European Journal of Education and Applied Psychology

№ 2 2020

PREMIER
Publishing

Vienna
2020

European Journal of Education and Applied Psychology

Scientific journal

№ 2 2020

ISSN 2310-5704

Proofreading Kristin Theissen

Cover design Andreas Vogel

Additional design Stephan Friedman

Editorial office Premier Publishing s.r.o.
Praha 8 – Karlín, Lyčkovo nám. 508/7, PSČ 18600

E-mail: pub@ppublishing.org

Homepage: ppublishing.org

European Journal of Education and Applied Psychology is an international, German/English/Russian language, peer-reviewed journal. It is published bimonthly with circulation of 1000 copies.

The decisive criterion for accepting a manuscript for publication is scientific quality. All research articles published in this journal have undergone a rigorous peer review. Based on initial screening by the editors, each paper is anonymized and reviewed by at least two anonymous referees. Recommending the articles for publishing, the reviewers confirm that in their opinion the submitted article contains important or new scientific results.

Premier Publishing s.r.o. is not responsible for the stylistic content of the article. The responsibility for the stylistic content lies on an author of an article.

Instructions for authors

Full instructions for manuscript preparation and submission can be found through the Premier Publishing s.r.o. home page at: http://ppublishing.org

Material disclaimer

The opinions expressed in the conference proceedings do not necessarily reflect those of the Premier Publishing s.r.o., the editor, the editorial board, or the organization to which the authors are affiliated.

Premier Publishing s.r.o. is not responsible for the stylistic content of the article. The responsibility for the stylistic content lies on an author of an article.

Included to the open access repositories:

ULRICHSWEB™ GLOBAL SERIALS DIRECTORY · НАУЧНАЯ ЭЛЕКТРОННАЯ БИБЛИОТЕКА eLIBRARY.RU · CYBERLENINKA

GIF® GLOBAL IMPACT FACTOR The journal has the GIF impact factor .468 for 2019.

Typeset in Berling by Ziegler Buchdruckerei, Linz, Austria.
Printed by Premier Publishing s.r.o., Vienna, Austria on acid-free paper.

Section 2. Education for Professors and Teachers

https://doi.org/10.29013/EJEAP-20-2-8-17

Tran Thi Gai,
Nguyen Thi Nhi,
Vinh University, Vietnam
E-mail: hongnhi1076@gmail.com

DEVELOP THE COLLABORATION PROBLEM SOLVING COMPETENCE OF STUDENTS THROUGH STEM EDUCATION IN TEACHING OF NATURAL SCIENCES IN VIETNAM SECONDARY SCHOOLS

Abstract. STEM is an integration between the fields of science, technology, engineering and math. Currently, STEM education is a teaching model developed in many countries in order to develop student competencies in line with practical needs. Collaborative problem solving is one of the important competencies of students in the learning process. This research focuses on analyzing the structure of collaborative problem – solving capacity and devising this capacity training process through the topic of STEM education. From that, teacher applys to the specific example in STEM topic "Manufacturing water filtration systems" for junior high school students in Vietnam.

Keywords: Competence, cooperation, problem solving, STEM, STEM education.

Introduction

STEM education is an effective way to develop student's capacity, especially the ability to collaborate problem solving. STEM is an area of integration of traditional subjects (science, technology, engineering and math) to solve real-world problems (Lents, Cifuentes & Carpi [14]) (Labov, Reid & Yamamoto [10]; Sanders 2009). STEM is the connection between subjects and is suitable for studying objects and phenomena in practice. The purpose of STEM teaching in schools is to develop student's problem-solving capabilities, the science field to explain the natural world and the technology is to propose adaptive human solutions. with the real world (Ronald et al. [14]). Cooperative problem-solving teaching has a strong role in STEM education (Kristy M. Meirick [9]). Students will learn collaboratively, work in groups to research and complete tasks, to test theory, plan and implement solutions. Learning is maximized because students share knowledge, practice skills, and discover new and important information together. According to (Harwood & Rudnitsky [7]), learning becomes more interesting and meaningful when students combine theoretical knowledge in lessons and perform real-world tasks as an engineer.

1. Collaboration problem solving competence

1.1. Collaborative concept of problem solving

PISA, 2015 [13] defines the capacity to collaborate on problem solving: "The capacity of an individual to effectively engage in a process whereby two or more

agents attempt to solve a problem by sharing the understanding and effort required to come to a solution".

Collaboration allegedly has advantages over individual problem solving because: a) there is a more effective division of labor; b) the solutions incorporate information from multiple sources of knowledge, perspectives, and experiences, and; c) the quality of solutions is stimulated by ideas of other group members (Crebbin [7]) (Aronson and Patnoe [1]; Schwartz [17]; Stasser and Titus [18]; Theiner and O'Connor [16]). A key factor that contributes to the success of CPS and distinguishes itself from individual problem solving is the role of communication between team members (Dillenbourg and Traum [3]; Fiore et al. [4]; Fiore and Schooler [5]).

The ATC21S project investigates the collaborative problem-solving structure in two aspects: society (cooperation) and awareness (problem solving). According to this project, problem-solving is collaborative or working with others to solve a common challenge, including contributing and exchanging knowledge ideas or resources to achieve a common goal. The social aspect refers to cooperation, focusing on managing the interaction and contribution of individuals, while the cognitive aspect emphasizes the use of personal knowledge and skills (Care, Scoular, & Griffin [2]). As such, the capacity to collaborate on problem solving is a harmonious combination between individual activities and among team members, in the community.

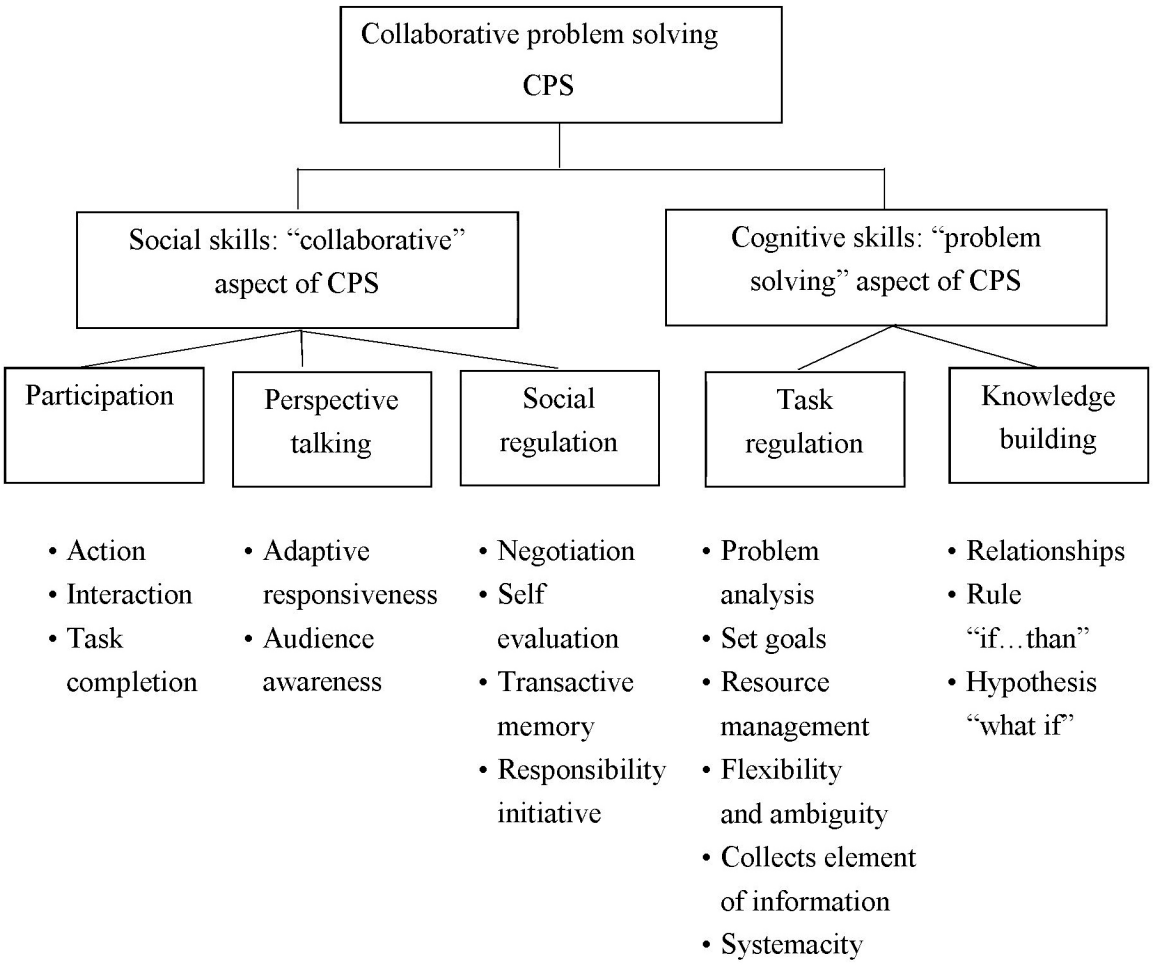

Figure 1. Structure of collaborative problem-solving capacity (Hesse et al. [8])

1.2. The structure of collaborative problem-solving capacity

According to the theory of teaching and learning skills of the 21st century (ATC21S), the author (Care et al. [2]) proposed the structure of CPS competencies including two main competencies: social competence (participation, commenting, social adjustment), and cognitive competence (task adjustment, knowledge building). According to Hesse et al, CPS is as a complex skill links critical thinking, problem solving, decision making and collaboration across both social and cognitive domains. Accordingly, CPS consists of a set of component skills comprising five separate sequences of individual competency and group level corresponding to social and cognitive skills (Hesse et al. [8]).

According to PISA 2015, the CPS structure consists of 4 skills of problem solving process and 3 skills of cooperation process.

Every structural approach of CPS makes it clearer the nature of CPS. The CPS structure under the ATC21S project goes into performance analysis at two levels of personal and social awareness. The approach of PISA 2015 is based on the process of cooperation and problem solving, so it can be easier to apply in teaching and assessment.

2. STEM and its relationship with developing collaborative problem-solving capacity

2.1. STEM concept

STEM is the abbreviation for the words Science, Technology, Engineering and Mathematics (Rodger W. [15], Lou et al. [11]). The development of Science, Technology, Engineering and Mathematics is described by the STEM cycle (Figure 1). Science is the process of creating scientific knowledge; Engineering is the process of using scientific knowledge to design new technologies to solve problems; Math is the tool used to capture results and share them with others.

In the STEM cycle, "Science" is understood not only as "Knowledge" in science subjects (such as Physics, Chemistry, Biology) but implies "Scientific process" to invent scientific knowledge. new. Similarly, "Engineering" in the STEM cycle is not only "Knowledge" in the field of "Engineering" but implies "Technical Process" to create new "Technology". The two aforementioned processes are continuous and closed into a science and technology creation cycle in the "spiral" model, which increases the amount of scientific knowledge every time and with it, the technology of development at a higher level.

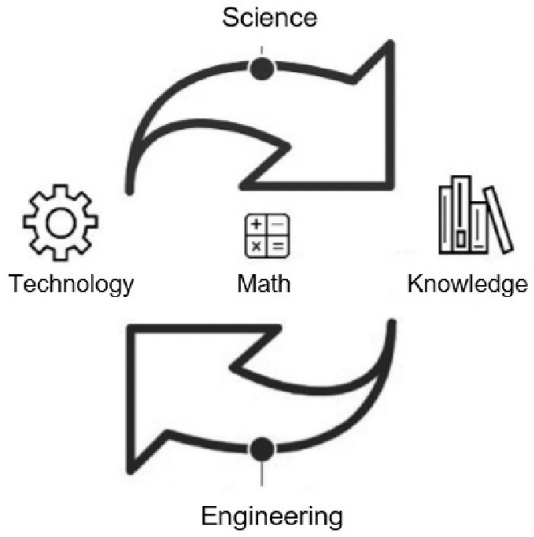

Figure 3. STEM cycle (knowatom.com)

2.2. STEM education

STEM education is a model of education based on interdisciplinary approach, helping students apply scientific, technological, technical and mathematical knowledge to solve some practical problems in specific contexts.

2.3. The process of training cooperative capacity to solve problems through the topic of STEM education

Designing STEM topics is done by us as follows: Selecting STEM education topics; Define goals of STEM education topic; Identify issues that need to be addressed in STEM education; Identify specific issues to use to solve problems in STEM topics; Designing learning activities; Design the criteria and test tool set, assessment of students.

The process of collaborative problem-solving capacity building is associated with the problem-solving process and is shown in every step of STEM lesson organization.

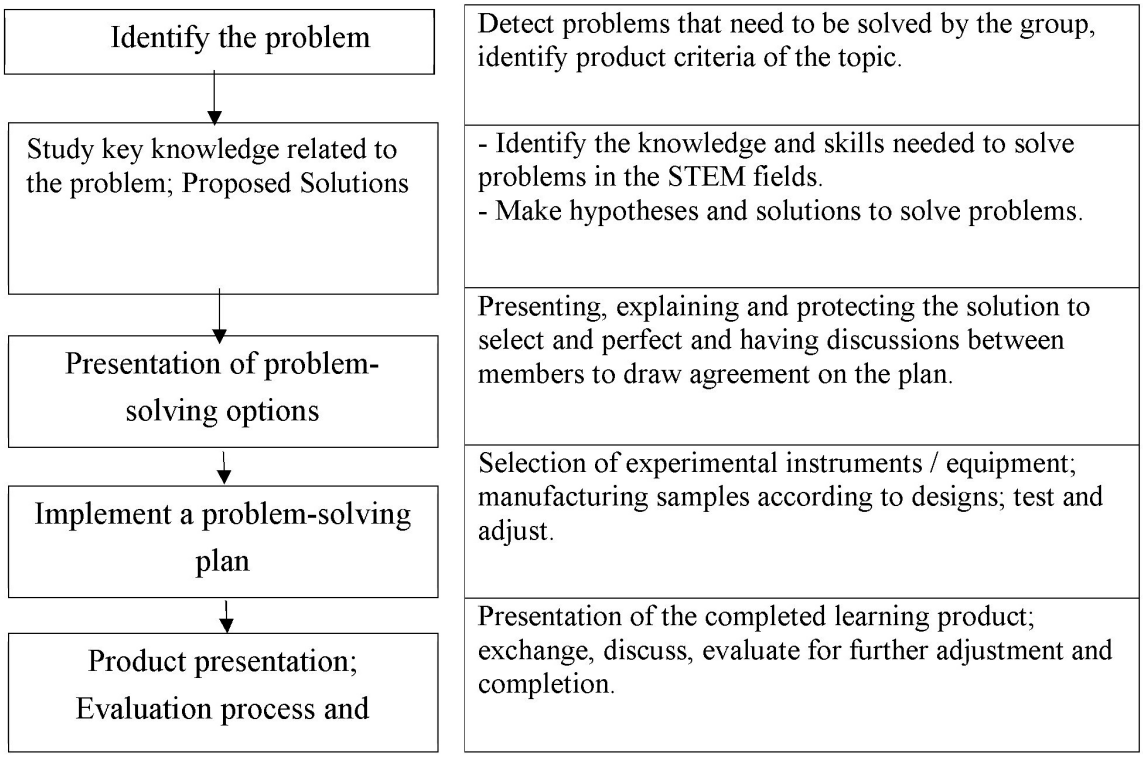

Figure 4. Process of collaborative problem-solving capacity building through STEM education topic

2.4. The relationship between STEM education and developing collaborative problem-solving capacity

The essence of organizing teaching STEM is the process of teachers directing students to solve practical problems. Students promote their knowledge, personal experience and group interaction to perform learning tasks. This relationship is expressed as follows:

Table 1.– Relationship between STEM lesson progress and collaborative problem-solving capacity development

STEM teaching organization process	**Develop collaborative problem-solving capacity**
Identify the problem	Discover and understand
Research key knowledge and propose design solutions	
Present and discuss design plans	Describe and speak
Fabrication of models / equipment, testing and evaluate	Planning and implementation
Presentation and discussion of manufactured products Product adjustment	Monitoring and reflection

2.5. Criteria for collaborative problem solving

Based on the matrix of OECD-published collaborative problem solving criteria, we developed a set of criteria to evaluate collaborative problem-solving competencies for use in STEM teaching as follows:

Table 2. – Criteria for evaluating problem solving cooperation

Skills process	**Establishing and maintaining shared understanding**	**Taking appropriate action to solve the problem**	**Establishing and maintaining team organization**
1	***2***	***3***	***4***
A. Exploring and Understanding	(A1) Discovering perspectives and abilities of team members.	(A2) Discovering the types of collaborative interaction needed to solve the problem, along with the goals.	(A3) Understanding roles to solve the problem.
	Level 3. Take the initiative in gathering members information and planning the capabilities of each team member.	Level 3. Flexible selection of a type of team collaboration that suits your needs and sets goals.	Level 3. Ensuring the role of members in problem solving.
	Level 2. Learn about team members and summarize the information collected used for group activities.	Level 2. Proposing satisfactory types of group cooperation.	Level 2. Identify the roles of yourself and other team members in problem solving.
	Level 1. Not actively exploring information of group members.	Level 1. Not proactive in proposing types of group cooperation.	Level 1. Identify your own role in problem solving.
B. Representing and Formulating	(B1) Building a shared representation and negotiating the meaning of the problem.	(B2) Identifying and describing tasks to be completed.	(B3) Communication protocols/rules of engagement.
	Level 3. Develop good sharing and actively negotiate the meaning of the issue.	Level 3. Clearly describe the tasks of the members and flexibly adjust the assignment of tasks for each member in accordance with the problem-solving situation.	Level 3. Proactively connecting members, bringing out roles of individuals and groups in order to well implement the principles of group activities.
	Level 2. Develop a shareable article and negotiate the meaning of a problem.	Level 2. Equal distribution of workload among members.	Level 2. Individual engaged in activities as assigned by a cooperative group.
	Level 1. Not proficient in developing a sharing article and not actively negotiating the meaning meaning.	Level 1. Define your duties when divided.	Level 1. Compliance with individual activities but not paying attention to the cooperation with other team members.
C. Planning and Executing	(C1) Communicating with team members about the actions to be/being performed.	(C2) Enacting plans.	(C3) Following rules of engagement, (e.g., prompting other team members to perform their tasks)
	Level 3. Flexibly adjust and agree on problem-solving plans suitable to practical conditions and circumstances.	Level 3. Always cooperating, flexible in solving complex problems.	Level 3. Always maintain and ensure teamwork principles when conditions change. Remind other members to follow the rules.

1	*2*	*3*	*4*
C. Planning and Executing	Level 2. Proactively propose solutions and participate in developing group action plans.	Level 2. Participate in activities and have connections with other members in the performance of tasks.	Level 2. Comply with the team operational principles in any situation.
	Level 1. Communicate only to give a few ideas to the group when asked.	Level 1. Participate in implementation independently, not paying attention to the connection among team members.	Level 1. Follow the rules when often reminded.
D. Monitoring and Reflecting	(D1) Monitoring and repairing the shared understanding.	(D2) Monitoring results of actions and evaluating success in solving the problem.	(D3) Monitoring, providing feedback, and adapting team organization and roles
	Level 3. Establish a new common understanding based on analysis of adjustments.	Level 3. Handling conflicts, arising conflicts, proposing to overcome difficulties and implementing effective solution to solve problems.	Level 3. Adjust yourself and the group members with activities, ensuring them adapts to the group work principle.
	Level 2. Confirming true and false information in correcting shared knowledge	Level 2. Monitor group activities and solve not too complex group problems.	Level 2. Self-regulating individual activities and coordination with team members.
	Level 1. Recognize the difference of individuals with shared knowledge.	Level 1. Implementation of a solution to simple personal problems.	Level 1. Individual self-adjustment according to group principle.

3. Develope problem-solving capacity through STEM education topic in teaching natural sciences through the topic of "Manufacturing water filtration systems"

Topic "Water filtration system"

Target audience: Grade 9 students

Time: 3 classes at school and 2 weeks at home

The current environment is increasingly polluted, especially water in remote areas that have no water system. This requires the easy handling of the water system and by using common inexpensive materials is extremely urgent.

Since then, the requirements are designed, manufactured groundwater treatment systems in rural areas contaminated with suspensions and alum.

(1) Goal of the topic

After completing this topic, students need to:

– Analyzing the reality of water pollution and the effects of water pollution on social life;

– Applying the knowledge in the subject and known knowledge, designing and manufacturing a water filtration system from easily-found materials such as coal, gravel, stone, and cotton;

– Describe the structure and operating principles of the water treatment system;

– Compare water that has been through water treatment system;

– Develop collaborative problem-solving capacity.

– Conscious of environmental protection.

(2) Equipment

Teachers will guide students to use some devices after learning the topic:

– Water bottles with tap;

– Some other materials such as gravel, stone, sand, cotton wool, activated carbon …

(3) Lesson progress

Activity 1: Identify the problem

– Target: Analyze the status of water pollution and the effects of water pollution on social life.
– Procedure:

Activities of teachers	Activities of students
Problem statement, task transfer: – Water pollution causes a big influence on the lives of people. The design of the water treatment system is of great significance. – Unify the task of "designing water filtration systems"; – Divide students into small groups, each group 4–6 students; – Teachers provide students with the following contents: Instruction sheet of project implementation; Project product evaluation form.	– Discuss the project topic; – Agree to select the project title; – Discuss, plan group activities; – Students can comment on the evaluation criteria provided by teachers.

Table 3. – Requirements for water filtration systems

Criteria	Request
Height	Not more than 50 cm
Weight	Not more than 12 kg
Material	Common materials (plastic bottles, sand, stone, gravel, activated carbon …)
Price	Not exceeding 50,000 VND
Wattage	Process at least 100 ml of water in 5 minutes
Expiry date	At least 1 year

Activity 2: Researching key knowledge and developing design drawings

– Target: Identify measures to treat polluted water sources and develop a water filtration system design.
– Procedure:

Activities of teachers	Activities of students
– Teachers observe and support students in the process of doing tasks	– Research documents, search for information from internet sources; – Proposing ideas and unifying design plans; – Develop and finalize the design of the water filtration system; – Select the form and prepare the content of the report.

Activity 3: Presentation and discussion of design options

Target: Completing the design of water filtration system.
Procedure:

Activities of teachers	Activities of students
1	***2***
– Organize for students in each group to present a plan for designing the water treatment system; discussion activities for each design. The question that explores the problem is "what substances does the polluted water usually contain? Which ion? "	– Each student group presents a design plan for 2 minutes. The remaining student groups pay attention. – Discussion: groups of students and teachers raised clarifying questions, criticized and

1	*2*
– Teachers comment, review and standardize the relevant knowledge, finalize issues that need attention, edit the design of the groups.	commented on the design; The group presents answers, arguments, defends points of view, or accepts appropriate comments to complete the design of their group.

Activity 4: Fabrication and testing of water filtration systems

– Target: Completing the design of water filtration system.

– Procedure:

Activities of teachers	**Activities of students**
Teachers support groups in the process of finishing products.	– HS tìm kiếm, chuẩn bị các vật liệu dự kiến; lắp đặt các thành phần của hệ thống xử lí nước theo bản thiết kế; – Thử nghiệm hoạt động của so sánh với các tiêu chí đánh giá sản phẩm (Phiếu đánh giá số 1). HS điều chỉnh lại thiết kế, ghi lại nội dung điều chỉnh và giải thích lý do (nếu cần phải điều chỉnh); – Hoàn thiện bảng ghi danh mục các vật liệu và tính giá thành chế tạo sản phẩm; – Hoàn thiện sản phẩm; chuẩn bị bài giới thiệu sản phẩm. – Students search and prepare expected materials; installing water treatment system components according to the blueprint; – Testing operation of comparison with product evaluation criteria (Evaluation sheet No. 1). Students readjust the design, record the adjusted content and explain the reasons (if need to adjust); – Complete the list of materials and calculate the cost of manufacturing products; – Finishing products; Prepare product introduction.

Table 4.– Requirements for report and product design

Criteria	**Maximum score**
Design drawings of the processing system are clearly drawn and in principle;	4
The design of the treatment system is clear, beautiful, creative, feasible, with material annotations;	2
Explain the operating principle of water treatment system;	2
Clearly presented, logical, vivid.	2

Activity 5: Presenting and discussing products "water filtration systems"

– *Target: Completing the design of water filtration system.*

– *Procedure:*

Activities of teachers	**Activities of students**
1	***2***
– Organize for students to prepare and display products at the same time.	– Students of each group present and analyze activities, costs and designs of water treatment systems.

1	*2*
– Teachers comment and announce the results of product marking at the request of Evaluation Form No. 1.The assessment process is self-assessed by students, students evaluate each other and teachers evaluate students. – Teachers ask questions for the report to clarify the mechanism of the water treatment system, inculcate new knowledge of the topic and related knowledge.	– Student groups simultaneously pour water, treat water, collect water and compare between pre-filtered and filtered water after being filtered through the system.

Teachers use questions to consolidate and expand knowledge for students

Question 1. Why should objects in the correct order (from top to bottom) be gravel, sand, coal, cotton, filter paper? Is it possible to change (for example in order of coal, gravel, sand, cotton, filter paper)?

Question 2. Do the same but change the size of the bottle. Tell me what happened? Explain. From which to draw comments?

Question 3. Why is activated carbon applied in water purification equipment?

Question 4. Is each coal whole?

Question 5. Why should we soak the filter paper?

Question 6. What should be paid attention to when pouring dirty water samples into the device?

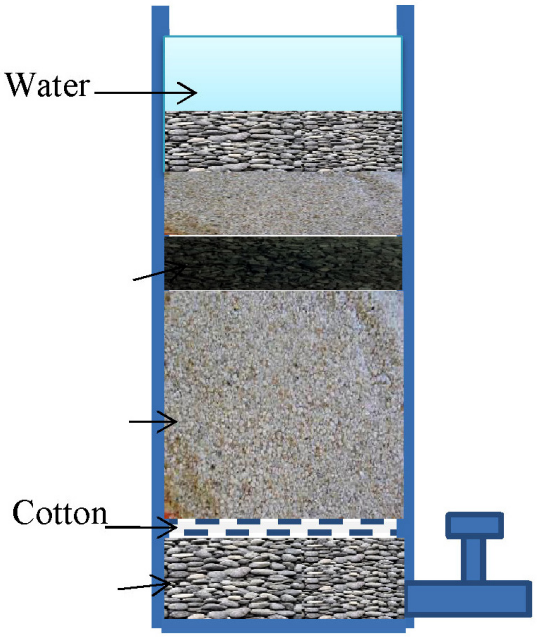

Figure 5.

Conclusion

Through the topic of STEM, students participate in all learning activities in a positive way, stemming from their own experiences, through cooperating with with teachers and with other students's knowledge, skills and additional experience, effectively solve learning problems. Therefore, organizing the topic of STEM is a way to develop cooperative capacity to solve problems for students.

References:

1. Aronson E. and Patnoe S. The jigsaw classroom: Building cooperation in the classroom (2nd ed.), Longman, – New York. 1997.
2. Care E., Scoular C. & Griffin P. Assessment of collaborative problem solving in education environments. Applied Measurement in Education, 29(4), 2016.– P. 250–264.
3. Dillenbourg P. Collaborative learning: Cognitive and computational approaches, Advances in Learning and Instruction Series, Elsevier Science, Inc, – New York, NY. 1999.
4. Fiore S. M. et al. "Toward an understanding of macrocognition in teams: Predicting process in complex collaborative contexts". The Journal of the Human Factors and Ergonomics Society,– Vol. 53. 2010.– P. 203–224.
5. Fiore S. M. and Schooler J. W. "Process mapping and shared cognition: Teamwork and the development of shared problem models", in Salas E. and Fiore S. M. (eds.), Team cognition: Understanding the factors that drive process and performance, American Psychological Association, Washington, DC, 2004.– P. 133–152.
6. Griffin P. & Care E. Assessment and Teaching of 21st Century Skills. Methods and Approach (Eds) Springer. Dordrecht. 2015.
7. Harwood J. & Rudnitsky A. Learning about scientific inquiry through engineering. Proceedings of the 2005. ASEE Annual Conference, – Portland, OR. 2005.
8. Hesse H., Care E., Buder J., Sassenberg K., Griffin P. Framework for teachable collaborative problem solving skills. 2015.
9. Kristy M. Meirick. How STEM Education Improves Student Learning. Meridian K-12 school Computer Technologies Journal,– Vol. 14.– Issue 1. 2011.
10. Labov J. B., Reid A. H. & Yamamoto K. R. Integrated biology and undergraduate science education: a new biology education for the twentyfirst century? CBE Life Science Education, 9, 2010.– P. 10–16.
11. Lou S. J., Liu Y. H., Shih R. C. & Tseng K. H. The senior high school students' learning behavioral model of STEM in PBL. International Journal of Technology and Design Education, 21(2), 2011.– P. 161–183.
12. Organisation for Economic Co-operation and Development. Draft collaborative problem solving framework. Unpublished manuscript, OECD. 2013.
13. PISA 2015. Draft Collaborative Problem Solving framework, OECD Programme for International Student Assessment, 2015.
14. Rockland R., Bloom D. S., Carpinelli J., Burr-Alexander L., Hirsch L. S. & Kimmel H. Advancing the "E" in K-12 STEM Education. Journal of Technology Studies, 36(1), 2010.– P. 53–64. Retrieved from EBSCOhost.
15. Rodger W. Bybee. What Is STEM Education? Science 27 Aug 2010.– Vol. 329.– Issue 5995. 2010.– P. 996–1004.
16. Theiner G. and O'Connor T. "The emergence of group cognition", in Corradini A. and O'Connor T. (eds.). Emergence in science and philosophy, Routledge, – New York. 2010.
17. Schwartz D. L. "The emergence of abstract dyad representations in dyad problem solving". The Journal of the Learning Sciences,– Vol. 4. 1995.– P. 321–354.
18. Stasser G. and Titus W. "Hidden profiles: A brief history". Psychological Inquiry,– Vol. 14/3 and – Vol. 14/4. 2003.– P. 304–313.