International Journal of Contemporary Educational Research (IJCER)

www.ijcer.net

Students' Attitude toward STEM Project-Based Learning in the Fun Cooking Activity to Learn about the Colloid System

Muhamad Imaduddin[1],
Dwi Novita Warih Praptaningrum[2], **Dyah Ayu Safitri**[1]
[1]Institut Agama Islam Negeri Kudus, Indonesia
[2]SMA Negeri 1 Kudus, Indonesia

To cite this article:

Imaduddin, M., Praptaningrum, D. N. W., & Safitri, D. A. (2020). Students' attitude toward STEM Project-Based Learning in the fun cooking activity to learn about the colloid system. *International Journal of Contemporary Educational Research, 8*(1), 14-26. DOI: https://doi.org/10.33200/ijcer.820898

International Journal of Contemporary Educational Research
Volume 8, Number 1, March 2021, 14-26 ISSN: 2148-3868

Students' Attitude toward STEM Project-Based Learning in the Fun Cooking Activity to Learn about the Colloid System

Muhamad Imaduddin[1*], Dwi Novita Warih Praptaningrum[2], Dyah Ayu Safitri[1]
[1,3]Institut Agama Islam Negeri Kudus, Indonesia
[2]SMA Negeri 1 Kudus, Indonesia

Abstract

This research revealed how the implementation of STEM Project-Based Learning (STEM PBL) in chemistry teaching on colloid system topics with heterogeneous groups of students in terms of habits, hobbies, goals, and gender-biased perceptions. Also, the research described students' attitudes towards STEM PBL, and the linkages between their attitude and understanding. Participants consisted of 101 students of high schools. Qualitative data were obtained through documentation, and narrative responses in group reports. Quantitative data were obtained through the questionnaire of students' attitudes toward STEM PBL and the comprehension tests. There are nine types of food products as STEM projects. The most frequent positive experience is that learning colloid topics is "fun", while the most frequent negative experience response is "time-consuming". The average score per item of attitude is higher in (1) the female's group, (2) the group who is used to cooking, (3) the group who has a passion, (4) the group who has a goal, and (5) groups that have gender-biased perceptions. There is no significant difference in attitude scores in the student group, except that the group with goals in the culinary field has a higher average attitude score than the group who have no aspirations. Students' understanding is not closely related to the attitude.

Keywords: Students' attitude, STEM Project-Based Learning, The fun cooking activity; Colloid system

Introduction

The development of science and technology in the last few years has increased the need for cooperative, collaborative, creative, and innovative individuals who can work in groups. The right way to do this is through education (Batdi, Talan, & Semerci, 2019). In these conditions, STEM (Science, Technology, Engineering, and Mathematics) as an interdisciplinary approach, which becomes a priority, is increasingly urgent to develop lifelong learning skills (B. Yildirim & Altun, 2015). The perceived potential of STEM is to fulfill students' learning experiences by assisting them in the ability to transfer classroom learning to the real world. Students can solve new problems and draw conclusions based on previously learned principles applied through science, technology, and engineering, and mathematics (Roberts, 2012). STEM leads to the practice of theoretical knowledge into a variety of products and findings that enhance students' innovative and productive skills (Morrison, 2006). The various problems faced by the global community are increasingly developing, requiring a multidisciplinary point of view, and the integration of STEM concepts to solve them. The STEM discipline and its role have a significant influence on solutions to problems of everyday life (Gülen, 2019). Meaningful learning with the STEM approach can be achieved by building a link between what is learned and real-life (Yalçin, Kiliç, & Atatay, 2016).

STEM is an educational approach that equips students with the ability to work together, systematic thinking, effective communication, thoroughness and curiosity, creativity, and problem-solving skills (Bybee, 2010; Dugger, 2010; Seage & Türegün, 2020). Although educators recognize the importance of STEM education, neither educators nor researchers consistently agree on and understand how to implement STEM at the secondary school level (Wang, Moore, Roehrig, & Park, 2011). Currently, STEM teaching is taught separately in each subject. Therefore, teaching STEM with an integrative point of view from various disciplines still needs to be developed and implemented by educators and researchers. Educators should be able to design appropriate project-based learning (PBL) strategies to increase students' interest in learning, and further facilitate the

* Corresponding Author: *Muhamad Imaduddin, imad@iainkudus.ac.id*

development and improvement of students' skills for their future (Tseng et al., 2013). The implementation of STEM PBL in various subjects in the school curriculum is a challenge to be developed.

There are different definitions and approaches to STEM in the literature. However, the similarity of these definitions and approaches is that STEM is an interdisciplinary approach and is implemented in a real-life context (Srikoom, Faikhamta, & Hanuscin, 2018). Not all students in the future will focus on activities formulating face creams, solving hydrocarbon problems, riding rockets, or specific things in the scientific field, but they certainly have and will be involved in their daily life with cooking activities, whether done personally or found in their daily lives (Grosser, 1984). Science and cooking have been developed into an interdisciplinary endeavor aimed at using food and cooking to teach chemistry, physics, and biology. Food and cooking can be a medium for collaboration across diverse groups, from collaborations between scientists and chefs to collaborations with the general public, students, instructors, and specialists in other academic fields, be it in science or non-science (Sörensen & Mouritsen, 2019). Cooking activities as a project in the teaching process are interesting to be developed because of the high opportunity to be applied in student's daily life. Cooking can demonstrate a concept inseparable from early STEM education. Cooking can be a deliberate and complex way to increase children's natural curiosity. Cooking is an activity that is accessible, relatable, memorable, and, most importantly, sustainable at home and daily. This makes cooking an excellent means of introducing and depicting scientific principles more closely (Colella, 2020).

Chemistry in the cooking process shows how chemistry is so close to the individual to the students. This activity also shows students that they practice chemistry every time they prepare food each day. Cooking activities are also simple experimental activities that can be carried out with minimal supervision. In the process of cooking with recipe guides, learners practice organizing scientific directions (Grosser, 1984). The environment (in this case the kitchen) is the largest laboratory and learning system imagined (Eshiet, 1996). The laboratory is a scientific work-place such as teaching, learning, practicing practical skills, finding new ideas, designing, and testing prototypes in engineering. Hayward (1992) revealed that the kitchen is a place filled with quality ingredients and is perhaps the safest chemical laboratory in the world. Jacobsen (2011) showed that the use of non-laboratory spaces in schools, such as rooms that are homey, can make chemistry accessible to all and more connected to every student's daily life. Other findings suggest that educators should help students synthesize multiple disciplines because interdisciplinary thinking does not emerge on its own. Cooking activities create a challenging integrative context for teaching chemistry, and offer new possibilities for teaching chemistry in a new learning environment, which goes beyond the chemistry laboratory (Nuora & Välisaari, 2019). One of the topics of chemistry that are closely related to cooking and food activities is the colloid system. The food that is produced generally exists in a colloid state as emulsions, foams, gels, and dispersions. Therefore, the study of food colloids is an important fundamental field of research activity in the field of food science and technology (Dickinson, 2015). Food colloids provide structure, texture, and taste in the mouth for various food products; for instance, mayonnaise, jelly, bread, jam, ice cream, etc. Food colloids contain hydrocolloid components providing thickening, gelling, emulsifying, and stabilizing characteristics in food products (J. Milani & Maleki, 2012).

This research is interesting because it turns cooking into a process in STEM Project-Based Learning. Cooking is an activity that is not carried out by all students in their daily lives, and is still associated with activities that are considered gender-biased in some cases (Mills, 2010; Neuman, Gottzén, & Fjellström, 2017; Pierce, 2010). Hands-on activities that are close to everyday life can be less challenging and do not provide valuable experiences for learners. This research is important to show whether the cooking project is appropriate to be implemented in heterogeneous classes. This is especially related to the cultural tendency to view cooking as an activity that is identical to women's daily work. This research revealed how the implementation of STEM PBL in chemistry teaching activities on colloid system topics with heterogeneous groups of students in terms of habits, hobbies, goals, and gender-biased perceptions in cooking activities. This research also described students' attitudes towards STEM PBL, and relates it to the understanding of the topic of the colloid system. Students' attitudes towards STEM PBL refers to how students think and feel about STEM and how they involve themselves in the learning process through PBL, which is a fun cooking activity. This condition is characterized by three main components, namely cognitive, affective, and behavior, which are organized towards STEM. Attitudes, in this case, reflect how students evaluate chemistry lessons about colloids and the learning environment for cooking activities, as well as how they react effectively to these learning (Han et al., 2014). Students' attitudes towards STEM are key factors that affect student motivation to study STEM subjects and overtake STEM careers (Maltese & Tai, 2011). STEM PBL is based on engineering designs that direct students' compartmentalized knowledge in science, technology, and mathematics to solve real problems in everyday life. The cooking activities presented in this research provide a simple description of learning that does not require complex technology, but is still oriented towards learning with a STEM approach and is project-based.

Research Questions

1) How is the implementation of STEM PBL in chemistry teaching activities on colloid system topics with heterogeneous groups of students in terms of habits, hobbies, goals, and gender-biased perceptions in cooking activities?
2) How are students' attitudes towards STEM PBL, and the relationship between attitudes and understanding the topic of the colloid system?

Method

Research Design

This research is action research implementing STEM Project-based learning in the classroom. This research was conducted on learning chemistry subjects about the topic of Colloid in 11th grade of high schools with the Indonesian national curriculum. The research was located in SMA Negeri 1 Kudus, Central Java Province, Indonesia. The project-based activity is a starting point for exploring the concept of chemistry. The project is the manufacture of processed food products related to the types and properties of the ingredients belonging to the colloid group. Cooking activities are set in groups of 4-5 people and students can explore the types of ingredients, techniques, and cooking products. At the end of the process, students' understanding of the colloid concept was tested through a test and a survey was conducted on their attitudes towards STEM-Project Based Learning.

Participants

Participants consisted of 101 students, namely 37 males and 64 females. Participants also have various perceptions related to cooking activities. The condition of the participants' perceptions in terms of whether cooking is their habit, hobby, or goal. It also reveals how their perceptions are related to the suitability of cooking activities for a certain gender. This condition is shown in Figure 1.

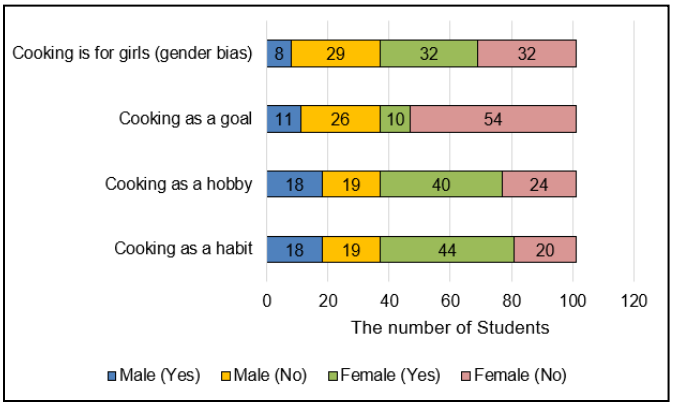


Figure 1. The condition of students' perceptions of cooking activities

Data Collection and Analysis

The research data is in the form of qualitative and quantitative data. Qualitative data showed the students' cooking products, identification of colloid concepts, and students' responses to the learning process. Quantitative data described attitudes towards STEM PBL and students' understanding of the chemistry topic. Qualitative data were obtained through (1) documentation of students' project products, and (2) narrative responses provided in group reports. The analysis of the documentation data used a narrative description of the activity, while the responses were analyzed using the word cloud analysis.

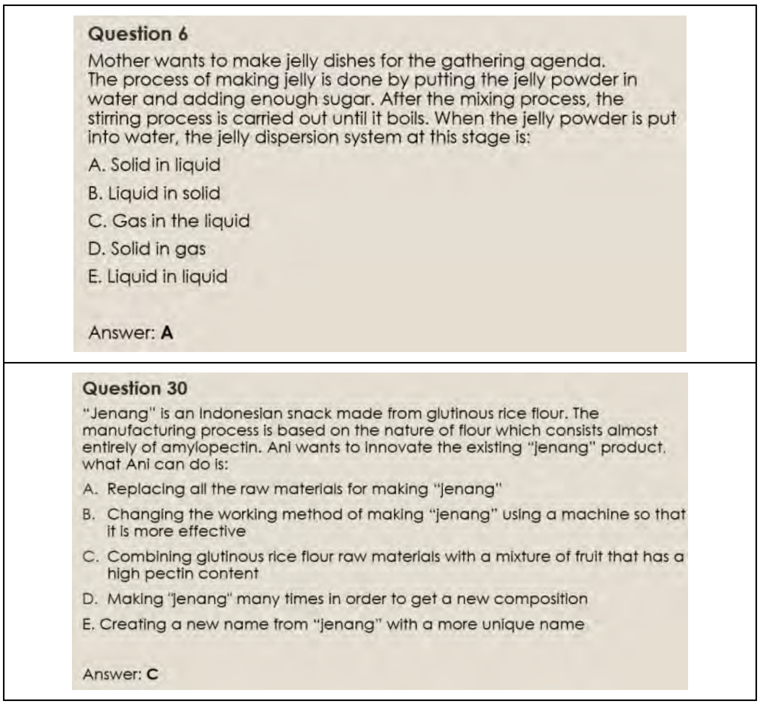
Quantitative data related to attitudes include (1) self-regulated learning; (2) collaborative learning environment; (3) interdisciplinary learning environment; (4) technology-based learning; and (5) hands-on activity. The Questionnaire of Students' Attitudes toward STEM PBL was adapted from Han & Carpenter (2014) by translating and modifying it according to the context of this study. The reliability of the test in the previous study showed Chronbach's alphas of 0.766 (Self-Regulated Learning), 0.861 (Collaborative Learning Environment), 0.780 (Interdisciplinary Learning Environment), 0.805 (Technology-based Learning), and 0.827 (Hands-on Activity). The overall internal consistency reliability coefficient was 0.871. In this study, the validity and reliability were tested through retesting the modified instruments. The validity of the items used Pearson correlation analysis, while the reliability of the instruments used the Cronbach's Alpha analysis as shown in Table 1. There is one item below 0.334 (r table N = 35) which is 0.314 indicating that one of the items on the ILE scale needs to be improved so that it can be used. In the reliability analysis, each scale has shown a reliable condition > r_{table} (0.334).

Table 1. Instrument Validity and Reliability

Scale	N (items) (r > 0,334)	Cronbach's Alpha
Self-regulated learning (SRL)	5	0.806
Collaborative learning environment (CLE)	5	0.740
Interdisciplinary learning environment (ILE)	4	0.674
Technology-based learning (TBL)	5	0.779
Hands-on activity (HA)	5	0.870

Attitude data analysis was carried out using descriptive statistics by showing the condition of students' attitudes based on gender groups, cooking habits, cooking hobbies, culinary goals, and gender-biased perceptions of cooking activities. Furthermore, the significance of differences in attitudes of each group was analyzed using the Mann-Whitney U test analysis.

Quantitative data in the form of students' understanding were obtained using the comprehension tests related to (1) explain the concept of the colloid system through various examples in everyday life, (2) classify the colloid system, (3) describing the properties of colloid, (4) identify hydrophilic and hydrophobic colloids, (5) describe the colloid production process, and (6) explain the application of colloid concepts in everyday life. The comprehension test consists of 30 multiple choice test items covering all of these indicators (maximum score= 30). The validity of the test is based on the validity of the content which is based on basic competence following the curriculum, and is linked to the STEM PBL context. An example of a comprehension test is shown in Figure 2. The reliability test results showed the Cronbach Alpha coefficient (r = 0.631)> r_{table} (0.244, N=60) so that the comprehension test is in a reliable condition. Testing the relationship between attitudes and understanding of the colloid concept was carried out using a non-parametric correlation test, namely the Spearman Rank test.


Question 6
Mother wants to make jelly dishes for the gathering agenda.
The process of making jelly is done by putting the jelly powder in water and adding enough sugar. After the mixing process, the stirring process is carried out until it boils. When the jelly powder is put into water, the jelly dispersion system at this stage is:
A. Solid in liquid
B. Liquid in solid
C. Gas in the liquid
D. Solid in gas
E. Liquid in liquid

Answer: **A**

Question 30
"Jenang" is an Indonesian snack made from glutinous rice flour. The manufacturing process is based on the nature of flour which consists almost entirely of amylopectin. Ani wants to innovate the existing "jenang" product, what Ani can do is:
A. Replacing all the raw materials for making "jenang"
B. Changing the working method of making "jenang" using a machine so that it is more effective
C. Combining glutinous rice flour raw materials with a mixture of fruit that has a high pectin content
D. Making "jenang" many times in order to get a new composition
E. Creating a new name from "jenang" with a more unique name

Answer: **C**

Figure 2. The comprehension test on colloid topics linked to the STEM PBL context

Results and Discussion

Students' product in STEM Project-Based Learning

There are nine types of products selected to be made in the STEM project from 23 groups as shown in Table 2. Also, a picture of the teacher and one of the groups is shown in a fun cooking activity. These products can identify the chemical aspects of colloids.

Table 2. Students' products and colloid identification according to the topic of chemistry subjects

No	Students' product	Identification of the colloid system	No	Students' product	Identification of the colloid system
1	 Macaroni schotel	(1) Emulsion: milk (2) Solid Emulsion: cheese and margarine	6	 Carbonara Spaghetti	(1) Emulsion: milk (2) Solid Emulsion: butter and cheese
2	 Donut	(1) Solid foam: bread (2) Emulsion: milk (3) Solid Emulsion: butter and margarine	7	 Pudding	(1) Emulsion: milk (2) Gel: jelly
3	 Burgers	(1) Solid foam: bread (2) Emulsion: mayonnaise (3) Solid Emulsion: cheese and margarine	8	 Dawet (*One of the Indonesian snacks*)	(1) Emulsion: coconut milk (2) Gel: dawet
4	 Toast	(1) Solid foam: bread (2) Emulsion: milk (3) Solid Emulsion: margarine (4) Gel: fruit jam	9	 Fruit salad	Emulsion: mayonnaise and milk
5	 Ice cream	Emulsion: coconut milk and sweetened condensed milk		 The teacher and one of the groups in a fun cooking activity	

Students' Responses to The Learning Process

Each group was asked to write down the results of their discussion regarding responses to STEM PBL learning through cooking activities. The results were then coded, recapitulated, and analyzed using the word cloud analysis. From the analysis, it can be shown how far each group has had positive or negative experiences in learning. The most positive experience that dominated the responses is that learning colloid topics is "FUN", while the most frequent negative experience response in the group is "TIME CONSUMING". The details of the analysis results are shown in Figure 3. Positive experiences dominate more than negative experiences of students.

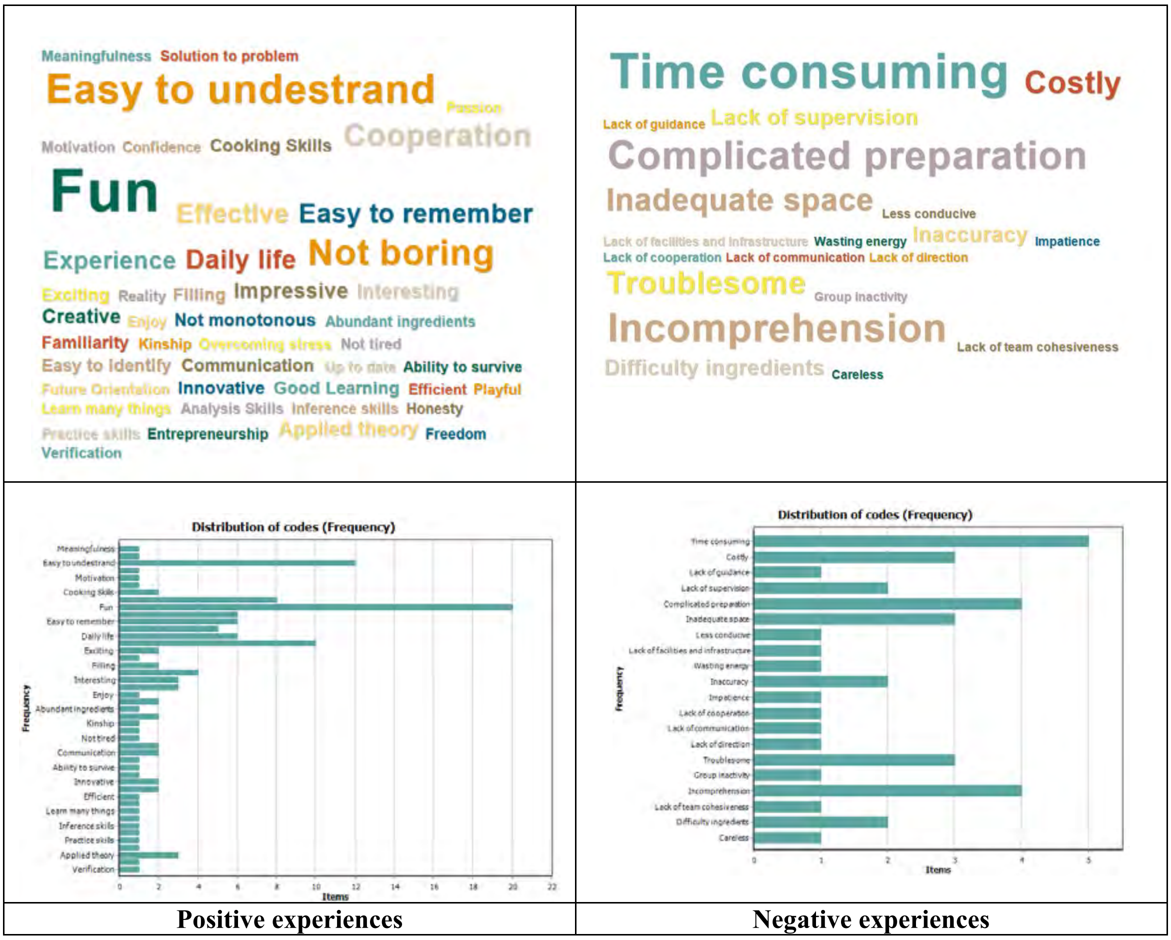
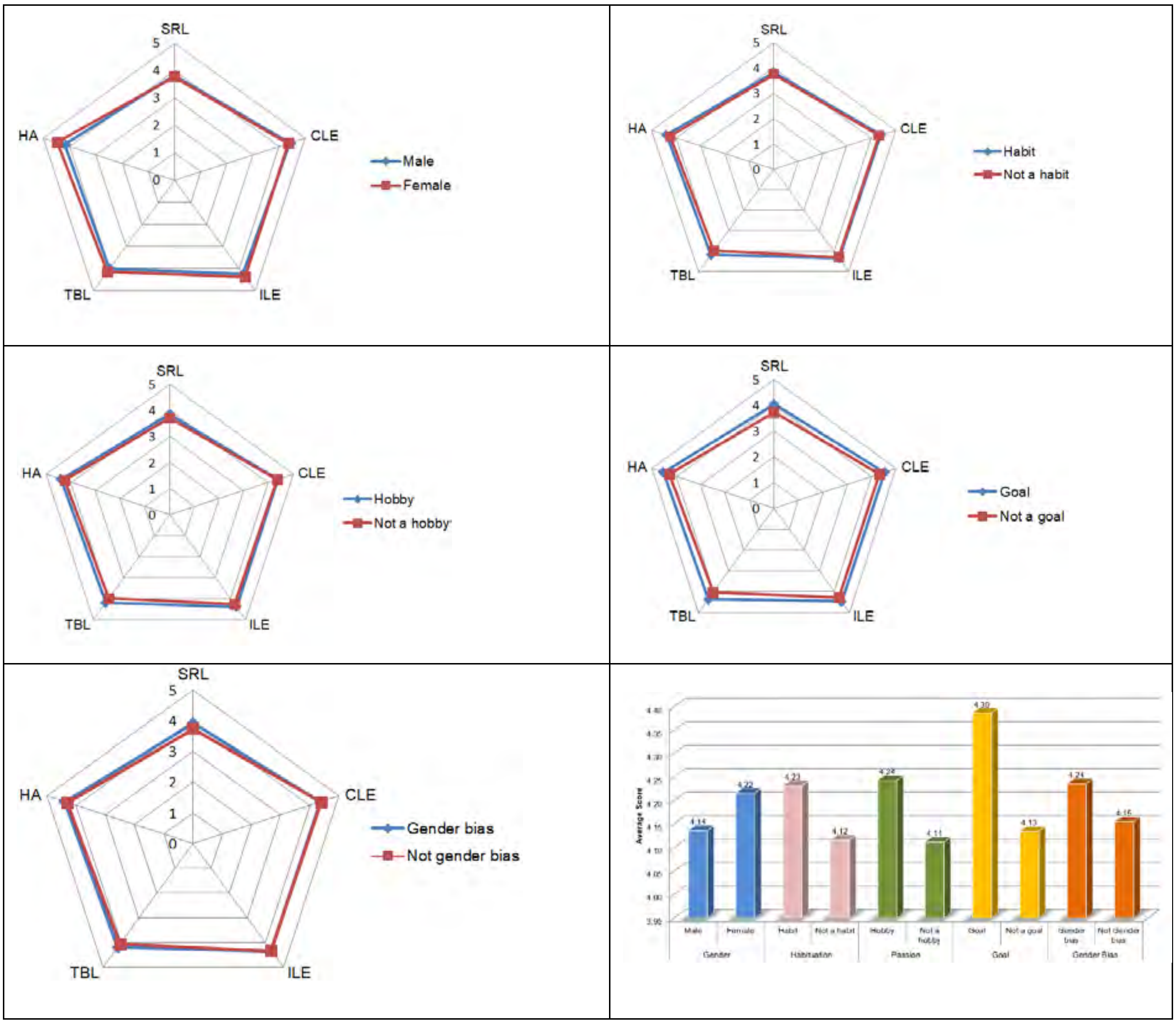


Figure 3. Word cloud analysis of the learning experience of group students based on their reports.

Students' Attitude toward STEM-Project Based Learning

Student groups are categorized based on gender, cooking habits, cooking hobbies, culinary goals, and gender-biased perceptions of cooking activities. These five factors are assumed to influence attitudes towards cooking activities in the STEM project on the topic of colloids. The results of the analysis of attitudes are shown descriptively as in Figure 4.



Note: SRL = Self-Regulated Learning; CLE = Collaborative learning environment; ILE = Interdisciplinary learning environment; TBL =Technology-based learning; HA = Hands-on activity

Figure 4. Descriptions of Student Group Attitudes Based on Categorization (1) Gender, (2) Cooking habits, (3) Hobby to cook, (4) Goals in the culinary field, and (5) Gender bias perceptions in cooking activities.

Figure 4. shows the average score per item is higher in (1) the female's group, (2) the group who is used to cooking, (3) the group who has a passion for cooking, (4) the group who has a goal in the culinary field, and (5) groups that have gender-biased perceptions. Based on these results, it is necessary to carry out further analysis to determine whether there are significant differences in attitudes in each of these groups of students. The results of the analysis using the Mann Whitney U Test are as shown in Table 3.

Overall, the students' average attitude per item was above 3.00 which indicates a good attitude towards STEM PBL. There is no significant difference in attitude scores in the student group, except for groups who have and do not have goals in the culinary field. The group with goals and aspirations in the culinary field had a higher average attitude score than the group who had no aspirations.

Table 3. Descriptive Analysis of Students' Attitudes towards STEM PBL and the Significance of the Differences in Each Group

Scale	Score Average per item (SD)										Score Average per item (SD) based on all items
	Gender		Habituation		Passion		Goal		Gender Bias		
	Male (N=37)	Female (N=64)	Habit (N=62)	Not a habit (N=39)	Hobby (N=58)	Not a hobby (N=43)	Goal (N=21)	Not a goal (N=80)	Gender Bias (N=40)	Not Gender Bias (N=61)	
SRL	3.83 (0.89)	3.78 (0.84)	3.83 (0.82)	3.75 (0.92)	3.86 (0.81)	3.72 (0.92)	4.04 (0.73)	3.74 (0.88)	3.91 (0.86)	3.73 (0.85)	3.80 (0.86)
CLE	4.41 (0.80)	4.35 (0.86)	4.40 (0.77)	4.32 (0.93)	4.38 (0.84)	4.35 (0.83)	4.53 (0.73)	4.33 (0.86)	4.35 (0.92)	4.38 (0.78)	4.37 (0.84)
ILE	4.24 (0.76)	4.38 (0.67)	4.35 (0.71)	4.30 (0.71)	4.38 (0.71)	4.26 (0.71)	4.48 (0.68)	4.29 (0.71)	4.33 (0.70)	4.32 (0.71)	4.33 (0.71)
TBL	4.01 (0.89)	4.15 (0.84)	4.18 (0.81)	3.97 (0.93)	4.19 (0.81)	3.98 (0.92)	4.35 (0.75)	4.03 (0.88)	4.19 (0.82)	4.04 (0.89)	4.10 (0.86)
HA	4.20 (0.82)	4.47 (0.71)	4.40 (0.73)	4.24 (0.84)	4.41 (0.73)	4.25 (0.84)	4.53 (0.61)	4.29 (0.81)	4.41 (0.77)	4.30 (0.78)	4.34 (0.78)
Student's attitude toward STEM PBL	4.14 (0.86)	4.22 (0.83)	4.23 (0.80)	4.12 (0.89)	4.24 (0.80)	4.11 (0.88)	4.39 (0.72)	4.13 (0.86)	4.24 (0.84)	4.15 (0.84)	4.19 (0.84)
	Asymp. Sig. (2-tailed)										
	0.288		0.126		0.136		0,016*		0.312		

The Relationship between Students' Attitudes and Understanding of Colloid Chemistry Topics

The average comprehension score (± SD) is 24.1 (± 2.5), with a minimum score achieved by students of 14 and a maximum score of 28. Based on the comprehension score on colloid topics, the relationship is analyzed with attitudes on students' attitudes towards STEM PBL as shown in Table 4.

Table 4. The relationship between students' understanding and attitudes toward STEM PBL

Scale	Correlation Coefficient	Sig. (2-tailed)	Level	Significance
Self-regulated learning (SRL)	0.043	0.669	Very weak	Not significant
Collaborative learning environment (CLE)	-0.04	0.692	Very weak	Not significant
Interdisciplinary learning environment (ILE)	-0.008	0.935	Very weak	Not significant
Technology-based learning (TBL)	0.064	0.524	Very weak	Not significant
Hands-on activity (HA)	-0.117	0.243	Very weak	Not significant
Attitude toward STEM PBL	-0.009	0.925	Very weak	Not significant

The results show that the condition of the relationship is very weak and it is not significant between students' understanding and attitudes towards STEM PBL. Students' understanding is not closely related to the attitude in the learning process. However, it is known that there is a positive relationship between students' understanding and attitude aspects, namely SRL and TBL.

Discussion

STEM PBL in The Fun Cooking Activity to Learn about the Colloid System

Cooking activities were chosen in the study of colloid topics because colloid systems are found in many components of food. Colloid systems are a type of heterogeneous mixture in which one part is consistently distributed to other parts. This system is formed when there is the dispersion of one part through another but does not mix to form a solution (J. M. Milani & Golkar, 2019). Foods that are mostly consumed by humans are usually in the colloid phase in the form of emulsions, foams, and dispersions (Dickinson, 2015; J. M. Milani & Golkar, 2019). The white foam in eggs is an example of a simple colloid system. This system has a dispersed phase which is air bubbles that are in the dispersing medium, namely egg whites, to produce foam.

Cooking is a complex depiction of art, especially the science behind the process, which depicts molecules that interact with each other and create a combination of taste and texture (Tkacik, 2010). Chemistry related to cooking activities, specifically the analysis of culinary recipes, is very appropriate to introduce chemistry to students who have neutral or negative attitudes towards science (Grosser, 1984). Previous studies revealed how students' knowledge of chemistry can create interesting dishes and fun activities. The students not only succeeded in applying the principles of chemistry in serving unique dishes, but they also demonstrated that the chemistry behind them perfected the dish (Tkacik, 2010). In learning about the topic of colloids, kitchen chemistry aims to change traditional learning, in which students are taught to memorize and recite information, into a classroom-based on experimental activities. Kitchen chemistry aims to create innovative science resources that make science teaching easier for teachers and more fun for students (Nja & Neji, 2013). The various activities and resources in the kitchen encourage collaborative learning and team building (Nja & Idoha, 2013; Nja & Neji, 2013). Teaching by utilizing kitchen resources makes students more active in learning situations and teaching chemistry topics. Students take ingredients for cooking from home and bring them to the classroom. The existing activities, although spending more time than conventional learning, provide a pleasant experience for students, and make it easier for them to understand memorization material on the topic of colloid chemistry. In the cooking process, students' mathematical abilities are also tested in determining the ratio of ingredients in processing, quantitative measurement of food ingredients, and unit conversions for measuring mass and volume of ingredients. The active participation of students and the use of familiar materials can increase understanding, as well as opportunities for entrepreneurial potential (Nja & Neji, 2013). As with the results of this research, previous research has also shown that through cooking activities, students were motivated and enthusiastic, and provided positive feedback (Nuora & Välisaari, 2019). Students consider the implementation of STEM PBL in groups as a positive thing. Students also revealed that the implementation of STEM PBL sometimes creates confusion so that it requires good planning and careful preparation, even though according to some students in this research that is so troublesome. Students adopt the view that the implementation of STEM PBL can be used for various other materials because the application of STEM PBL is very useful and fun to be able to learn by doing and experiencing (Akdağ & Güneş, 2016).

Cooking activities, of course, do not only involve students' knowledge of colloid topics. Other knowledge related to technological, engineering, and mathematical aspects also played a role in the completion of this project. Several studies indicate that the low STEM score is due to the lack of students' ability to put STEM concepts in context and apply their knowledge in everyday life (Hahn, 2017). The kitchen is a virtual laboratory for exploring all kinds of STEM topics, such as measurement, patterns, properties of matter, cause and effect, and many other topics (Bright Horizons Education Team, 2020). STEM integration is teaching with an interdisciplinary approach that removes the boundaries between science, technology, engineering, and mathematics (Wang et al., 2011). The framework in presenting colloid topic learning through cooking activities that shows the relationship to each STEM aspect is shown in Figure 5. Cooking & preparing food are part of everyday life which means life learning takes place in a natural context, and for some students, it becomes more enjoyable because it gets delicious results and makes them full. Cooking, furthermore, is a necessity to survive to serve diversified food for daily needs. This research is interesting with the choice of various types of dishes that are freely made by students.

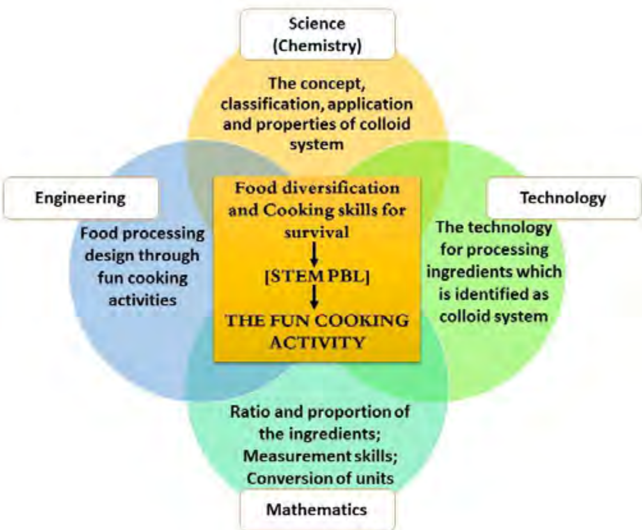


Figure 5. The Framework of The Fun Cooking Activity as STEM-Project Based Learning

Project-Based Learning (PBL) is a student-driven process, while the teacher acts as a facilitator. PBL focuses on problem-solving. In this case, it is a project to process food ingredients including the colloid system phase for survival and daily life. This is different from traditional approaches which tend to be teacher-centered and controlled. In PBL students are no longer motivated externally, PBL gives students autonomy in doing work individually or in groups (Habók & Nagy, 2016). The implementation of PBL through a series of stages as developed by various previous researches (Hidayah & Belajar, 2017; Widarti, Rokhim, & Syafruddin, 2020). The research implemented a STEM approach using project-based learning model stages. PBL is grouped into three main stages, namely (1) Skill competency debriefing, including the formulation of expected learning outcome, understanding the concept of teaching material, skill training; (2) Project work, including designing the project theme, marking the project proposal, executing the tasks of projects; (3) Evaluation, including presentation of the project report (Jalinus, Nabawi, & Mardin, 2017). In this research, the steps were modified from the simple stages that have been developed by Meli (2020) consisting of the main stages, namely (1) Launching STEM PBL; (2) STEM PBL Monitoring; and (3) Evaluating STEM PBL. The details of the activities per stage can be described in detail as shown in Figure 6.

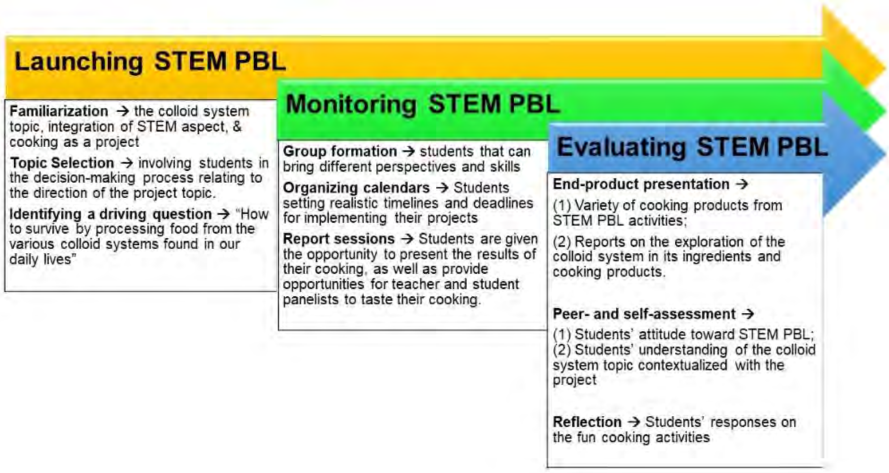


Figure 6. The Stages of The Fun Cooking Activity as STEM Project-Based Learning

Students' Attitudes toward STEM PBL and The Relationship between Students' Attitudes and Understanding of Colloid Chemistry Topics

Even though cooking is a great activity to teach chemistry with the STEM PBL approach, teachers also need to pay attention that this cooking activity is related to habits, hobbies, student future orientation, and culturally there is still a chance for gender bias in this activity. Daily cooking activities are still associated with the role of women at home (Fürst, 1997; Mills, 2010; Neuman et al., 2017; Pierce, 2010). This research showed a more positive attitude in groups of female students, groups of students who are used to cooking, groups of students who have aspirations in the culinary field, and groups of students who still think cooking is more appropriate for women. Even so, a significant difference in group attitudes was shown in groups with future orientation in the culinary field. Thus, it is shown that the attitude toward STEM PBL is closely related to internal factors of students.

Internal conditions related to future goals in the culinary field showed how SRL is in goal setting, planning, and self-monitoring (Puspitasari, Purwanto, & Noviyani, 2013; Santrock, 2011; Schunk, Pintrich, & Mecce, 2008) to achieve what is expected. STEM PBL is certainly a good opportunity to monitor students themselves in the culinary field. This fun cooking activity allowed students to collaborate and contribute to groups. The findings of this research showed different results from previous research which showed that there is no significant relationship between attitudes towards group work and goal achievement orientation profiles, and men are significantly more likely to avoid work than women (Z. Yildirim, 2004). Goal orientation showed differences in attitudes, while gender did not show significant differences. This is like the previous studies related to gender (Karisan, Macalalag, & Johnson, 2019).

This cooking project not only requires students to understand the existing recipe procedures but gives them space to be creative with art (Tkacik, 2010). STEM which is also directed by the integration of art into STE(A)M shows the importance of an interdisciplinary approach (Burke & Danaher, 2018). This project also develops students' abilities to explore learning resources through technology. They can access information via videos found on the internet to improve their cooking skills. Videos have the opportunity to individually improve the skills of low-skilled students (Glass, 2005). Access to technology learning resources can provide (1) visualization of the cooking process; (2) certainty during the cooking process; (3) replicating the cooking process (4) managing flexible cooking work times; and (5) repeated access to the video if needed (Surgenor et al., 2017). STEM PBL through the fun cooking activities provides opportunities for students to do hands-on activities to understand the concept of colloid chemistry. This activity allows students to gain real experience from the conceptual knowledge they acquire in class (Sutaphan & Yuenyong, 2019). Students can understand how the various types of colloids are in food ingredients that are processed in the cooking process, and get an impression of the usefulness of colloid knowledge in their daily lives to develop a variety of recipes and food products.

This research showed that the condition of students' attitudes and understanding is at a good level after a fun cooking activity. However, this research has not been able to show a significant relationship between the attitudes towards STEM PBL shown by students and their understanding of the topic of the colloid system. This is also relevant to research findings relating to hands-on activities with general performance assessments that have not improved (Pfaff & Weinberg, 2009). However, it was shown that there was a positive relationship between SRL and TBL and student understanding. This provides a direction for improvement in the pedagogical design concerning the design of STEM Project-Based Learning modules in the future. In this condition, students showed their confidence in their potential to learn things related to the topic and the completion of the STEM PBL project. Students also showed ease in finding information related to the field of food processing, as well as the ease of using various technologies in the culinary field, such as rice cookers, toaster machines, mixers, and blenders. Students had a positive attitude towards the development of existing technology and its use in the culinary field.

Conclusion

This research showed the implementation of STEM PBL through fun cooking activities on colloid topics using three main stages, namely (1) Launching STEM PBL; (2) STEM PBL Monitoring; and (3) Evaluating STEM PBL. The implementation showed the various product variants produced by the students with material categories which include emulsion systems, solid emulsions, solid foams, and gels. The implementation of cooking activities was carried out in heterogeneous groups of students by observing it from the aspects of (1) habits; (2) hobbies; (3) goals; and (4) gender bias perceptions in cooking activities. It is known that the most positive response that came from STEM PBL activities is “fun”, while the most frequent negative response is “time-consuming”.

Based on the conditions of the heterogeneous group, research showed that a better attitude is shown by (1) the female's group, (2) the group who is used to cooking, (3) the group who has a passion, (4) the group who has a goal, and (5) groups that have gender-biased perceptions. Although, a significant difference only occurs in the group of students who have different future orientations in the culinary and non-culinary fields. Students with aspirations in the culinary field showed significantly better attitudes. Students’ understanding is also not closely related to attitudes towards the STEM PBL, but a positive relationship can be seen in students' understanding of colloid topics with aspects of students’ self-regulated learning and technology-based learning.

This condition implies that cooking is one of the fun activities that can be implemented to teach science, in this case, chemistry with the STEM approach. Cooking is an activity that involves multidisciplinary studies, although this research focuses more on the topic of chemistry about the colloid system. This cooking activity has not been explored in more depth with other scientific themes. Another limitation of this research is that the variety of activities is not limited to a special pattern, meaning that the use of technology, basic ingredients, and types of processed food products produced by student groups cannot be predicted in advance. This is because it is following the choice of student groups, so that the resulting variety is not as much, or is evenly distributed.

Recommendations

This research verified that cooking activity could be implemented as a STEM project in chemistry teaching. Further designs are needed to implement cooking activities on other chemical topics and across subjects, as well as to increase the level of techniques and technology required in food processing, for example through the implementation of conventional and modern biotechnology in the food sector.

Acknowledgments or Notes

We thank you for the participation of the students of SMA Negeri 1 Kudus, as well as the institutions that have provided support facilities during the research data collection process.

References

Akdağ, F. T., & Güneş, T. (2016). Assessment Of Stem Applicatons In Terms of Students' Opinions. *Participatory Educational Research*, *Special Issues 2016-III*, 161–169.

Batdi, V., Talan, T., & Semerci, Ç. (2019). Meta-Analytic and Analysis of STEM Education To cite this article : Meta-Analytic and Meta-Thematic Analysis of STEM Education. *International Journal of Education in Mathematics, Science and Technology (IJEMST)*, *7*(4), 382–399.

Bright Horizons Education Team. (2020). *How to Incorporate STEM in the Kitchen*. Bright Horizons Family Solutions. https://www.brighthorizons.com/family-resources/incorporate-stem-kitchen

Burke, R., & Danaher, P. (2018). Interdisciplinary Teaching and Learning within Molecular Gastronomy Education: Does it Benefit Students? *International Journal of Molecular Gastronomy*, *1*, 1–12.

Bybee, R. W. (2010). Advancing STEM Education: A 2020 Vision. *Technology and Engineering Teacher*, *70*, 30–35.

Colella, J. (2020). *Beyond the Kitchen: Cooking in the STEM Classroom*. The Cook's Cook LLC. https://thecookscook.com/columns/the-kids-cook/beyond-the-kitchen-cooking-in-the-stem-classroom/

Dickinson, E. (2015). Colloids in food: Ingredients, structure, and stability. *The Annual Review of Food Science and Technology*, *6*(November), 211–233. https://doi.org/10.1146/annurev-food-022814-015651

Dugger, W. E. (2010). Evolution of STEM in the United States. *6Th Biennial International Conference on Technology Education Research*, *March*, 1–8. http://www.iteea.org/Resources/PressRoom/AustraliaPaper.pdf

Eshiet, I. T. (1996). *Improvisation in Science Teaching-Philosophy and Practice*. Abak Belpot (Nig.) Co.

Fürst, E. L. orang. (1997). Cooking and femininity. *Women's Studies International Forum*, *20*(3), 441–449. https://doi.org/10.1016/S0277-5395(97)00027-7

Glass, S. (2005). Integrating Educational Technologies into the Culinary Classroom and Instructional Kitchen. *Online Submission*, 1–15. https://files.eric.ed.gov/fulltext/ED495295.pdf

Grosser, A. E. (1984). Cooking with chemistry. *Journal of Chemical Education*, *61*(4), 362–363. https://doi.org/10.1021/ed061p362

Gülen, S. (2019). The effect of STEM education roles on the solution of daily life problems. *Participatory Educational Research*, *6*(2), 37–50. https://doi.org/10.17275/per.19.11.6.2

Habók, A., & Nagy, J. (2016). In-service teachers' perceptions of project-based learning. *SpringerPlus*, *5*(1), 1–14. https://doi.org/10.1186/s40064-016-1725-4

Hahn, K. (2017). *Making science concepts real with cooking and school gardens*. Michigan State University. https://www.canr.msu.edu/news/making_science_concepts_real_with_cooking_and_school_gardens

Han, S., & Carpenter, D. (2014). Construct validation of student attitude toward science, technology, engineering, and mathematics project-based learning. *Middle Grades Research Journal*, *9*(3), 27–41.

Hayward, D. (1992). Do it your self Chemistry for Elementary Schools. , 37 (99) 1-3. *International Newsletter on Chemical Education. . IUPAC (UK)*, *37*(99), 1–3.

Hidayah, N., & Belajar, A. (2017). Pengembangan model project based learning terhadap motivasi dan aktivitas belajar siswa [Development of a project based learning model on students' motivation and learning activities]. *AdMathEdu*, *7*(2), 157–176.

Jacobsen, E. K. (2011). The kitchen is your laboratory: A research-based term-paper assignment in a science writing course. *Journal of Chemical Education*, *88*, 1018–1019. https://doi.org/10.1021/ed1011184

Jalinus, N., Nabawi, R. A., & Mardin, A. (2017). *The Seven Steps of Project Based Learning Model to Enhance Productive Competences of Vocational Students*. *January*. https://doi.org/10.2991/ictvt-17.2017.43

Karisan, D., Macalalag, A., & Johnson, J. (2019). The effect of methods course on pre-service teachers' awareness and intentions of teaching science, technology, engineering, and mathematics (STEM) subjects. *International Journal of Research in Education and Science*, *5*(1), 22–35.

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education*, *95*(5), 877–907. https://doi.org/10.1002/sce.20441

Meli, P. (2020). *Teaching and Learning in a Project-Based World*. https://blog.100mentors.com/teaching-and-learning-pbl-4/

Milani, J. M., & Golkar, A. (2019). Introductory Chapter: Some New Aspects of Colloidal Systems in Foods. In J. M. Milani (Ed.), *Some New Aspects of Colloidal Systems in Foods* (pp. 1–9). IntechOpen. https://doi.org/10.1016/j.colsurfa.2011.12.014

Milani, J., & Maleki, G. (2012). Hydrocolloids in Food Industry. In B. Valdez (Ed.), *Food Industrial Processes - Methods and Equipment* (Issue February, p. 38). InTech. https://doi.org/10.5772/32358

Mills, M. A. (2010). *Cooking with Love: Food, Gender, and Power* [Georgia State University]. https://scholarworks.gsu.edu/anthro_theses/38

Morrison, J. S. (2006). Attributes of STEM education: The student, the school, the classroom. *TIES (Teaching Institude for Excellence in STEM)*, *47*(7–8), 1–7. http://www.ncbi.nlm.nih.gov/pubmed/9793365

Neuman, N., Gottzén, L., & Fjellström, C. (2017). Narratives of progress: cooking and gender equality among Swedish men. *Journal of Gender Studies*, *26*(2), 151–163. https://doi.org/10.1080/09589236.2015.1090306

Nja, C. O., & Idoha, K. (2013). Kitchen Resources Classroom Interaction and Academic Performance and Retention of SS2 Chemistry Students in Thermochemistry. *Journal of Education and Practice*, *4*(8), 169–173.

Nja, C. O., & Neji, H. A. (2013). A chemistry class with kitchen resources and students' entrepreneurial ability. *British Journal of Education*, *1*(1), 1–6.

Nuora, P., & Välisaari, J. (2019). Kitchen chemistry course for chemistry education students: influences on chemistry teaching and teacher education – a multiple case study. *Chemistry Teacher International*, *0*(0), 1–10. https://doi.org/10.1515/cti-2018-0021

Pfaff, T. J., & Weinberg, A. (2009). Do hands-on activities increase student understanding?: A case study. *Journal of Statistics Education*, *17*(3). https://doi.org/10.1080/10691898.2009.11889536

Pierce, S. J. (2010). *Kitchen Cache : the Hidden Meaning of Gender and Cooking in Twentieth-Century American Kitchens*. *December*.

Puspitasari, A., Purwanto, E., & Noviyani, D. I. (2013). Self regulated learning ditinjau dari goal orientation. *Educational Psychology Journal*, *2*(1), 1–6.

Roberts, A. (2012). A Justification for STEM Education. *Technology and Engineering Teachere*, *May/June*(June), 1–5. http://botbrain.com/index.

Santrock, J. W. (2011). *Educational Psychology* (Fifth edit). McGraw-Hil.

Schunk, H. ., Pintrich, P. R., & Mecce, L. J. (2008). *Motivational in eduation: theory, research, and application*. Pearson Press.

Seage, S. J., & Türegün, M. (2020). The effects of blended learning on STEM achievement of elementary school students. *International Journal of Research in Education and Science*, *6*(1), 133–140. https://doi.org/10.46328/ijres.v6i1.728

Sörensen, P. M., & Mouritsen, O. G. (2019). Science education and public understanding of science via food, cooking, and flavour. *International Journal of Gastronomy and Food Science*, *15*(October 2018), 36–47. https://doi.org/10.1016/j.ijgfs.2018.11.006

Srikoom, W., Faikhamta, C., & Hanuscin, D. L. (2018). Dimensions of Effective STEM Integrated Teaching Practice. *K-12 STEM Education*, *4*(2), 313–330. https://pdfs.semanticscholar.org/f70e/61c9196d3af8ae6990753d12ecbc4c0ea758.pdf?_ga=2.194362734.2132636689.1570570157-155469691.1570570157

Surgenor, D., Hollywood, L., Furey, S., Lavelle, F., McGowan, L., Spence, M., Raats, M., McCloat, A., Mooney, E., Caraher, M., & Dean, M. (2017). The impact of video technology on learning: A cooking skills experiment. *Appetite*, *114*, 306–312. https://doi.org/10.1016/j.appet.2017.03.037

Sutaphan, S., & Yuenyong, C. (2019). STEM Education Teaching approach: Inquiry from the Context Based. *Journal of Physics: Conference Series*, *1340*(1). https://doi.org/10.1088/1742-6596/1340/1/012003

Tkacik, D. (2010). *Students can learn chemistry through cooking tasty food*. The Tartan. Carnegie Mellon's Student Newspaper. https://thetartan.org/2010/11/22/scitech/foodandchemistry

Wang, H., Moore, T. J., Roehrig, G. H., & Park, M. S. (2011). STEM Integration : Teacher Perceptions and Practice STEM Integration : Teacher Perceptions and Practice. *Journal of Pre-College Engineering Education Research (J-PEER)*, *1*(2), 1–13. https://doi.org/10.5703/1288284314636

Widarti, H. R., Rokhim, D. A., & Syafruddin, A. B. (2020). The development of electrolysis cell teaching material based on stem-pjbl approach assisted by learning video: A need analysis. *Jurnal Pendidikan IPA Indonesia*, *9*(3), 309–318. https://doi.org/10.15294/jpii.v9i3.25199

Yalçin, N., Kiliç, B., & Atatay, Ç. (2016). A Model Suggestion For STEM Activity Design Within The Scope Of The Curriculum. *Participatory Educational Research*, *Special Issue 2016-III*, 95–107.

Yildirim, B., & Altun, Y. (2015). Investigating the Effect of STEM Education and Engineering Applications on Science Laboratory Lectures. *El-Cezeri Journal of Science and Engineering*, *2*(2), 28–40. https://doi.org/10.13140/RG.2.1.2296.0800

Yildirim, Z. (2004). Relationship between Achievement Goal Orientation and Collaboration in Project-Based Learning Process. *American Educational Research Association Annual Meeting*, *1999*. http://search.ebscohost.com.proxy-ub.rug.nl/login.aspx?direct=true&db=eric&AN=ED493521&site=ehost-live&scope=site