Asking Phase on How to Land to The Moon: Engineering Design Process (EDP) For STEM Education

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Received: 20 June 2024; Accepted: 24 June 2024

Abstract
STEM education is important for the twenty-first-century student, and there are several challenges that educators face when it comes to implementing it. One of the greatest challenges in implementing STEM education in schools is addressing the misconceptions and stereotypes that surround these subjects. Some people, even teachers, believe that STEM subjects are too difficult or only suitable for certain students. This can create barriers to participation and discourage students from pursuing their interests in these fields. Theory based on Social Constructivism is the central pillar in the discussion of this article, and it focuses on the Asking Phase in Engineering Design Process (EDP). Students are required to identify the needs and constraints when university students apply the Asking Phase in one of the Engineering Design Process in a parachute activity with the title Landing to the Moon. There are four questions involved namely, how does students discuss on the main goal of the activity, resources that they have, needs or challenges to be considered, and the available resources that can overcome the challenges and achieve their goals. A case study has been designed and the method of selecting respondents is through cluster sampling, which is to choose seven groups of Science Education students at public universities in Selangor. The results of the study showed that four (4) aspects of achievement are required for the goal of the project, three (3) main resources were chosen to start the project, eight (8) challenges need to be considered, and nine (9) ways to overcome the challenges and to ultimately achieve the project.

Keywords: Asking phase, Engineering design process, Science education; STEM; Social constructivism

Introduction

The declining trend of the interest of the people of this country towards the STEM stream, especially among school leavers in choosing a stream at the college or university level, is of great concern to the Malaysian government. The facts that happen at school show that learning at school rarely teaches students problem-solving skills, this happens because students do not understand the problem well, cannot make the right plan or strategy to solve the problem, and face difficulties in implementing the plan, resulting in students to respond incorrectly or inaccurately (An Nuril *et al*., 2024). The president of the Peninsular Malay Students Association (GPMS), Fazreen Fauzi in Berita Harian (April 23, 2024), said the country is expected to see the drop in Malay scientists and technology experts in at least another 15 years

when 89 percent of Malay students are found to be disinterested in the subject science, mathematics, engineering and technology (STEM). He also mentioned, it could cause a shortage of manpower in fields related to technology, engineering and medicine, thereby hindering the country's progress in innovation and technological development. STEM education is considered important in today's development because it contributes to economic development, innovation and provides attractive job opportunities.

There are several main factors that influence the downward trend in STEM, among them is the student factor. The less than satisfactory achievement of Science and Mathematics subjects during the examination caused students to lose motivation to follow the STEM stream and this resulted in the failure of the 60:40 policy to be achieved. Guidance from teachers is expected to help students to re-increase their motivation towards STEM through involvement in STEM activities. M. Jaya et al. (2023) said this is indeed a teacher's concern as an important factor in the world of education to create a learning atmosphere that can make students have these abilities. Therefore, the recruitment of trainee teachers to enter the field of STEM education provides a bright opportunity to overcome the lack of interest of school students in the field of STEM. Agudelo Rodríguez *et al*. (2024) mentioned that more practical aspects are expected in STEM education subjects to enable the development of skills and capacity to realize concrete actions for trainee teachers. The need to strengthen and seek consensus on concepts is partly due to the promotion of STEM as a pedagogical strategy with an integrative approach since its inception (Martín-Páez *et al*., 2019). Sanders (2009) emphasizes that STEM education is a pedagogical approach based on technology or engineering design that deliberately integrates the conceptual content and procedures of science and/or mathematics education with practical concepts.

Social Constructivism is the basis theory of the study. The purpose of this research was to identify the needs and constraints when university students apply the Asking Phase in one of the Engineering Design Process in a parachute activity entitled Landing to the Moon. Specifically, this answers the questions: How does students discuss on the main goal of the activity, resources they have, needs or challenges to be taken in account, and the available resources that can overcome the challenges and achieve your goals.

The Ministry of Education (MOE) has set the goal of STEM education to produce STEM-literate students who are able to identify, apply, and integrate STEM concepts to understand problems and solve them creatively and innovatively through STEM-integrated learning that applies the real-world context and use a hands-on approach on and open exploration (KPM, 2023). One of the six (6) competencies in the STEM Teacher Competence Framework or KomSTEM is STEM Knowledge and Skills. The role of teachers in the STEM field is important in the implementation of STEM education because they are the main flags and implementers in using appropriate teaching techniques to provide the best learning environment for students (Kelley et al., 2020). The MOE in its blueprints for 2013-2025, mentioned on the implementation of STEM education by suggesting three (3) main elements, namely knowledge, skills, and values, being integrated into STEM subjects through an inquiry approach,

project-based learning, and problem-based learning in the context of the real world (MOE, 2013).

According to Ahmad Al Hilmi and Lilia (2023), the level of teachers' pedagogical knowledge of STEM content is at a high level. Teachers' attitudes show positive results, as well as the level of science teachers' pedagogical skills and evaluations are at a high level to ensure that the teaching and facilitation process runs well. The study conducted by Shamsuddin and Noorashikim (2021) shows that the level of readiness of STEM teachers to implement STEM education is moderate, while the level of knowledge and attitude of teachers towards STEM education is high. Recently, Abd. Halim *et al.* (2023) also conducted a similar study on preschool teachers in the teaching and facilitation of early mathematics based on STEM, showing a high level of knowledge and willingness to teach but a moderate interest and teaching attitude. In addition, knowledge and interest have a positive and significant relationship with attitude, while attitude has a positive and significant relationship with willingness to teach.

In order to overcome the problem of STEM teachers, the analysis results from the study of Rahayu *et al.* (2018) found that it is necessary to have an effective curriculum and maximize access to STEM for teachers, hold a routine mentoring program for teachers on an ongoing basis, increase confidence and motivation for teachers in the use of STEM. A comparative study between pre-service teachers and veteran teachers in terms of the influence of teaching experience in the knowledge, motivation, and implementation of STEM teaching and learning showed that there is a significant difference in the knowledge, motivation, and implementation of STEM Teaching and Learning. Novice teachers were found to be ahead of veteran teachers in terms of knowledge and motivation, however veteran teachers implement STEM Teaching and Learning more often than novice teachers (Aminah and K Han, 2020).

The Ministry of Education challenge in realizing the desire of the Malaysian government to want its people to choose STEM fields can be seen from Khusnidar’s (2019) study of preschool teachers in applying STEM education, which states that teachers lack mastery of pedagogy in the context of science teaching and a lack of tools to carry out investigative activities. This finding is contradicting from the findings of Jamunarani and Siti Raihamah's (2021) study on primary school Mathematics teachers in Batang Padang district on their willingness to implement STEM education and found that Mathematics teachers have a willingness to implement STEM education. Some studies mention about the construction of modules to overcome this challenge, one of which is from the study of Muzirah *et al*. (2022), which aims to describe the content and test the usability of the STEM Teaching Module in the learning of Statistics and Probability in KSSM Mathematics Form Two on mathematics teachers in secondary schools around the Kota Bharu, Kelantan. Studies found that most respondents agreed on the use of special features that is easy to understand, student-centered activities which can attract interest in learning statistics, lighten the task and save the teacher's time, attractive cover and easy-to-carry size but all must comply with the content of the textbook.

Methodology

The instructor gave the scenario to each group of participants:

"*As some scientists, you are required to build a parachute drone that is strong and safe to land. The built drone must be strong and protect the sensitive equipment inside the drone. Therefore, as a simulation, each group was asked to build a parachute drone model. This activity also requires each group to create a support material for an egg that needs to land when released from a height of several meters*."

A case study in the form of research design was carried out on fifth-semester students who are pursuing a Bachelor's Degree in Science Education. They were required to take the subject of Integrated Science, Technology, Engineering, and Mathematics (STEM) Education during the program. A ten students per group, total seven groups were interviewed. Qualitative data was chosen because several data collection methods were used in this study, including interviews, classroom observations, notes made by the researcher, and some notes and images made by the participants. There is an interview plan that has been implemented, whereby the objective stated is to identify how university students explore the needs and constraints in the Asking Phase of EDP. They are asked to answer four (4) questions for this phase, which are (i) What is the main goal of this project? (ii) What resources do you have? (iii) What needs or challenges need to be considered? (iv) How can the available resources overcome the challenges and achieve the project goals?

Four levels of data analysis were conducted in this study. In the first stage, the researcher observes the video recordings, listens to the voice recorder, and transcribes them using a written protocol. This transcription covers the interaction between the researcher and the group of participants during the interview session and the researcher's notes during and after the interview. In the second stage, the raw data were organized, arranged in transcription, and processed according to specific themes and subthemes to produce a written protocol. In the third stage, a case study is prepared for each group of participants using the information obtained from the transcription. Finally, coding was done to clarify the written text, and observations were recorded for each study participant in each protocol designed. This was followed by categorizing it into sub-constructs of the Asking Phase in EDP.

Results and Discussion

What is the main goal of the Project?

In the discussion that the students did in their respective groups about this project, it was found that the participants used four aspects of achievement, namely, the load (egg) did not break, to slow down the descent of egg, the parachute drone landed safely, and minimize the force of impact.

Table 1 summarizes two aspects of achievement as project goals: the load (egg) does not break, to slow down the descent of egg, the parachute drone landed safely, and minimize the force of impact:

Table 1: The Goal of the Project

Achievement aspects	Group of Participants

(i) The load (eggs) does not break	2, 6
(ii) To slow down the descent of egg	7
(iii) The parachute drone lands safely	1, 3, 4, 5, 6
(iv) Minimize the force of impact	7

There are four aspects of achievement in the results obtained. In accordance with the goal of the project, five groups of participants chose Aspect 3 to make sure the parachute drone lands safely. Aspects 2 and 3 are the least chosen by the group and the only group that focused on that is Group 7.

The primary goal of the activity is to design and build a system that safely delivers a raw egg to the ground without breaking when dropped from a significant height. This activity aims to (i) apply Physics and Engineering Principles: the participants must understand and apply concepts such as gravity, air resistance, force, and impact absorption, (ii) encourage Problem-Solving and Creativity: the participants must think creatively to develop solutions for protecting the egg and ensuring a smooth descent, (iii) teach Design and Prototyping Skills: The activity involves the entire cycle of designing, building, testing, and refining a prototype, mirroring real-world engineering processes, (iv) promote Teamwork and Collaboration: When done in groups, the activity fosters teamwork, as participants must collaborate, share ideas, and distribute tasks effectively to achieve their goal, (v) enhance Critical Thinking and Analysis: the participants analyze the success and failures of their designs, requiring them to think critically about why certain aspects worked or did not work and how to improve them, and (vi) Hands-On Learning Experience: This practical, hands-on activity helps solidify theoretical knowledge through experiential learning, making abstract concepts more concrete and understandable.

What resources do you have?

In the discussion during this project, it was found that students use eight resources to create the drone parachute.

Table 2 summarizes the resources that they had: egg, straw, plastic, string, rubber band, cello tape, previous knowledge, and scissors.

Table 2: The Resources

Resources	Group of Participants
(i) Egg	1, 2, 3, 5, 6, 7
(ii) Straw	1, 2, 3, 5, 6, 7
(iii) Plastic	1, 2, 3, 6, 7
(iv) String	1, 2, 3, 5, 6, 7
(v) Rubber band	1, 5, 6,
(vi) Cello tape	2, 5, 6, 7
(vii) Previous knowledge	4, 5,
(viii) Scissors	5

There are three items' chosen by six groups (Group 1, 2, 3, 5, 6, and 7) ~~of~~ namely egg, straw, and string as their main resources for the activity. The least resources that they needed were scissors, which was chosen only by Group 5 (Table 2).

We would need a variety of materials and tools to conduct the activity. Here is a list of potential resources; (i) parachute material (plastic bags, fabric scraps, and papers), (ii) strings (thread, yarn, fishing line, lightweight string or twine), (iii) egg protection (bubble wrap, foam, cotton balls, cardboard), and (iv) fasteners (tape, glue, rubber bands).

What needs or challenges need to be considered?
During the group about this project, it was found that the participants had comes out with eight challenges that needed to be considered to complete the project. The challenges are parachute design, egg protection, weight distribution, environmental factors, deployment, safety concerns, and team coordination.

Table 3 summarizes eight challenges that needed to be considered to complete the project: parachute design, egg protection, weight distribution, environmental factors, deployment, safety concerns, team coordination, and resource utilization.

Table 3: The Challenges of the Project

Challenges	Group of Participants
(i) Parachute design	1, 3
(ii) Egg protection	1, 2, 3, 6
(iii) Weight Distribution	6
(iv) Environmental Factors	1, 2, 3, 4, 5, 6
(v) Deployment	2, 6
(vi) Safety Concerns	4
(vii) Team Coordination	5
(viii) Resource Utilization	2, 4, 7

From the result, the main challenges of the project whereby six groups had chosen is Challenge 4. Challenge 3, 6 and 7 are the least challenge chosen by the group facing whereby only one group involved for respective challenges (Table 3).

To conduct an activity where an egg is safely dropped using a parachute involves several challenges: (i) A Parachute Design: Choosing the suitable material for the parachute that balances weight and durability and determining the appropriate size to ensure enough drag to slow the descent but not too large to make the setup cumbersome. (ii) The Egg Protection: Finding suitable materials and methods to cushion the egg against impact and designing a container that securely holds the egg and absorbs shocks effectively. (iii) A Weight Distribution: Ensuring the weight is evenly distributed so the parachute descends straight down rather than tilting or spinning, which could lead to an unsafe landing. (iv) Environmental Factors: Wind

can affect the descent path and speed, making it unpredictable and determining the optimal height from which to drop the parachute for the best chance of a safe landing. (v) The Deployment: Ensuring the parachute deploys correctly without tangling or failing to open fully. (vi) Multiple trials may be needed to refine the design, requiring time and resources, dealing with failures, and understanding the reasons behind them to improve the design in the Testing and Iteration. (vii) We also need to be concerned with safety by conducting the activity in a safe environment to avoid injuries from falling objects and ensuring that the drop area is clear of people and obstacles. Lastly, (viii) effective communication and collaboration among team members to ensure all aspects of the design and drop are well-executed.

How can the available resources overcome the challenges and achieve the project goals?

In the discussion that the students did in their respective groups about this project, it was found that the participants had five ways to overcome the challenges and achieve the project; they are parachute design, egg protection, weight distribution, team coordination, and resource utilization.

Table 4 summarizes nine challenges need to be considered to complete the project: parachute design, egg protection, weight distribution, environmental factors, deployment, safety concerns, team coordination, and resource utilization.

Table 4: The Overcome Challenges and Achieve the Project

Overcome	Group of Participants
(i) Parachute design	1, 2, 3, 6,
(ii) Egg protection	3,
(iii) Weight Distribution	7
(iv) Environmental Factors	-
(v) Deployment	-
(vi) Testing and Iteration	-
(vii) Safety Concerns	-
(viii) Team Coordination	5,
(ix) Resource utilization	1, 2, 4, 6, 7

There are nine ways to overcome the challenges and achieve the project's goal. The preferable ways to overcome the challenges of the project is Overcome 9. Five groups of participants chose Overcome 9 as their main way to overcome challenges. Overcome 2, 3 and 8 are the least preferred with only one group choosing it whereby while Overcome 4, 5, 6 and 7 is not significant for them (Table 4).

Overcoming the challenges of the egg parachute activity involves the strategic use of available resources. Use lightweight and durable materials like plastic bags, fabric, or nylon for Parachute Design. Even a garbage bag can work effectively if specific materials are not available. Test different sizes by cutting parachutes of varying dimensions from the chosen material and observing their performance in controlled drops. For egg protection, the use of materials like bubble wrap, foam, or

even crumpled paper to cushion the egg. If these are unavailable, household items like cotton balls or even thick socks can provide some cushioning. Create a container using cardboard, plastic cups, or small boxes. Ensure the egg is snugly fit and cushioned inside. Next, we need to balance the egg and its protective casing at the center of the parachute strings for Weight Distribution. Adjust the length of the strings if needed to ensure an even weight distribution. Environmental factors should also not be taken lightly. Conduct the drop indoors, if possible, to minimize the impact of wind. Choose a day with calm weather outdoors and drop from a sheltered area. Use a consistent height for each test. Drop from a balcony, staircase, or ladder to have enough height for the parachute to deploy correctly. For Deployment, ensure the parachute is adequately folded, and the strings are untangled before each drop. A simple rigging system can be created to ensure smooth deployment, such as tying strings to evenly spaced points on the parachute. We can start with small-scale tests to identify potential issues for Testing and Iteration. Gradually increase the height and complexity of the tests. Document each trial to learn from any failures and make necessary adjustments. Then, conduct the activity in an open area free of obstructions and away from people. Ensure all participants know the drop zone and stay clear during tests for Safety Concerns. Last is team coordination; we need to assign specific roles to team members, such as one person handling the parachute, another securing the egg, and another documenting the results. Regularly communicate and review the plan to ensure everyone is aligned.

From the findings research mentioned above, the researcher found some significant themes through how to relate research results to theory, research, policy, and current practice or past, and extrapolate the results of the study to future practice in fields that are unknown or have never been experienced (Nik Azis, 2014). This theme was created based on the observations of the researcher after discussions with mathematics experts on the findings of this study obtained, agreed, and presented as a contribution to the study to be more meaningful and can benefit the needs of this study and follow-up studies are carried out.

Table 5: New Themes Based on Research Findings for Asking Phase in EDP

Category	New Emergent Theme
The Goal of the Project Resources Challenges Overcome the Challenges	Achievement

Achievement is the best theme due to the study's findings, which identify the needs and constraints when university students apply the Asking Phase in one of the Engineering Design Processes in the parachute Landing to the Moon activity (Table 5). It involves knowledge, attitudes, and teaching experience that strongly relate to teachers' readiness to implement STEM education (Shamsuddin & Noorashikim, 2021).

Conclusions

In conclusion, the results of this study provide three implications for educational practice, higher education mathematics curriculum, and further research. Educational practices that need to be refined include teaching and learning about STEM education, applying the theory used, Social Constructivism, in this study and developing pre-service teachers' awareness of deep basic knowledge about STEM education. The Malaysian Ministry of Education needs to strengthen the STEM education policy, especially teacher education. Finally, further research can be done on students who follow STEM education for preschool or primary school, who belong to the group of prospective teachers who study in Teaching Institutions (IPG) throughout Malaysia, not only to help them overcome the difficulties of teaching but also to know how to find suitable activities for their students.

Acknowledgments

Authors would like to express their gratitude to Science Education Department and Mathematics Education Department for providing the resources in terms of participant preparation and classroom facilities that is needed to complete this study. We would like to express our deepest gratitude to Faculty of Education, UiTM, for the expertise, insightful views, unwavering support, and guidance throughout this research process. Also, special appreciation to our colleagues at the Faculty of Education for their feedback and opinions by helping us prepare quality articles. Finally, we would like to thank all participants in this study for their time and willingness to share their learning experiences. Their contributions were invaluable in helping us understand the study and draw meaningful conclusions.

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