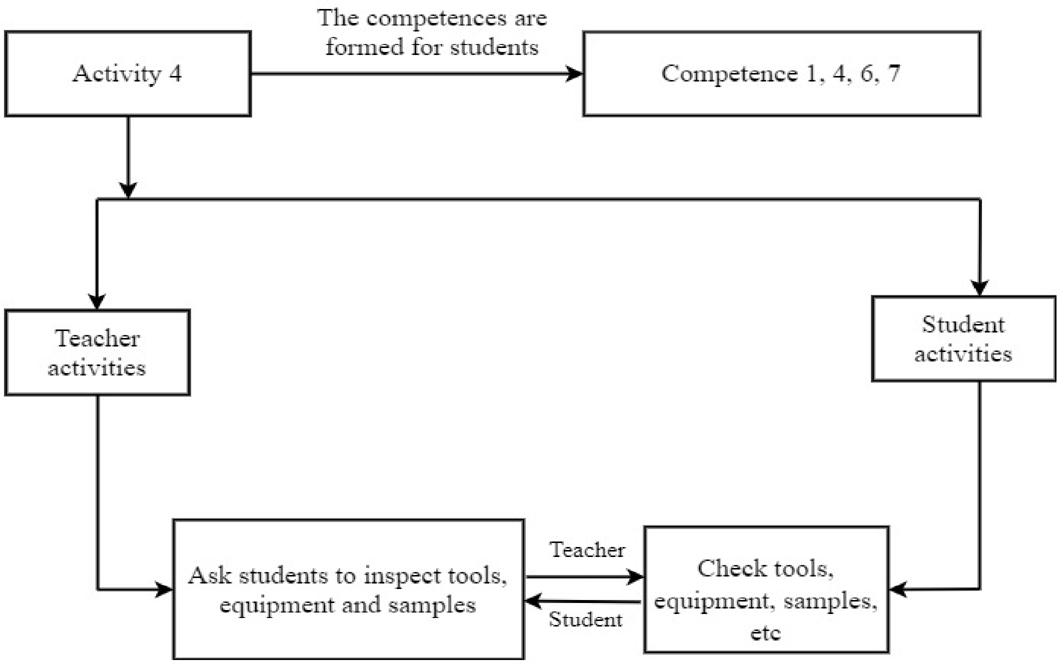
Activity 3: Devide the practice group (Scheme 5)

Scheme 5. Activity of dividing the practice group.



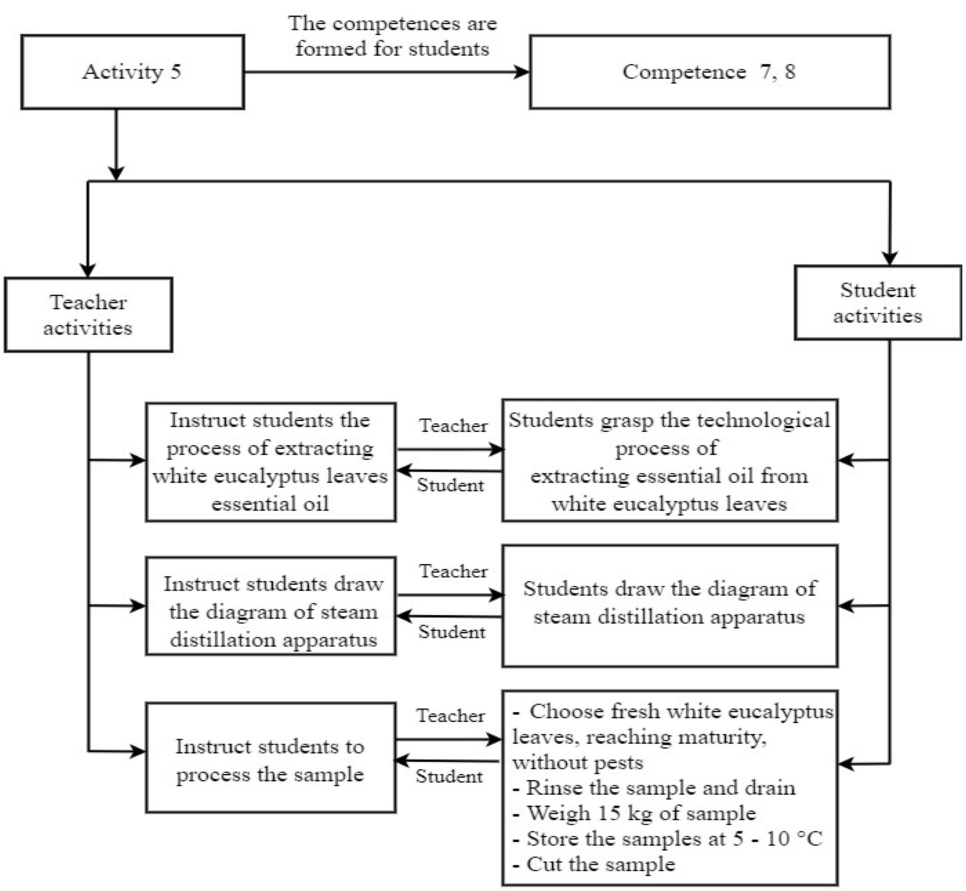
Activity 4: Test tools, equipment and samples before conducting experiments (Scheme 6).

Scheme 6. Activity of testing tools, equipment and samples before conducting experiments.

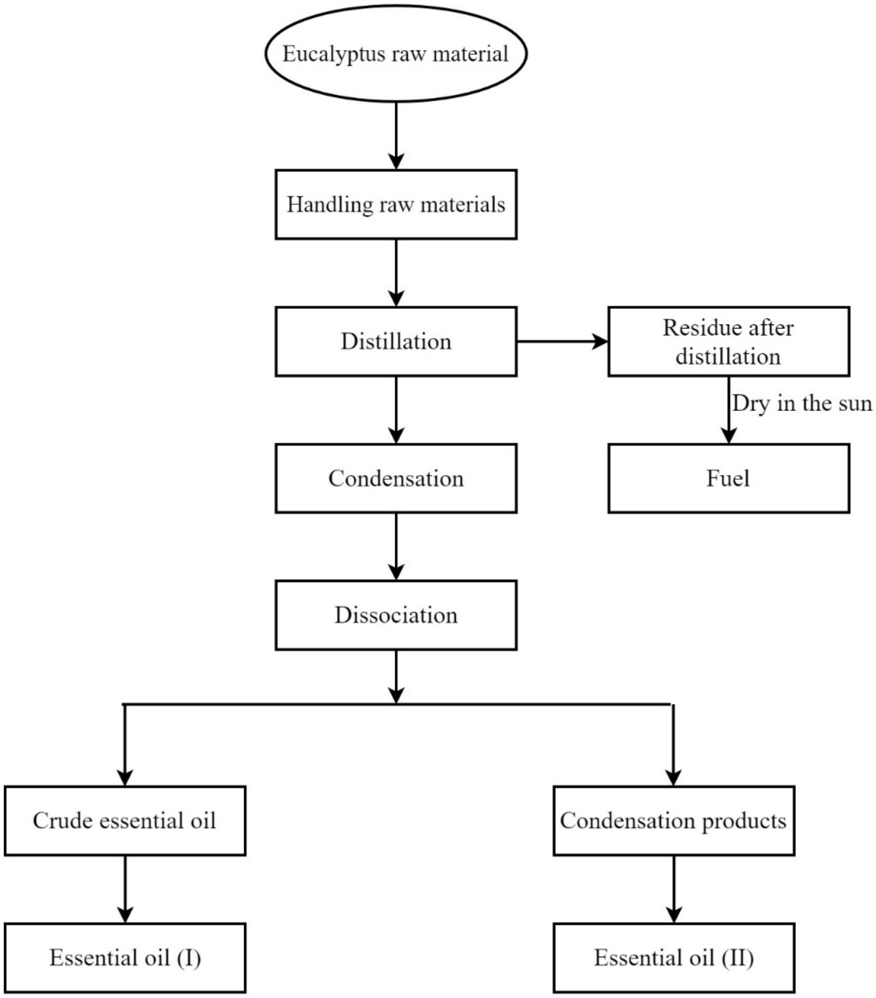


Activity 5: Guide students to practice experiments (Scheme 7 and 8)

Scheme 7. Activity of guiding students to practice experiments.

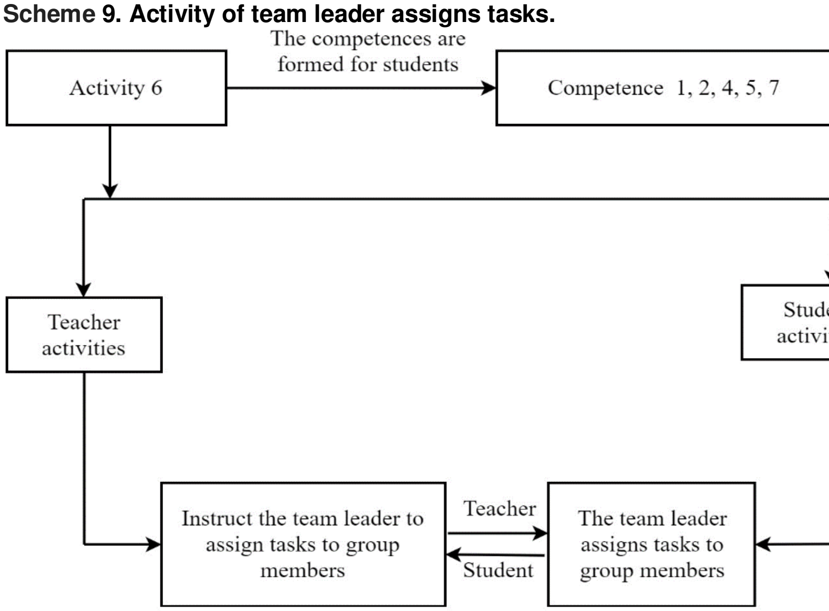


Scheme 8. Process of extracting eucalyptus essential oil.

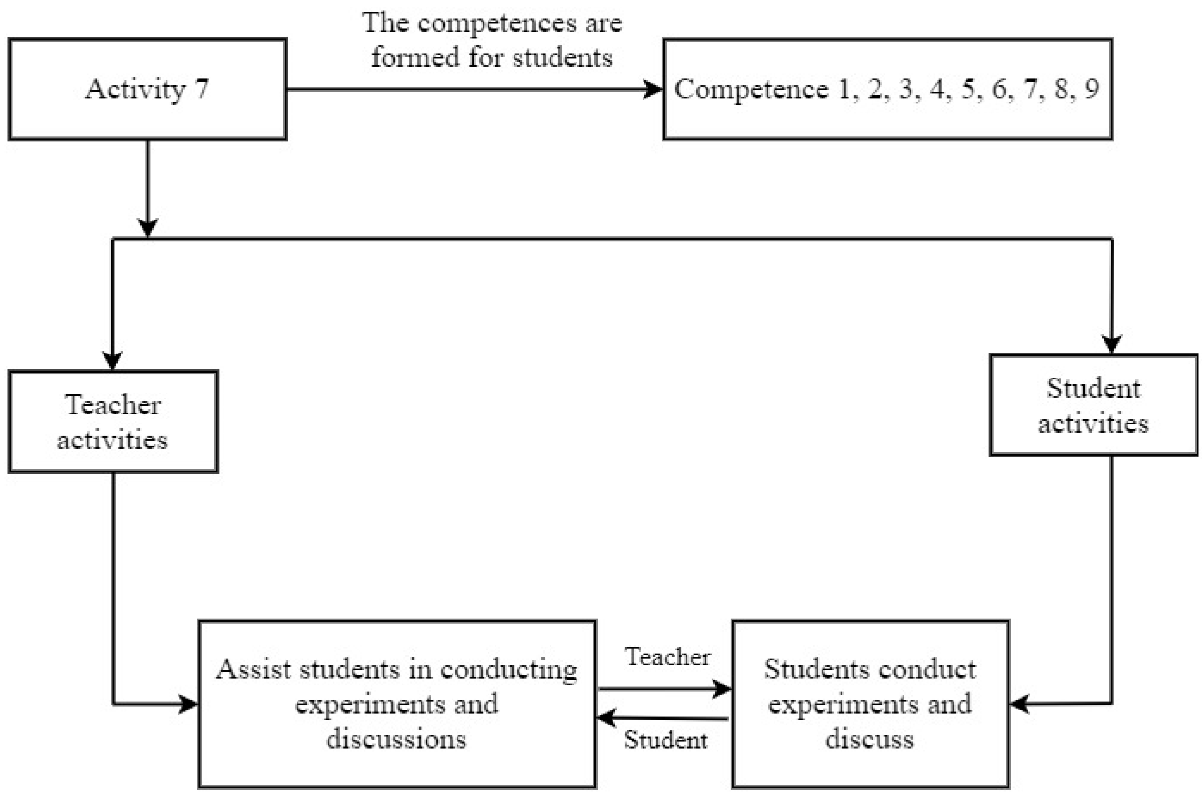


Activity 6: Team leader assigns tasks (Scheme 9).

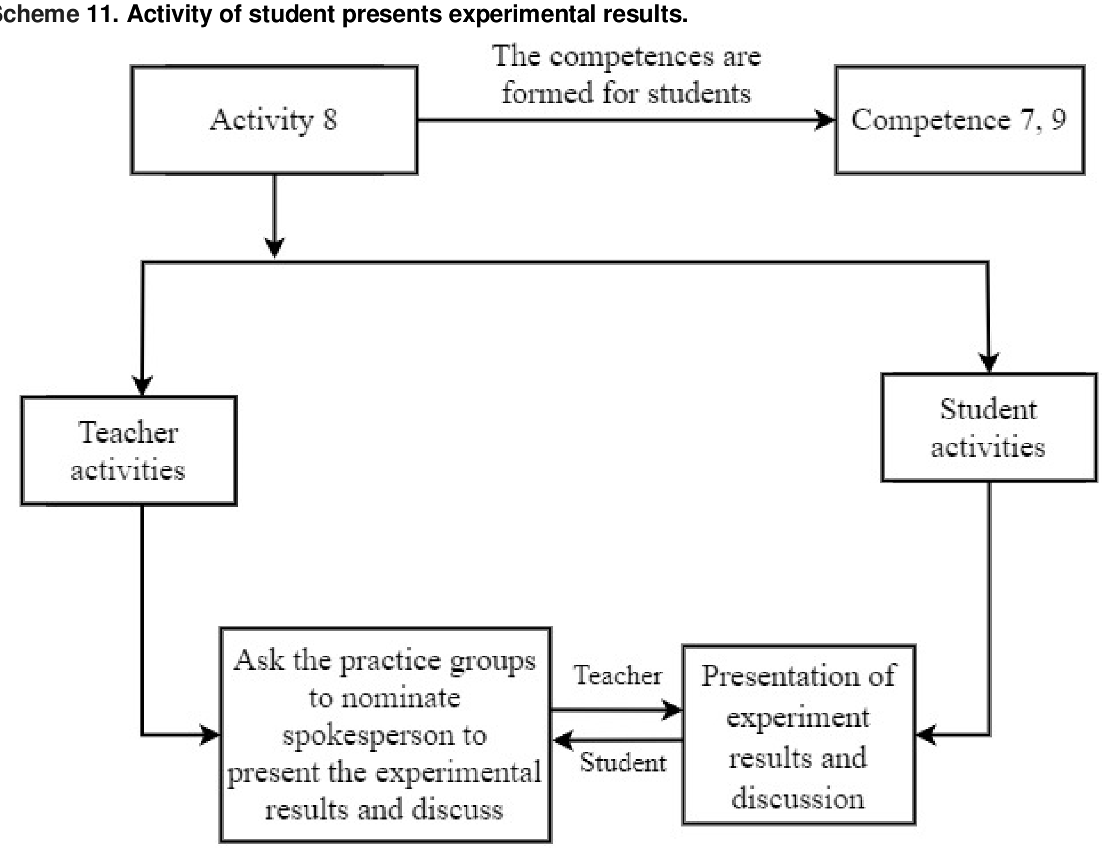
Scheme 9. Activity of team leader assigns tasks.



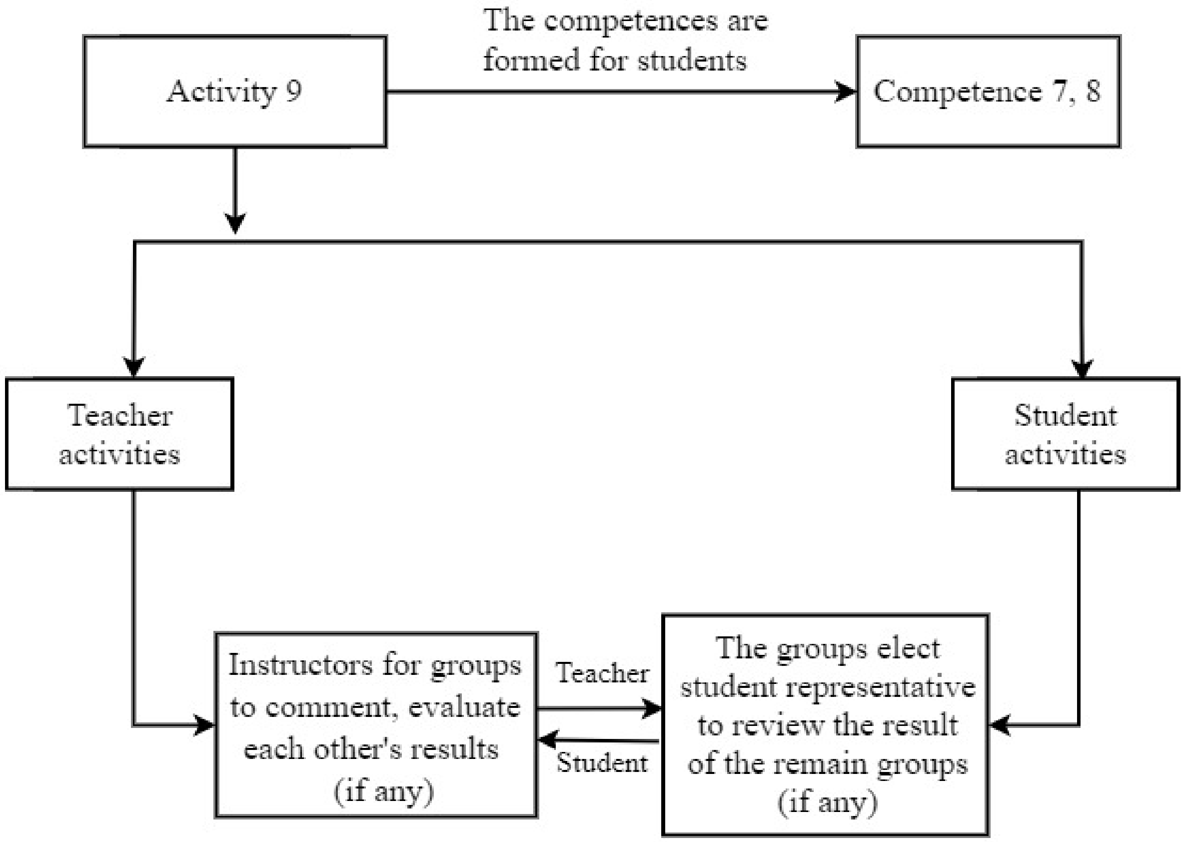
Activity 7: Conduct experiments and discussions (Scheme 10).
Scheme 10. **Activity of conducting experiments and discussions.**



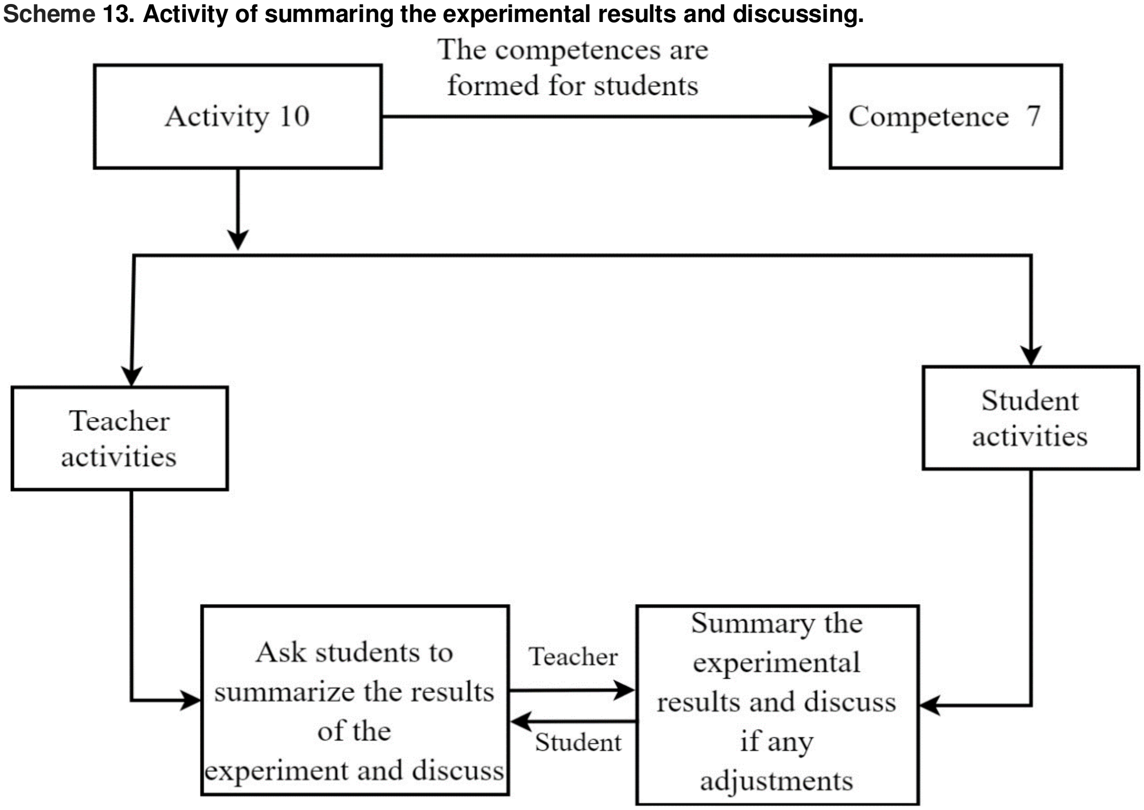
Activity 8: Students present experimental results (Scheme 11).
Scheme 11. **Activity of student presents experimental results.**



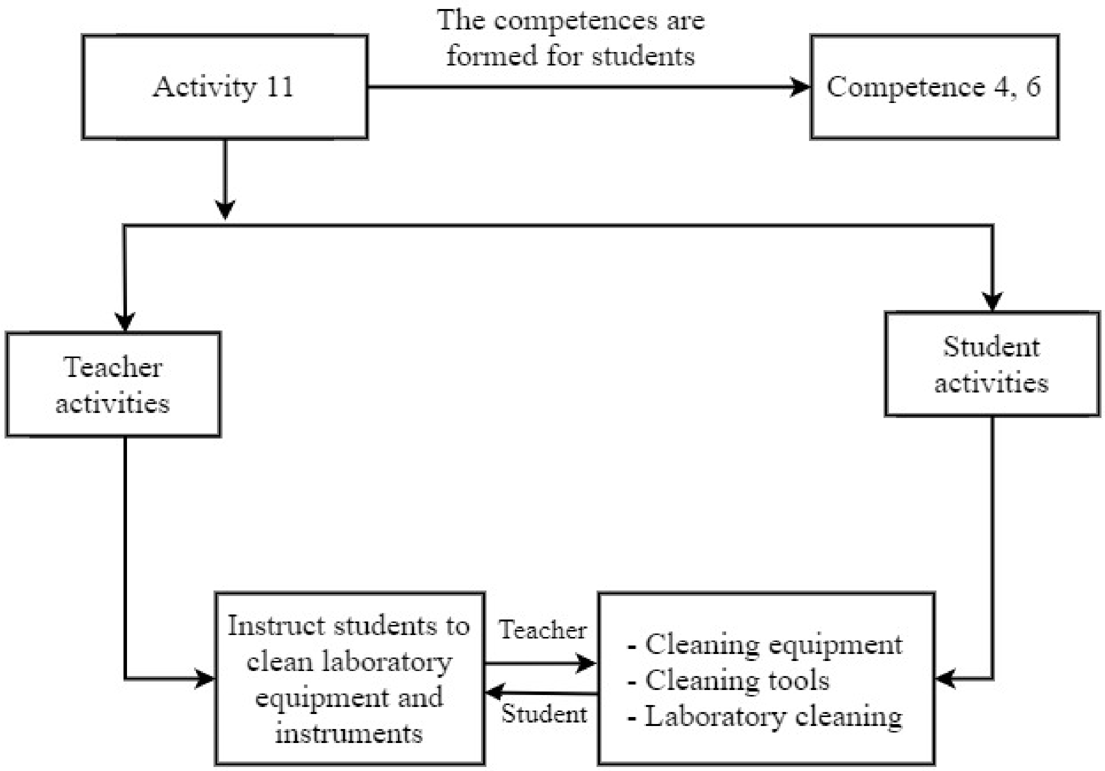
Activity 9: The groups commented, mutual result evaluation (Scheme 12).
Scheme 12. **Activity the groups commented, mutual result evaluation.**



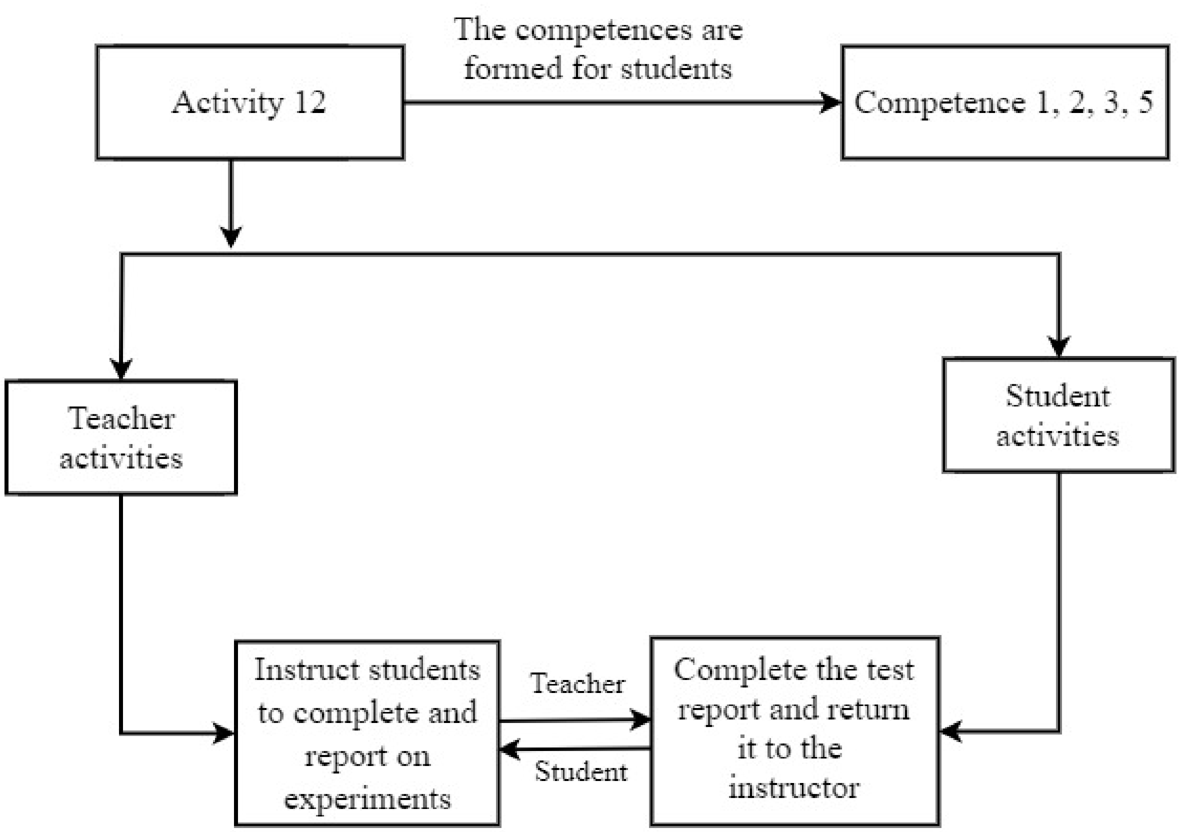
Activity 10: Summary the experimental results and discussing (Scheme 13).
Scheme 13. **Activity of summaring the experimental results and discussing.**



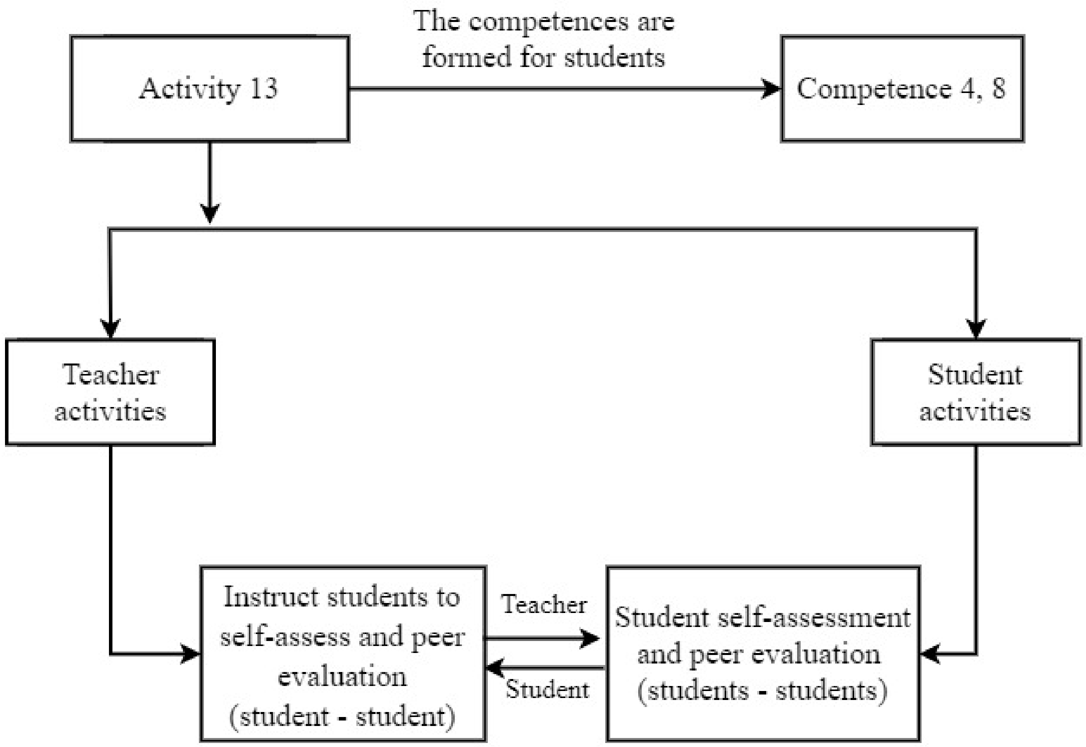
Activity 11: Clean laboratory equipment and instruments (Scheme 14)
Scheme 14. Activity of cleaning laboratory equipment and instruments.



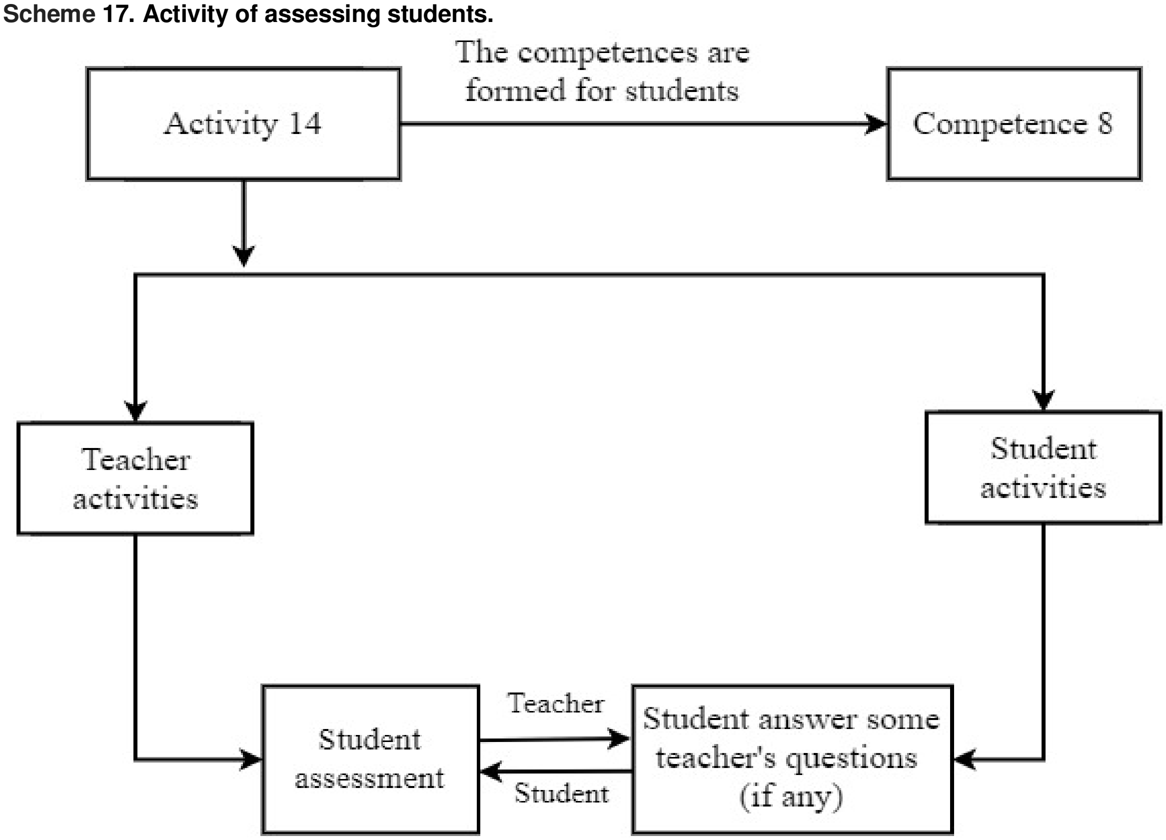
Activity 12: Finalize and report on experiments (Scheme 15).
Scheme 15. Activity of finalizing and reporting on experiments.



Activity 13: Self-evaluation and peer evaluation (Scheme 16)
Scheme 16. Activity of self-evaluation and peer evaluation.



Activity 14: Assess students (Scheme 17).
Scheme 17. Activity of assessing students.



Discussion questions for students: In the process of organizing teaching activities, faculty will guide students to discuss the following problems [4- 8].

1. Describe an overview of eucalyptus trees.

Eucalyptus trees belong to the species of carpentry. The curved elongated leaves have a bluish white mold or dark green color that contain the aroma of Eucalyptone oil, which is fragrant with cajeput oil, also known as eucalyptus oil. Eucalyptus species are generally fast growing, narrow foliage. Within 5 - 6 years, the height is over 7 m and the trunk diameter is about 9 - 10 cm. The wooden tree is 20 - 25m high, soft shells flake off into patches.

2. List some types of eucalyptus that are imported and grown in Vietnam.

- Eucalyptus robusta Smith.
- Eucalyptus camaldulensis.
- Eucalyptus exserta F.v Muell.
- Eucalyptus tereticornis.
- Eucalyptus maculata Hool, var, citrio.
- Eucalyptus globulus.
- Eucalyptus grandis.
- Eucalyptus saligna.

3. Why use eucalyptus leaves to separate essential oils without using other parts?

The amount of essential oil present in the leaves accounts for more than the other parts.

4. How to harvest eucalyptus leaf material.

- Leaves can be harvested for the first time 6 to 8 months after planting.
- Only pick the leaves on the outer small branches to ensure the tree grows.
- By the second year, you can cut the whole tree, then you can just collect the essential oil and the wood from the trunk and branches.
- After the second year, many branches develop on the remaining stumps and can continue to be harvested to collect essential oils.
- When cut only leaving one branch to grow most strongly, the leaf output can reach 2 - 5 kg of leaves per tree, one hectare of eucalyptus can harvest 4 - 10 tons of leaves.

5. Classify essential oils.

- Pure essential oils: Absolutely no toxins, no chemical preservatives so very safe for users.
- Impure essential oils: Essential oils are blended from pure essential oils with other chemicals and still retain the aroma of essential oils.

6. Describe the physical properties of essential oils.

- Essential oils usually exist in liquid form at room temperature, fragrant, colorless or pale yellow.
- Essential oil has a low density compared to water, high refractive index.
- Essential oils are volatile, insoluble or slightly soluble in water but soluble in organic solvents such as ethers, alcohols, etc.

7. Identify the chemical composition of the essential oil.

Hydrocarbon, phenol, ester, aldehyde.

8. Identify the chemical composition and the use of eucalyptus oil.

a) The chemical composition of eucalyptus essential oil:

- Limonene ($C_{10}H_{16}$)
- $\alpha-$Pinene ($C_{10}H_{16}$)
- Terpinene ($C_{10}H_{16}$)
- 1, 8-Cineole ($C_{10}H_{18}O$)

b) Eucalyptus essential oil uses:

- High antiseptic properties.
- Treating fever, flu effectively.
- Treatment of skin burns.
- Limiting varicose veins.

9. Why do samples need to be collected and stored properly?

Make sure to get the best quality essential oil and the highest essential oil content.

10. Describe common extraction methods for essential oils.

- Steam distillation method.
- Extraction method.
- Method of immersion (Hot Maceration).
- Method of pressing (Expression or Cold Pressing).
- Microwave method.

11. Why use steam-distillation to extract essential oils from white eucalyptus leaves?

- The basis of this method is that the boiling temperature of the mixture will be lower than the boiling temperature of the constituents. Therefore, when steam distillation of essential oil components will be separated at a temperature lower than the boiling temperature of water, thus limiting the chemical denaturation (oxidation, pyrolysis ...) of the essential oil components.
- Distillation time is relatively fast.

12. Identify factors that affect the essential oil collection performance.

- Diffusion.
- Hydrolysis.
- Temperature.

13. Indicate the equipment and tools necessary to produce eucalyptus essential oil by steam distillation.

- Watch scale 100 kg.
- Refrigerator for material storage at 5 - 10^{o}C.
- Cutting machines.
- Steam distillation system.
- Burettes, pipettes, flasks, beakers.

14. Explain the process of producing essential oil from white eucalyptus leaves.

- The sample after being processed, put into steam distillation system, heated to 100 ^{o}C.
- The mixture of water and essential oil is released into the condenser of the distillation, then flows to the condensation equipment (Fig. 1 and 2).

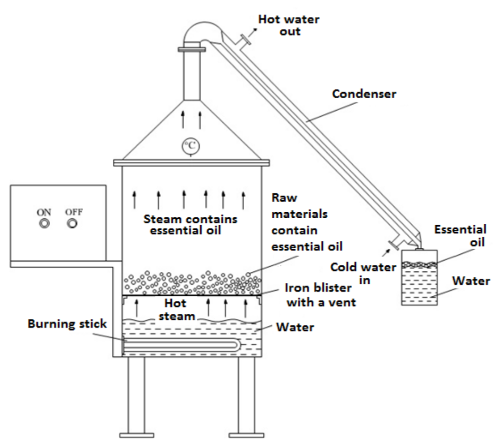


Fig. 1. Diagram of steam distillation system.

Fig. 2. Steam distillation apparatus in the lab.

- The mixture is separated into 2 phases.
- A lighter layer of essential oil will float to the surface of the water, the water below can be returned to the distillation to ensure the highest amount of essential oil is obtained.
- The collected essential oil products are stored in glass jars, tightly closed and stored in the dark.

15. Indicate the types of products and their characteristics during the extraction of essential oils.

- Concrete oil: Obtained from the method of static extraction, mainly used to produce crude essential oils. It is a wax and fat product that has a viscous form that can be used directly.
- Absolute oil: Obtained by thoroughly extracting the condensed products with a sufficient amount of ethanol and then suddenly cooling (- 5℃ to 10℃) to precipitate and filter the wax and fat. The resulting oily fluid is then rotary evaporated in a vacuum to remove ethanol and obtain a pure essential oil.
- Bouquet: The remaining water after settling, decanting to obtain essential oils in steam distillation method of essential oils of high value and can be considered as a product in aromatherapy technology.
- Resinoid: This form is collected directly from the wood of the living trunk.
- Pomade: A fat containing aroma obtained in the marinating method.
- Hydrosol: Condensation is separated after separation of essential oils. This hydrosol contains water-soluble aromatic components and some poorly soluble essential oils, so it still has a slight aroma.

III. RESULTS AND DISCUSSION

To evaluate the impact of the learning process under CDIO, we selected an experimental group (Ex) and a control group (Co) with each group of 38 students participating, in which the experimental group was taught according to the CDIO approach. The analytical data are shown in Table 1, 2 and Fig. 3.

Table 1: 45-minute test results for practice groups.

xi	Number of students scoring xi		% of students achieving x_i		% of students scoring x_i or below	
	Ex	Co	Ex	Co	Ex	Co
5.0	0	2	0.00	5.26	0.00	5.26
5.5	0	3	0.00	7.89	0.00	13.15
6.0	0	3	0.00	7.89	0.00	21.04
6.5	0	6	0.00	15.79	0.00	36.83
7.0	0	2	0.00	5.26	0.00	42.09
7.5	3	2	7.89	5.26	7.89	47.35
8.0	5	3	13.16	7.89	21.05	55.24
8.5	8	5	21.05	13.16	42.10	68.40
9.0	8	6	21.05	15.79	63.15	84.19
9.5	9	5	23.68	13.16	86.83	97.35
10.0	5	1	13.16	2.63	99.99	99.98
	38	**38**				

Table 2: Data analysis.

		Experiment (Ex)	Control (Co)
Data description	Mode	9.5	6.5
	Median	9	8
	Mean	8.89	7.64
	Standard deviation	0.75	1.49
Data comparison	p-Value	2.41592E-05	
	ES	0.84	

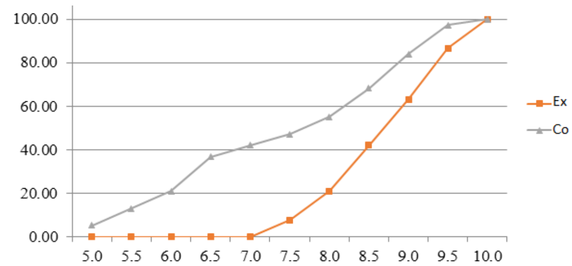


Fig. 3. The cumulative line graph shows the test results of experimental and control groups.

From the results of pedagogical experimental data processing, the learning quality of experimental group students is higher than the corresponding control group after being influenced by the teaching process based on CDIO approach, specifically was:

(1) The average score of experimental group is higher than the control group.

(2) The standard deviation of the experimental group students is lower than the control group students, demonstrating the dispersion around the average of the scores in the experimental group smaller than the control group.

(3) The graph of cumulative lines of experimental group is always separated to the right and at the bottom compared to the control group, so it can confirm the academic performance of students in the experimental group is higher than the control group.

(4) The p-value between the experimental group and the control group ($p < 0.05$) showed a clear difference in scores after using CDIO procedure of experimental groups and control groups that were not likely to occur randomly.

(5) The ES value between the experimental group and the control group when investigated according to Cohen criteria table shows that the scale of the impact of this study is large [0.80; 1.00] [9], demonstrating that the impact is already at a large threshold and the impact results are significant..

IV. CONCLUSION

Based on 12 CDIO standards, we have designed a practical laboratory capacity framework for the third-year chemistry pedagogical students and gave many positive results: (1) Students work in groups effectively; (2) Students can establish a process of experimental practice; (3) Students have many practical experiences in the lab; (4) Students know how to evaluate peers and self-assess; (5) Students develop critical thinking through teacher-led discussion.

The results have motivated students to be interested in laboratory exercises, promote active learning and increase the effectiveness of training chemistry students at Educational Universities.

V. FUTURE SCOPE

In the future, experimental lessons will be organized to teach according to these activities to develop teaching practice of chemistry for chemistry pedagogicalstudents.

ACKNOWLEDGEMENTS

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Conflict of Interest. The authors do not have any conflicts of interest.

REFERENCES

[1]. Crawley, E., Malmqvist, J., Ostlund, S., and Brodeur, D. (2007). *Rethinking Engineering Education: The CDIO Approach*, Springer.

[2]. Gunnarsson, S., Wiklund, I., Svensson, T., Kindgren, A., & Granath, S. (2007). Large scale use of the CDIO Syllabus in formulation of program and course goals. In *3rd International CDIO Conference, Cambridge, Mass., USA*.

[3].http://www.cdio.org/cdio-vision (accessed May 2020).

[4]. Sartorelli P., Marquioreto A.D., Amaral-Baroli A., Lima M.E., & Moreno P.R. (2007). Chemical composition and antimicrobial activity of the essential oils from two species of *Eucalyptus*. Phytother. *Res. 21,* 231–233.

[5]. Stephen K., O'Shea, Daniel D., Von Riesen, and Lauren L. Rossi. (2012). Isolation and Analysis of Essential Oils from Spices. *Journal of Chemical Education*, *89* (5) , 665-668. DOI: 10.1021/ed101141w.

[6]. Riccardo Amorati, Mario C. Foti, & Luca Valgimigli (2013). Antioxidant Activity of Essential Oils, *Journal of Agricultural and Food Chemistry*, *61*, 46, 10835-10847

[7]. David L. Garin (1976). Steam distillation of essential oils - Carvone from caraway. *Journal of Chemical Education 53*(2), 105. DOI: 10.1021/ed053p105.

[8]. Zrira S., Bessiere J.M., Menut C., Elamrani A., & Benjilali B., (2004). Chemical composition of the essential oil of nine *Eucalyptus* species growing on Morrocco. *Flavour Fragr., J.* 19:172–175

[9]. Chen, H., Cohen, P., & Chen, S. (2010). How big is a big odds ratio? Interpreting the magnitudes of odds ratios in epidemiological studies. *Communications in Statistics-Simulation and Computation*, 39, 860-864. doi: 10.1080/03610911003650383

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