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Developing the Entrepreneur Alcohol STEM Education Unit through Design Thinking Process

Surachet Sunsawat
Khon Kaen University Demonstration Secondary School (Modindaeng), Thailand
Faculty of Education, Khon Kaen University, Thailand
Email: surasan@kku.ac.th

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Abstract. The paper clarifies the process and content of STEM lesson plan development for Grade 10 students who are studying in Thailand school. The learning activities of entrepreneur alcohol STEM education unit was developed regarding the stages of design thinking that consist of 5 stages. These include Empathy, Define, Ideation, Prototyping and Testing. The unit will be organized 2 hours a week for 15 weeks. The activities of week 1 – 3 engage students how the company adopt the design thinking process for developing their products, systems, or services. The 4th week provides students with the scenario of the problem of creating products related to alcoholic beverages including khao mak, liquor, beer, sato, wine, and shochu. The 5th week challenged students to find empathy related to alcoholic beverages. The 6th week was provided to visualize students' understanding of demanding alcoholic beverages. The activities of week 7 – 8 were provided regarding the ideation to construct students' scientific concepts about alcohol. The activities of week 10 – 13 were provided to scaffold students to develop and test prototypes about alcohol. The activities of week 14 – 15 were provided to support students to complete the prototype and presentation regarding business model canvas. The unit clarifies the scenario of lesson plan how to enhance students to develop prototypes regarding students' understanding about problems and empathy. Students may apply STEM knowledge for designing prototypes about alcohol artifacts.
Keywords: STEM education, Alcohol, Entrepreneur, Design Thinking

1. Introduction

There is increasing agreement on the critical role that innovation plays in the face of global economic, health, and social uncertainty. Innovation is becoming a higher priority for both developed and emerging countries in order to guarantee long-term, sustainable productivity development. Given this focus on innovation, it is crucial to comprehend the conditions and variables affecting innovation processes. Furthermore, it's critical to understand the requirements for creating an innovation-driven business (IDE). This entails a thorough comprehension of the environment in which IDEs function, their contribution to economic expansion, the generation of jobs, and the enhancement of communities (Ali et al., 2021; OECD, 2013; Onside, 202; Santisteban & Mauricio, 2017).

In order to improve economic competitiveness and societal growth and raise the standard of living for its people, Thailand is also working to move the country closer to the "Thailand 4.0" paradigm, which calls for reform in the research and innovation ecosystem. In an attempt to achieve the Thailand 4.0 goal, STEM education has been promoted as a national policy in Thailand. STEM may be the most represented educational reform agenda since it is easy to link it to a variety of industries, such as information and communications technology, the medical field, and sustainability innovations. the advancement of career readiness and STEM literacy. Because individuals must interact with the natural and physical world using at least some STEM-related knowledge, skills, and attitudes, all students should obtain STEM education. Students who intend to pursue STEM careers should not be the only ones targeted by STEM education. Preparation for the STEM workforce includes 21st century skills, STEM concepts, STEM abilities, and attitudes toward STEM careers (ONESDC, 2019; Yuenyong, 2019)

STEM education is a broad concept that includes many different topics and approaches. According to educational literature, STEM can be redesigned as a multidisciplinary learning approach that uses problem-based learning strategies, engineering design-based studies, or project-based learning to integrate knowledge from the various STEM subjects into current STEM education programs (Bybee, 2010; Duc et.al., 2019; Guarin et.al., 2019; Tinh et.al., 2021; Yuenyong, 2019)

STEM education has emphasized on implication for careers need or problem solving as quality citizen which combine knowledge and skills through practice. Teaching and learning STEM will be triggered through real-world problem solving (ASE, 2010; Ebal et.al., 2019; Mordeno et.al., 2019; Villaruz et.al., 2019). STEM emphasizes the teaching and acquisition of academic information from science and/or mathematics, engineering techniques that are applicable to technology, and materials and processes, according to Moore et al. (2015). Procedures that can be used to organize student participation are at the heart of STEM education teaching and learning. Through the process of incorporating knowledge into practice assignments, students will acquire not only solidified knowledge but also the vital soft and fluid abilities they will require in the future; this involves teaching both procedural and content-based curricula (Koes-H et.al., 2021; Suparee and Yuenyong, 2021a; Theerasan and Yuenyong, 2019; Williams, 2011).

The idea is that approach, not content, should be the focus of STEM education. Although content can be applied through situational activities, Williams (2019) highlights the value of STEM education when learning takes place through process activities. Students can also learn from failure by focusing on process tasks, although this may take some time. This demonstrates the value of student centers in STEM education. Various STEM teaching and learning activities could arise from this. Activities that engage students in a STEM process and alternate between thinking and doing are necessary to enhance their learning in STEM education.

A full learning experience is provided by incorporating entrepreneurial education into STEM curricula, which improves students' practical and creative skills and better equips them for future demands in social and professional development. Furthermore, there is great potential for entrepreneurial STEM education to improve student learning and academic outcomes (Eltanahy et al., 2020; Mwasiaji et al., 2022). The majority of current research focuses on the skills that students learn when combining entrepreneurial education with STEM education. From a knowledge standpoint, incorporating entrepreneurial education within STEM instruction helps students organize their thoughts, incorporate information from other fields, and support the learning outcomes of entrepreneurial endeavors (Eltanahy et al., 2020); From the perspective of skills, incorporating entrepreneurial education within STEM education can increase the impact of STEM education, improve teamwork, communication, resilience, autonomy, and the ability to spot opportunities for business (Dahl & Grunwald, 2022; Eltanahy et al., 2020; Yazıcı et al., 2023).

To engage students in learning about STEM education, the learning activities need to enhance students to solve problems through issues of science, technology, and society (STS). The local and everyday life issues may foster student ability to think critically for solving problems in developing some innovations (Bauphitak et.al., 2024; Suparee and Yuenyong, 2021b; Sutaphan and Yuenyong, 2019; Wongsila and Yuenyong, 2019). Effective integration into the curriculum can enhance student engagement and understanding of complex scientific concepts. Designing a STEM lesson plan that incorporates alcohol production requires careful consideration of interdisciplinary approaches, real-world applications, and ethical implications (Nipyrakis et.al., 2024).

According to STEM education, real-world problems need to be addressed in the classroom. The manufacturing of alcohol is a fascinating subject that can be integrated into STEM (Science, Technology, Engineering, and Mathematics) education. Effective integration into the curriculum can enhance student engagement and understanding of complex scientific concepts. The STEM topics pertaining to the manufacture of alcohol probably engage students to practice integrated knowledge for some prototypes. This integrated knowledge, for example, could be highlighted as follows. Students can gain knowledge about microbial culture, fermentation enzymes, yeast metabolism, and biochemistry from a biological perspective. Anaerobic yeast metabolism, such as that of Saccharomyces cerevisiae, produces carbon dioxide and ethanol by breaking down carbohydrates like glucose. For instance, enzymes like zymase catalyze the fermentation process, which turns sugar into alcohol. Understanding the ideal yeast growth parameters, such as temperature, pH, and food requirements, is the goal of microbial culture. The fermentation chemical equation is connected to biochemistry (Ju et.al., 2023). Knowledge of chemistry would be applied to problem-solving. When students need to learn about the structure of ethanol and the reactions that go into making it, organic chemistry would be taken into consideration. Students must also comprehend the chemical and physical characteristics of alcohol, such as its molecular structure (C_2H_5OH), boiling point, flammability, and solubility. Because fractional distillation separates ethanol from a fermentation mixture according to boiling points, students may also study about distillation. Additionally, when students need to keep an eye on and regulate the pH during fermentation for the best microbial activity, they should take Acid-Base Chemistry and pH into consideration (Chiorri et.al., 2023).

Fermentation process and alcohol production may allow students to learn science, technology, engineers, mathematics, culture, and business. Applications of alcohol production are about bioethanol and alcoholic beverages. Bioethanol is produced through fermentation that can be used as a renewable energy source, reducing dependence on fossil fuels. Alcoholic beverages, in the food industry, are alcohol that is produced for beverages like beer and wine, which also involves fermentation. Students may learn about technology and engineering about designing microbial conditions and optimizing fermentation. Microbial conditions are related to temperature, pH, and Oxygen. Yeast performs best at optimal temperatures (around 25-30°C). Too high temperatures may kill the yeast, while too low temperatures may slow down the fermentation process. Yeast fermentation works best at a slightly acidic pH (around 4-5). Initial aerobic conditions are beneficial to yeast growth, but anaerobic conditions are required for ethanol production. Engineering in alcohol production probably involves fermenters, distillation, automation and sensors. Fermenters are designing and optimizing fermentation tanks (bioreactors) that involves understanding fluid dynamics, temperature control, and oxygen regulation. After fermentation, distillation is used to concentrate alcohol, separating ethanol from water based on their different boiling points. Modern alcohol production utilizes sensors to monitor fermentation rates, temperature, and alcohol content. Mathematical calculations (yield optimization) or engineering design principles for distillation could be also introduced to students (Chai et.al., 2022).

Traditional science teaching approaches in science classrooms often prioritize topic coverage and memorization learning. Therefore, rather than just giving students scientific facts to memorize, the aim of this project is to develop a lesson plan that incorporates design thinking to involve students in the learning process. It is expected that by implementing activities developed with the design thinking technique, students will be able to learn scientific topics through hands-on processes.

2. Design thinking as STEM pedagogy

Research on design and design thinking is not new, especially in engineering. Nonetheless, different professional areas continue to perceive design and design thinking in different ways. While design in engineering can occasionally be routine and taken for granted, design in business management, for instance, typically requires careful and thoughtful planning and thought in order to be innovative and inventive. Theory-based interventions that can produce outcomes that are pertinent and verifiable to a particular real-world scenario are required by design research in education. Historically, it has been challenging to operationalize design principles for curriculum and education due to the uncertainty surrounding the meanings of design and design thinking, particularly in the engineering industry. For instance, university engineering education has evolved from a "engineering science" approach to reflective practices shown by cornerstone courses and project-based learning (PBL) (Li et.al., 2019).

The majority of innovation processes are thought to make use of design thinking toolkits. It is also believed that design thinking is a creative, human-centered method of problem-solving that inspires change, evolution, and creativity in new lifestyles and company management strategies. Since design culture and its methods have permeated fields like corporate innovation, it is considered that design thinking in the educational setting is a complex process of conceiving new realities. The phrase "design thinking," which combines the words "thinking" and "design," describes the capacity to use design tools in circumstances where problems need to be solved. Combining the creative design approach with traditional thinking, which is predicated on planning and analytical problem solving, Design Thinking has developed into a valuable toolkit for any innovation process (Tschimmel, 2012).

Fundamental characteristic of design thinking relies on the designer’s capacity to consider human’s needs and new visions of living well (human-centerd approach), available material and technical resources, and the constrains and opportunities of a project (Carlgren et.al., 2016; Fachrunnisa et.al., 2021). Moreover, another important component of design thinking is that it allows researchers and end users to collaborate through framing problems and test solutions, using participatory processes.

The "double diamond" is a well-known and established expression of design thought. The double diamond is often defined as having five phases that are applied iteratively. Diverging and converging phases separate the five steps, with diverging phases broadening viewpoints and converging phases increasing focus. Five steps are commonly defined within these double diamonds. (1) Empathy: the point of view of the user is elicited. (2) Define: Knowledge about the user is distilled and formulated as specific needs, wants or requirements (problem definition). (3) Ideation: ideas for solutions are formulated based on the specific needs and requirements one is aiming to satisfy. (4) Prototyping: ideas are implemented in first stage products or services. (5) Testing: potential users and other relevant stakeholders test and provide feedback on the prototypes. These five steps are iterative, and the process may be partially or completely revisited several times (Kelley, 2001; Li et.al., 2019).

However, tackling problems in a given situation always involves limits. Thus, designers must convert their creative ideas into real prototypes in order to verify whether such ideas work and address the problem within the specified restrictions. This is possible through prototype testing. This method is frequently iterative until designers archive a solution to the identified challenge (Henriksen, 2017).

3. Methodology

This study aims to provide with an understanding of the process and idea behind the creation of a lesson plan on entrepreneur alcohol using a STEM approach and design thinking. To shed light on the assessment and creation of STEM education lesson plans for secondary school students, the qualitative approach has been proposed as a concept and technique. The Khon Kaen University Demonstration School professional learning community (KKUDS PLC) expert panel discussion produced the course plan.

3.1 Participants

Participants in this study included members of KKUDS PLC addressing in the part of planning the design thinking of STEM lesson plan. The members included a science teacher and five expert panel committees. The five STEM education experts included (1) a male and a female experts who has been working as science educator at Faculty of Education, Khon Kaen University for about 15 years, and (2) one male and two female experts who has been working as lecturers at Khon Kaen University Demonstration school for 15 years.

3.2 Method of inquiry

Only the portion of the planning process that we completed using KKUDS PLC will be explained in this paper. The first version of the Entrepreneur Alcohol STEM Education Lesson plan was created for students in grade 10. The topic's educational knowledge was discussed in relation to design thinking.

There were two rounds to the expert panel discussion on updating the STEM education lesson plan. The report of expert suggestions on expert panel discussion was used to gather the issues with the revision of STEM education lesson plans. After that, the suggestions were grouped in order to create hypotheses for future lesson plan revisions.

4. Findings

The findings were divided into two parts. The first section will provide assumptions of revising the Entrepreneur Alcohol STEM education lesson plan. Second, the section will provide the revised STEM lesson plan.

4.1 Assumptions of revising the Entrepreneur Alcohol STEM education lesson plan

Through a panel discussion with experts, the assumptions on the revision of the entrepreneur alcohol STEM education lesson plan were categorized. The following problems could be used to clarify the premise of lesson plan revision. The committee recommended the following changes to the lesson plan.

1. Considering how to offer some scaffolding questions to help students gain empathy or comprehension of the issues surrounding the growing production of alcohol.

2. The teacher should ask students to assess the prototype using scientific tools and scientific justification during the test portion. Because the exercises in the engineering design part may involve design sensors or mathematics, the teacher may ask for assistance from others.

3. When designing learning activities about alcohol beverages, there are several critical issues to be aware of to ensure the educational experience is both safe and ethical. These included:

- Legal Compliance: Verify that the events adhere to local alcohol laws and regulations, particularly those pertaining to minors. Instead of encouraging consumption, activities should concentrate on commercial and scientific elements.
- Ethical Considerations: Stress the effects of alcohol on society and its ethical use. Don't give the impression that drinking is being supported or encouraged.
- Health and Safety: Inform students about the dangers of alcohol, such as addiction, health problems, and how it affects both physical and mental health. Emphasize the risks of incorrect handling (such as methanol's flammability and toxicity).
- Cultural Sensitivity: There are cultural and religious ramifications to both the manufacture and usage of alcohol. Recognize the many backgrounds of your kids and honor their values and beliefs.
- Focus on Scientific Learning: Prioritize teaching the chemistry, biology, and physics involved in alcohol production and usage rather than focusing on the product's recreational aspects.
- Environmental Impact: Discuss the environmental consequences of alcohol production, such as water usage, byproduct disposal, and carbon footprint.
- Clear Objectives: Maintain a clear emphasis on STEM education and entrepreneurship, ensuring that the activities focus on innovation, problem-solving, and societal benefits rather than promoting the alcohol industry.
- Safety in Experiments: Ensure that all experiments involving alcohol are conducted safely in a controlled environment, with appropriate safety equipment and supervision.
- Public Perception: Be prepared to address concerns from parents, school administrators, or the community about the educational purpose of focusing on alcohol-related products.
- Alternative Applications: Include discussions and projects about non-consumable uses of alcohol (e.g., sanitizers, cleaning products) to broaden the scope of the learning activities and avoid solely focusing on beverages.

4.2 Revised the STEM lesson plan on design thinking about the Entrepreneur Alcohol STEM Education

The revised the STEM lesson plan on design thinking about the entrepreneur alcohol STEM Education could be provided in table 1. This table outlines a 15-week Entrepreneur Alcohol STEM education unit designed to engage students in the design thinking process while addressing real-world challenges related to alcohol-based products. The curriculum integrates creativity, critical thinking, and problem-solving, gradually progressing from understanding design thinking principles to prototype development and presentation. Students are encouraged to empathize with consumers, define specific problems, ideate innovative solutions, and test their prototypes while applying scientific concepts related to alcohol. Through activities such as exploring consumer behavior, formulating unique product ideas, experimenting with alcohol properties, and analyzing market demand, the unit fosters a comprehensive learning experience. By the end of the program, students are expected to present their finalized prototypes and business plans, demonstrating their mastery of STEM concepts and entrepreneurial skills

TABLE 1: Outline of the Entrepreneur Alcohol STEM education Unit through Design Thinking Process

Week	Objectives	Activities
1st – 3rd week	To provide students overview of design thinking process	Challenge students to explain what and how some company could generate their service and product for human. Students may clarify the following use cases through the process of design thinking (1. Empathize, 2. Define, 3. Ideate, 4. Prototype, and 5. Test). The example of use cases include: 1) Design Thinking and improving traffic signs in South Korea, and 2) H&M Company Innovates Plastic Packaging
4th week	To engage students to some problems for generating their creative thinking for developing some prototypes of drinking alcohol.	Assign students to find the solution about the problem of creating products related to alcoholic beverages includes khao mak, liquor, beer, sato, wine, and shochu.
5th week	To support students to apply the concept of empathize for developing their understanding the problem.	Exploring consumer behavior in various aspects about alcoholic beverage products to understand 'users' or customer groups Which is a point of opinion in daily life in various aspects of consumption. Is it interesting to deal with the issue or not? how? Is it enough to develop further?
6th week	To support students to apply the concept of define as a part of design thinking to clarify the possible solutions.	Ask students to clarify customer groups and demand for alcoholic beverages that are unique and creative in each local area or are the least harmful to health. Students may clarify also how to create the bands or what materials could produce the unique products.
7th week	To support students to apply the concept of ideate as a part of design thinking to generate the possible knowledge and strategies for developing their alcoholic prototypes.	Students brainstorming to list what the everyday life products of alcohol (e.g. Hand washing gel, wound cleanser, liquor, beer, sato, khoamak, Paint remover, and so on)
8th week	To support students to apply the concept of ideate as a part of design thinking to generate the possible knowledge and strategies for developing their alcoholic prototypes.	- Activities of preparing non-consumable alcohol type, for examples; making alcohol hand washing gel. - Activity to explain alcohol with its functional groups - OH alcohol (Alcohol)
9th week	To support students to apply the concept of ideate as a part of design thinking to generate the possible knowledge and strategies for developing their alcoholic prototypes.	Alcohol testing activity for both methanol and ethanol that relying on the following properties: Properties of ethanol - Is it a colorless liquid that dissolves well in water and evaporates easily? - Does it have a boiling point of 78 C and a density of 0.806 g/cm3? - Is it flammable and gives off a colorless flame? Is it the least toxic? - Does it have an attractive smell and is used to make alcoholic drinks?

TABLE 1: (Cont')

Week	Objectives	Activities
10th week	To support students developing prototypes about alcohol beverages.	- Presenting basic concepts for producing alcoholic beverages. (Drink type Target group, production method, raw materials)
11th week	To support students developing prototypes about alcohol beverages.	- An alcoholic beverage production experiment was conducted according to the production method in week 10.
12th week	To support students developing prototypes about alcohol beverages.	- An alcohol production experiment was conducted to adjust production methods in week 11. - Package design and branding
13th week	To support students to apply the concept of test as a part of design thinking to do the testing and revise the prototype.	Testing, improving and developing creative innovations lead to commercial products. - Test alcohol percentage - Taste test - Test the demand for alcoholic beverages by doing a survey. - Test the supply chain by calculating the number of raw materials to be supplied according to demand, calculating costs, setting prices.
14th – 15th week	To support students to reach the prototype and presentation	- Presenting work pieces to further business development presented according to the framework of Business Model Canvas

5. Conclusion

The concept of developing a STEM lesson plan using the design thinking approach as a pedagogy to teach the activity is presented in this STEM lesson plan. It is thought that this lesson plan's use of design thinking is suitable for introducing students to STEM subjects and the engineering design process. Encourage students to create alcohol-related activities as the initial step in the design thinking process. The scenario, which is thought to be sensible, is related to everyday occurrences for students and is meant to evoke empathy for the situation and human needs. Students' excitement for the task of creating alcoholic beverages may be influenced by their understanding of human needs.

Teachers try to give students the chance to interact with scientific concepts, alcohol types, and alcohol testing through the design process of creating alcoholic beverages. In order to prevent hand burns from heat transfer from a hot pot to the hand, students should think about materials that can withstand heat transfer. In addition, there are other scientific ideas like energy for the purpose of evaluating alcohol and the use of the arts in the creation of alcohol beverages. Additionally, teachers try to get students to think like engineers when they verify the prototype's usefulness by using a thermometer, a scientific tool, to measure the temperature and make sure it meets user needs.

Because of activities like encouraging students to consider human needs in design, engaging them with innovation design, and arousing their engineering design mindset, it is thought that design thinking and this lesson plan will help students become more interested in a mindful career as innovators. Students who participate in these activities develop critical thinking, creative thinking, teamwork, and communication skills—all of which are deemed essential for careers in the twenty-first century and for becoming good citizens.

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