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Research Article

INTEGRATED CAREER-BASED STEM LESSON "ROLLER COASTER ENGINEER" IN TEACHING KINETIC AND POTENTIAL ENERGY - PHYSICS 10

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ABSTRACT

The paper aims to present an integrated career-based STEM lesson, "Roller Coaster Engineer," in teaching the Kinetic and Potential Energy of the 10th-grade Physics Curriculum. Based on the theoretical foundation of STEM education and career-oriented education, STEM learning activities were designed for a roller coaster engineer to increase students' STEM career interests and foster career-oriented competence. An experiment with 116 10th graders was conducted, and the result shows that the lesson "Roller Coaster Engineer" meets the competence requirements for kinetic and potential energy. In addition, a survey (STEM-CIS-STEM Career Interest Survey) was also conducted to explore student's STEM career interests, and the results show that students feel more confident about STEM jobs after the lesson. Therefore, students were more interested in STEM careers, which contributed significantly to students' choice of a STEM career. The results also support the idea that students have a good awareness of engineering careers.

Keywords: career orientation; integration; science education; STEM education; upper secondary

1. Introduction

The Vietnam 2018 General Education Curriculum emphasizes the importance of career orientation, particularly at the upper secondary level (Grades 10-12). For the new curriculum, career orientation includes all school activities in coordination with families and communities to equip students with knowledge and career orientation competence. It is implemented through all subjects and educational activities (Ministry of Education and Training, 2018). A crucial aspect of career orientation education is the reasonable impact of aligning students' choices with practical conditions and circumstances. This is done by equipping students with the pragmatic competence necessary for the future workforce (Pham & Nguyen, 2021). Therefore, the effectiveness of career orientation education in school

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depends partially on the cooperation of subject teachers. Several studies have been conducted to integrate career orientation in teaching physics and have shown positive effects (Nguyen, 2020).

STEM education is regarded as a suitable approach that aligns with the current trends due to the workforce in STEM fields. A number of studies have demonstrated that STEM education can yield specific benefits in developing students' competence (Kazu & Yalçın, 2021). In Vietnam, STEM education was clearly defined in the 2018 Curriculum as an interdisciplinary approach enabling students to apply science, technology, engineering, and math to deal with practical problems (MOET, 2018). Specifically, the Ministry of Education and Training has issued Document No. 3089/BGDĐT-GDTrH on implementing STEM education in secondary education, guiding how to implement STEM education in formal learning (MOET, 2020).

Decision No. 522/QĐ-TTg, signed on May 14, 2018, by the Prime Minister with the Project on Vocational Education and General Education from 2018 to 2025, clearly assisted the command to focus on integrating career orientation into the curriculum following the STEM education. According to Wiebe (2018), students' attitudes toward STEM careers remain stable and balanced during their high school years (Wiebe et al., 2018). Hutchinson and Bentley (2011) also pointed out that students tend to seek subject teachers to ask about career-related issues rather than seeking guidance from career counselors (Hutchinson & Bentley, 2011). It highlights the importance of integrating career orientation into the implementation of STEM education for science subjects (Physics, Chemistry, Biology) in upper secondary school curricula. Science teachers play a crucial role in promoting STEM career orientation. Dökme (2022) argues that students' motivation toward STEM fields is not dependent on grade level, type of high school, and family income, yet influenced by the level of experience in participating in STEM activities and especially by the presence of a role model in the STEM field (Dökme et al., 2022). These results contribute to the affirmation of the role of STEM education in career orientation. The integration of career orientation in STEM education can increase the effectiveness of career guidance for students, especially in science fields.

It is essential for young people to better understand the fields of natural science and engineering by developing appropriate programs and activities (Shahali et al., 2017). Among three forms of implementing STEM education in high schools, STEM lesson is the most popular form with thematic content attached to the subject curriculum and integrated into the teaching process. Some studies have shown positive results in integrating career education in STEM topics in Physics (Le, 2022; Nguyen & Le, 2023; Pham, 2022). However, most studies have integrated careers in STEM experiential activities and focused on the content of special topics in the Physics curriculum. Therefore, research on delivering STEM lessons integrating career orientation in teaching core content is needed.

Kinetic energy and potential energy in the physics curriculum for Grade 10 are closely connected with some requirements of being a roller coaster engineer who does research and designs a roller coaster system in an amusement park. According to Decision No. 27/2018/QD-TTg dated July 6, 2018, of the Prime Minister, this job belongs to the Civil Engineering Construction industry. The principle of a roller coaster is associated with knowledge of kinetic energy, potential energy, the transformation between these kinds of energy, and the law of conservation of mechanical energy, which may support calculations in the structural design of the track system to ensure the roller coaster operates efficiently and safely. The research aims to build a STEM lesson that integrates the career orientation "Roller Coaster Engineer" in teaching "Kinetic and Potential Energy" to enhance learning, simultaneously increase students' interest in STEM careers, and contribute to fostering students' career-oriented competence.

2. Research methods

This study will review related literature on STEM education and integrated career-oriented education, combined with an analysis of requirements for Kinetic and Potential Energy in the curriculum, a STEM lesson "Roller Coaster Engineer" was developed. The learning tasks in the lesson were designed closely to the work of a roller coaster engineer. In the lesson, the learning activities aimed at guiding students on how to apply knowledge about kinetic and potential energy and how to combine related skills to learn about the job. Then the lesson was conducted with 10th-grade students in the second semester of the 2022-2023 school year to evaluate the effectiveness of the STEM lesson.

2.1. Participants

An experiment was conducted with 116 students in Grade 10 in Ho Chi Minh City and Binh Duong Province, of whom 60.3% were female and 30.7% were male. All students learn the STEM lesson for the first time, so they have no engineering design experience. Facilities for experiments ensure adequate equipment to create favorable learning conditions for students.

2.2. The experiment

The STEM lesson was conducted in 4 class periods, each of 45 minutes, combined with time working at home. The teacher held the lesson in a classroom for the first two periods with activity 1 - Identify problems and activity 2 - Research background knowledge to propose solutions. Then, the teacher assigned homework with specific instructions for students to carry out activities 3 - Choosing solutions and 4 - Manufacturing products, testing, and evaluating. Activity 5 - Discussion, sharing, and adjustment - were implemented in class during the last two periods.

2.3. Data collection

We collected data on physics competence, career orientation competence, and STEM career interest. We recorded by filming and taking photos of class sessions, observing and taking notes, students' products, and questionnaires. Data collection methods and tools are presented in Table 1.

Table 1. *Methods and tools in the experiment*

No.	Purposes	Data collection tools
1	STEM career interest	STEM Career Interest Survey (STEM-CIS)
2	Career orientation competence	Learning products Written test
3	Academic performance (physics competence)	Observe; Question and Answer Learning products

The STEM-CIS (STEM Career Interest Survey) developed and standardized by Kier et al. (2014) was used in this study. The study adapted the survey to be appropriate to Vietnamese education practices. The adapted one has four sections: self-efficacy for science, mathematics, engineering, and technology; student interest; outcome expectancy; and personal goals. The Vietnamese STEM-CIS consisted of 30 questions on a 10-point Likert response scale from 1 - strongly disagree to 4 - strongly agree.

Students' career orientation competence was observed through learning products and students' presentations of roller coaster design and model. The written test is designed to make students present their understanding of the roller coaster engineering profession and thereby identify their personal qualities suitable for the profession.

To record students' academic performance, observations and the question-and-answer methods were used. Also, student's products were analyzed during class participation. Besides, students' interest was surveyed with a questionnaire of 12 questions and three essay questions.

3. Results and discussion

3.1. Theoretical framework for integrated STEM career-oriented education in teaching science

In general, STEM education has three main characteristics: (1) integration; (2) learning through practice, which means applying knowledge to solve real-world problems; and (3) addressing specific local issues and global trends (Nguyen, 2019). According to Document No. 3089/BGDĐT-GDTrH, STEM lessons are encouraged to be used commonly in the core school curriculum under the engineering design process (MOET, 2020). *The Engineering Design Process* is used by engineers to work on and solve problems. It involves the process of identifying needs and issues requiring innovation in practice, and then proposing technical solutions and technologies that meet the identified needs. It also encompasses implementing the technical solutions and technologies, testing and evaluating their effectiveness in meeting the identified needs, and addressing the presented issues (Nguyen et al., 2019). This process serves as a framework that supports learning science, mathematics, engineering, and technology (STEM) through the practical resolution of real-world problems (Kelley & Knowles, 2016). For STEM implementation in school, the engineering design process is modified with five main phases, including (1) identifying a problem, (2) exploring knowledge, (3) designing, (4) making a prototype, and (5) sharing. This process paves a good way for career-oriented education.

Integrating career orientation in teaching is the combination of goals, content, and methods of career-oriented education in teaching subjects to form a unified entity that synchronously impacts the students (Nguyen, 2019). According to Cohen (2012), learning activities in class must ensure four cognitive-behavioral blocks for career development to ensure practical career orientation in teaching STEM-related subjects (Cohen & Pattterson, 2012). The first aspect is **Awareness,** meaning students must understand the career, such as the required knowledge, skills, and working conditions. Secondly, students should realize the linkage between career and lifelong meaning: **Relevance**. Thirdly, **Engagement** means the experiences in a specific career. In other words, students can gain insight into their competence and connections to suitable career paths. Finally, **Self-efficacy** means confidence in performing career-related tasks. It requires appropriate activities for students to be more familiar with the career during the learning process. Cohen and Patterson (2012) assert that *awareness* about the career is the most essential among the four blocks of career development.

STEM education and career-oriented education in teaching interfere with each other toward the objectives of the general education curriculum. Integrating career orientation within the STEM topic provides an environment for students to take on specific professional roles within real-world career situations. An integrated STEM career-based lesson in teaching science performs objectives, learning content, and teaching methods closely adaptive to the theory of STEM education and career-oriented education.

- *Regarding the objectives,* STEM career-based lessons emphasize the specialized competence of science subjects and career-oriented competence, including career awareness, understanding and practice of skills related to specific careers, skills of decision-making, and planning of learning paths.
- *The lesson must reveal a clear and reasonable connection between a career and a subject in the curriculum*. Through the lesson, students achieve scientific knowledge and information about the related career, such as required knowledge, skills, and working conditions. It is a prerequisite for integrated STEM career-oriented education, ensuring that students acquire subject knowledge, gain *awareness* of related professional fields, and see the *value of subject knowledge in real-life* situations.
- The integrated STEM career-based lesson is delivered in *Role-based learning*. The learning tasks are built to resemble what the employees do in real life. The tasks help students achieve the science objectives and understand the related careers. It gives students experiences and insights into the careers they are learning about.

The combination of real-world context, role-based learning, and appropriate engineering processes is essential for integrated career-based STEM lessons within formal school settings.

3.2. *Integrated career-based STEM lesson* "Roller coaster engineer"

3.2.1. Learning tasks associated with the job of a roller coaster engineer

One of the essential work of a roller coaster engineer is to design the system to ensure the coaster can operate effectively and safely under practical local conditions. The integrated career-based STEM lesson "Roller Coaster Engineer" enables students to learn about construction engineering, in which students design and create a model of a roller coaster system to meet the following criteria: *(1) the track must have at least one circular loop with a diameter of 10 cm so that marble can slide smoothly on the track; (2) the model is suitable for a space of 40m in length, 40m in width, and 50m in height; (3) the model is on a scale of 1:100 compared to the actual size; and (4) the model is beautiful and safe for the roller coaster.*

In this task, students need to analyze the operation of a roller coaster based on the conversion of kinetic and potential energy. Besides, they apply the law of conservation of mechanical energy to find the appropriate size for the model and ensure that the marble can move the track entirely. The connection of criteria with STEM knowledge and career orientation is shown in Figure 1.

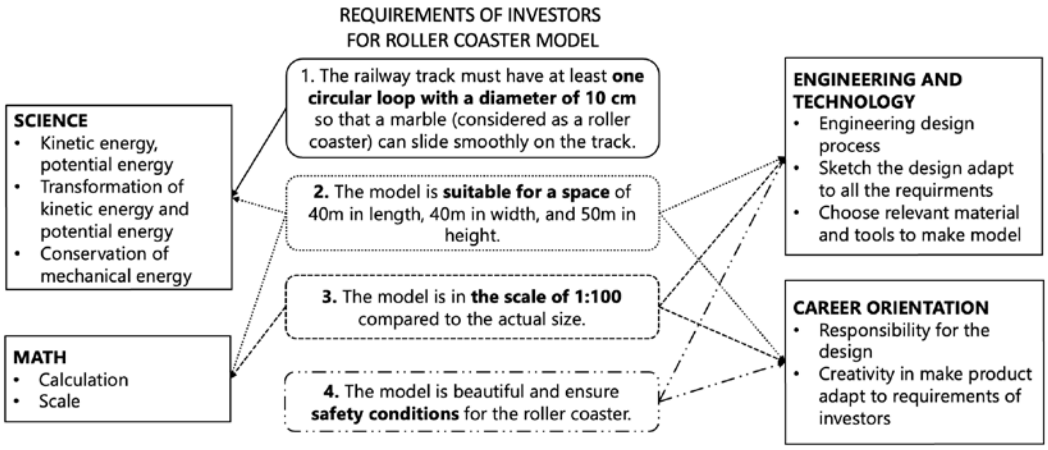
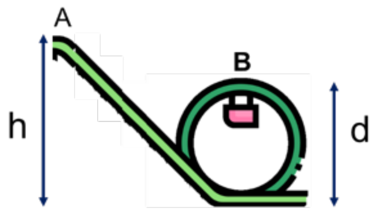


Figure 1. *Diagram of the connection between Roller coaster requirements and STEM and career orientation knowledge*

Problem	*Solution*
Find the initial height of the track where the roller coaster starts sliding downhill to slide over the circular track of diameter d. *Given that the velocity of the coaster at the top of the track must satisfy the*	*Let potential energy energy zero at ground level.* *Apply the conservation of mechanical energy, we have*

condition $v_B \geq \sqrt{g\frac{d}{2}}$ to let the coaster move the whole circle.



$$W_A = W_B$$
$$\leftrightarrow \frac{1}{2}mv_A^2 + mgh_A = \frac{1}{2}mv_B^2 + mgh_B$$
$$\leftrightarrow mgh = \frac{1}{2}mv_B^2 + mgd$$
$$\leftrightarrow v_B = \sqrt{2g(h-d)}$$

With the condition of the velocity of the coaster at the top of the track, we have

$$\sqrt{2g(h-d)} \geq \sqrt{g\frac{d}{2}} \rightarrow 2g(h-d) \geq g\frac{d}{2}$$

$$\rightarrow h \geq \frac{5}{4}d$$

3.2.2. Lesson objectives

With the learning task above, the lesson meets some physics competence and career orientation competence as follows.

[P1] State the formula for kinetic energy and potential energy in a uniform gravity.

[P2] Analyze the transformation of an object's kinetic and potential energy in the roller coaster.

[P3] State the law of conservation of mechanical energy.

[P4] Propose a simple roller coaster design that applies the law of conservation of mechanical energy.

[P5] Create a roller coaster model.

[C1] Presents a description of the social needs and the development of the roller coaster engineering profession.

[C2] Identify qualities and abilities that are or are not compatible with the requirements of the roller coaster engineer.

3.2.3. Learning process

Table 2 presents five activities in the STEM lesson following the Engineering Design Process.

Table 2. *The learning process of the STEM lesson "Roller Coaster Engineer"*

Activity	Activity content and learning product	Integrated Career orientation
1. Define and analyze the problem	- Students watch videos about a roller coaster and answer questions to learn about the job of a roller coaster engineer. - Students take on the role of an engineer, receiving a project to design and create a roller coaster model.	Information about the career and social needs of a roller coaster engineer.
2. Explore background knowledge and propose solutions	- Students analyze the conservation of kinetic and potential energy in a roller coaster, then solve the problem of finding the initial height of the track. - Students propose solutions to design a roller coaster model that meets the investor's shape, size, and safety requirements.	-Analyse the requirements of investors to come up with appropriate solutions. - Recognize competencies for engineers: problem-solving…

3. Choose a solution	- Students work in groups to present a design that meets all requirements to convince the investors. - The design needs to show a model of the roller coaster system on a scale of 1:100 suitable for the given space, with at least one circle loop, especially showing the elements that ensure effective operation and safety.	- Carry out career activities: draw a roller coaster design that meets the requirements.
4. Conduct, test, and evaluate	- Students create and adjust the model to meet the criteria. - Students check and ensure the accuracy and safety of the product based on investor evaluation criteria provided by the teacher.	- Carry out career activities: create roller coaster model, test and adjust product to convince the investors.
5. Share, discuss and improve	- Students present the model and discuss it with teachers and classmates. - Students create a plan to improve the model based on comments from teachers and classmates.	- Present products to convince investors about roller coaster design.

3.3. The experiment results

3.3.1. Change in STEM career interest

A paired-sample t-test was conducted to evaluate the impact of the lesson on students' STEM career interests. There was a statistically significant increase in almost all components with relatively high effect sizes (ES), as shown in Table 3. This reveals that the integrated STEM career-based lesson partially contributed to orienting students to choose and pursue a STEM career in the future (Christensen & Knezek, 2017; Wiebe et al., 2018). Besides, the SD of all four factors (Self-Efficacy, Personal Goal, Outcome expectation, and Interest) decreased after the lesson, showing that students' perspective toward STEM careers was more focused after the lesson. This means that the integrated career-based STEM lesson made them feel more familiar with the STEM careers, so they believe that they can do STEM jobs and get more benefits from STEM jobs.

Table 3. *Paired-sample t-test for the STEM-CIS*

Component	Pre-test		Post-test		p	Mean Difference	SD for difference	ES
	Mean	SD	Mean	SD				
Self-Efficacy	6.82	1.20	7.53	0.89	<.001	0.71	0.90	**0.79**
Personal Goal	6.93	1.29	7.65	1.04	<.001	0.72	1.15	0.63
Outcome expectation	7.35	1.35	7.96	0.96	<.001	0.61	1.16	0.52
Interest	6.60	1.44	7.60	1.07	<.001	1.00	1.21	**0.83**
Science	6.85	1.29	7.61	0.93	<.001	0.76	0.83	**0.90**
Math	6.78	1.58	7.48	1.37	<.001	0.70	1.11	0.63
Technology	7.25	1.28	7.98	0.90	<.001	0.72	1.11	0.65
Engineering	6.77	1.28	7.64	1.07	<.001	0.87	1.33	0.65

N = 116.

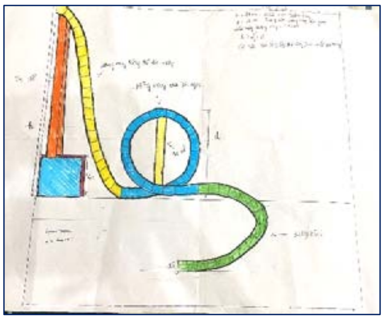
Cohen (1988) proposed the following interpretation of the ES values. An ES near 0.2 means a small effect, near 0.5 means a medium effect, and near 0.8 means a significant effect.

In particular, the ES for Self-efficacy was relatively significant at 0.79, showing that students were more confident with tasks related to STEM careers after the lesson. According to SCCT theory, self-efficacy directly impacts student interest, which in turn also affects job choice (Lent et al., 1994). This is also reflected in the research, shown through the t-test results and ES for interest factor. The ES for Interest was significant at 0.83, indicating that the integrated career-based STEM lesson significantly impacts students' STEM career interests.

Regarding STEM subjects, the changes in all four factors in science were more significant than in other disciplines, as shown by the large ES of 0.9. This is consistent with reality because the integrated career-based STEM lesson is built into Physics teaching. This indicates that the orientation of delivering the integrated career-based STEM lesson in teaching science is appropriate.

3.3.2. Students' career orientation competence

Students' career awareness was recorded in the process of designing and manufacturing. The results show that 24/25 groups determined the appropriate parameters for the circle size and initial height of the rail, meeting the space conditions given by the investor: no more than 50 cm height (scale 1:100). Almost all groups calculated the appropriate length and width, requiring the land area to be no more than 40 cm x 40 cm (scale 1:100). The most typical product is of the TPK.N6 group (Figure 2 on the right). They presented the idea of building an entire roller coaster system instead of just a section of the roller coaster system. This shows that they are aware of the completeness of the product that a roller coaster design engineer needs to make. The team was very creative when they proposed to attach an electromagnet as a traction motor to the marble to demonstrate the operation of the roller coaster system.



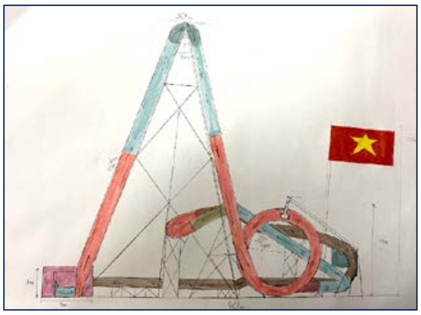


Figure 2. *Illustration of students' design products*

In the manufacturing, completing, and testing phase, 24/25 groups created a roller coaster model with height and circle size adapted to the space requirements and let the marble move the rail entirely. In particular, more than half of the groups demonstrated unique decorations with ideas from real life, such as bird's nests or dragon images. The products were also supplemented with decorative details such as lights, flowers, gardens, and small play areas. According to the students' sharing, decorative details can attract investors but ultimately ensure the game's safety. This shows that the experience of playing the role of a roller coaster engineer has given students awareness about the role, tasks, and work that needs to be performed in this role.

Figure 3. *Illustration of a student's roller coaster model*

Besides, the results of the written test showed that 111/116 (about 95.69%) of the students could` list the work of a roller coaster engineer. More than 60% of students presented their thoughts about social needs and the development of the profession with relevant reasons.

I think this profession may be a highly needed job because the entertainment needs are increasing. From there, many parks and entertainment areas can be built. (TPK4)

In my opinion, the future of the roller coaster profession is promising. Firstly, the career is familiar and new, attracting many young enthusiasts. Secondly, salary and income are quite high, attracting everyone. Thirdly, this profession is also a fun, exciting experience. (TPK27)

With the goal of self-assessment of their suitability to become a roller coaster engineer, students shared their thoughts in the written test. The results reveal that students found the career very interesting, and they were able to respond well to qualities such as being careful, listening, and communicating in group work. However, more than 50% of students self-identified their limitations in calculation and design abilities, so they need to practice more to meet the standards to become an engineer.

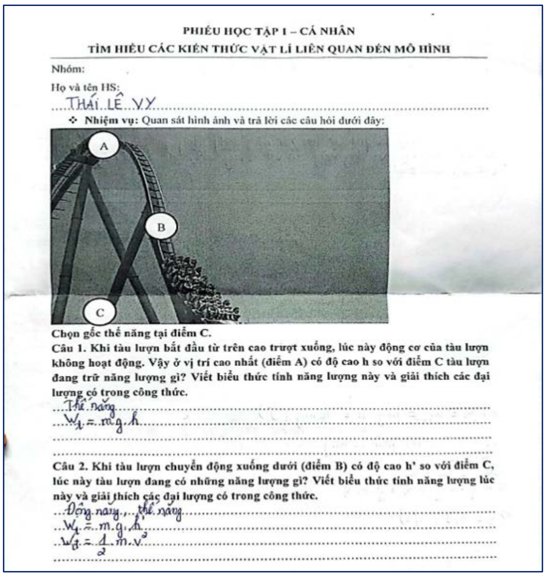
I feel that I can listen and do group work, but I do not meet the competencies of measuring, calculating, and analyzing information. (A8HS29)

I feel that I am suitable for honesty, coordination, and listening, but I do not have the skills to use design software, lack responsibility, and lack creativity. I think I need to improve on these points to become an engineer. (TPK2)

I feel like I am not creative and innovative enough to meet the requirements that the model is creative and safe for players (A11HS10)

3.3.3. Students' academic performance

In the activity of exploring background knowledge, most students were able to state the formula of gravitational potential energy and kinetic energy, thereby analyzing the energy transformation in the roller coaster, as illustrated in Figure 4. More than 80% of students could state the law of conservation of mechanical energy and apply knowledge to practice exercises. However, a few students made incorrect statements without clarifying the experimental conditions.



PHIẾU HỌC TẬP 1 – CÁ NHÂN
TÌM HIỂU CÁC KIẾN THỨC VẬT LÍ LIÊN QUAN ĐẾN MÔ HÌNH

Nhóm:

Họ và tên HS: THÁI LÊ VY

❖ Nhiệm vụ: Quan sát hình ảnh và trả lời các câu hỏi dưới đây:

Chọn gốc thế năng tại điểm C.

Câu 1. Khi tàu lượn bắt đầu từ trên cao trượt xuống, lúc này động cơ của tàu lượn không hoạt động. Vậy ở vị trí cao nhất (điểm A) có độ cao h so với điểm C tàu lượn đang trữ năng lượng gì? Viết biểu thức tính năng lượng này và giải thích các đại lượng có trong công thức.

Thế năng

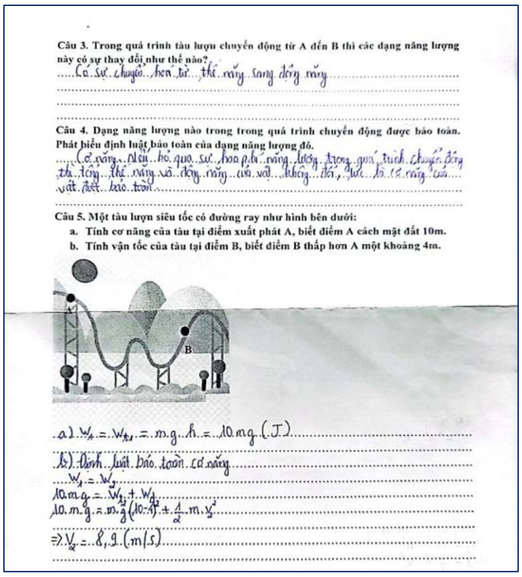
$W_t = m.g.h$

Câu 2. Khi tàu lượn chuyển động xuống dưới (điểm B) có độ cao h' so với điểm C, lúc này tàu lượn đang có những năng lượng gì? Viết biểu thức tính năng lượng lúc này và giải thích các đại lượng có trong công thức.

Động năng, thế năng

$W_t = m.g.h$

$W_đ = \frac{1}{2}.m.v^2$



Câu 3. Trong quá trình tàu lượn chuyển động từ A đến B thì các dạng năng lượng này có sự thay đổi như thế nào?

Có sự chuyển hoá từ thế năng sang động năng

Câu 4. Dạng năng lượng nào trong trong quá trình chuyển động được bảo toàn. Phát biểu định luật bảo toàn của dạng năng lượng đó.

Cơ năng. Nếu bỏ qua sự hao phí năng lượng trong quá trình chuyển động thì tổng thế năng và động năng của vật không đổi, ... là cơ năng của vật được bảo toàn

Câu 5. Một tàu lượn siêu tốc có đường ray như hình bên dưới:

a. Tính cơ năng của tàu tại điểm xuất phát A, biết điểm A cách mặt đất 10m.

b. Tính vận tốc của tàu tại điểm B, biết điểm B thấp hơn A một khoảng 4m.

a) $W_1 = W_{t1} = m.g.h = 10mg$ (J)

b) Định luật bảo toàn cơ năng

$W_1 = W_2$

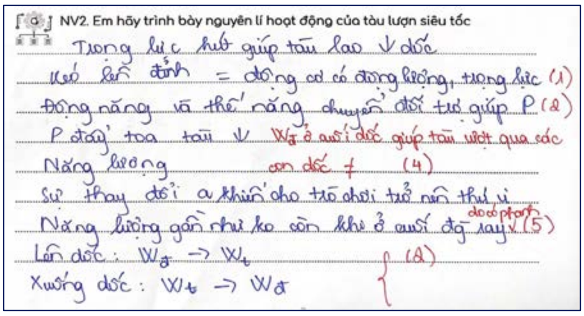
$10.m.g = W_{t2} + W_{đ2}$

$10.m.g = m.g(10-4) + \frac{1}{2}.m.v_2^2$

$\Rightarrow v_2 = 8,9$ (m/s)

***Figure 4.** Illustration of students' results in learning kinetic energy - potential energy - the law of conservation of mechanical energy based on the roller coaster model*

In analyzing the principle of a roller coaster, about 19.5% of students described the conservation of kinetic and potential energy in the operation of a roller coaster and analyzed in detail the energy conversion at the time the coaster goes up and down. About 46.3% of students could only state the operating principles of a roller coaster but could not thoroughly analyze the energy conversion processes when the train goes to the top and downhill. The remaining students were still confused and could not detail the operating principles of the roller coaster.



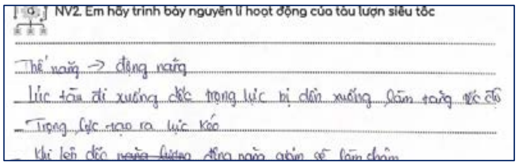
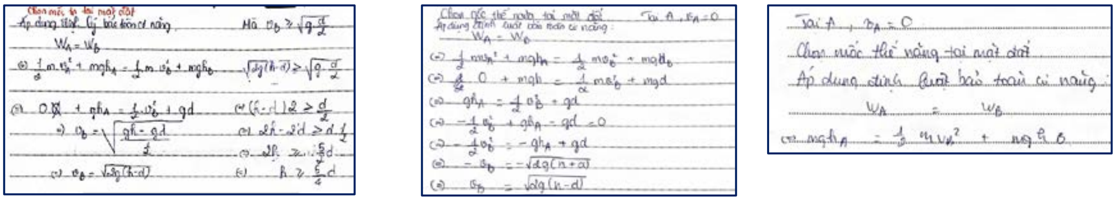


***Figure 5.** Illustration of students' results analyzing the energy transformation in the motion of the coaster*

In the activity of finding the height condition of the track (in section 3.2.1), about 18.1% of students applied the law of conservation of mechanical energy and the speed condition as given to determine the initial height of the rail to let the marble overcome the spiral with radius R (Figure 6a). About 38.8% of students could apply the law of conservation of mechanical energy to determine the object's speed at the highest point of the spiral but could not find the initial height of the track (Figure 6b). The remaining 43.1% realized that the problem needed to apply the law of conservation of mechanical energy but still could not find the expression for the roller coaster's speed at the circle's highest position (Figure 6c).



(a) *(b)* *(c)*

Figure 6. *Illustration of students' results finding the initial height of the slide track*

3.3.4. Students' reflection on integrated career-based STEM lesson

We received feedback from students on interest in the lesson topic. The results show that students find the lesson about the principles and structure of roller coasters easy to understand. Therefore, they are interested in this kind of lesson with career-related experiences and are ready to participate in similar lessons. The results of the essay answers show that most students are pleased to learn about a topic as practical and close as this one. Regarding the difficulties, most students find designing technical drawings and making models difficult because this is the first time students are exposed to them. In addition, study time is another obstacle. Students want the time to be longer to complete their learning tasks.

4. Conclusion

An integrated career-based STEM lesson "Roller Coaster Engineer" in teaching kinetic and potential energy content is clarified in this research. The results of experiments show that students meet the requirements in the science subject and are fostered in career-oriented competencies simultaneously. More specifically, students show more interest in STEM careers. This shows that building STEM topics based on specific jobs in appropriate career fields can contribute to career education for students. Based on the results of the experiment, we also realized that it is necessary to emphasize the work of the roller coaster engineer in the learning task to increase student experience. Besides, the research can be conducted with more students to improve the reliability of the results.

❖ ***Conflict of Interest:*** *Authors have no conflict of interest to declare.*

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BÀI HỌC STEM TÍCH HỢP GIÁO DỤC HƯỚNG NGHIỆP "KĨ SƯ THIẾT KẾ TÀU LƯỢN SIÊU TỐC" TRONG DẠY HỌC NỘI DUNG ĐỘNG NĂNG VÀ THẾ NĂNG – VẬT LÍ 10

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TÓM TẮT

Nghiên cứu trình bày bài học STEM "Kĩ sư tàu lượn siêu tốc" *trong dạy học nội dung Động năng và thế năng thuộc chương trình Vật lí lớp 10. Dựa trên cơ sở lí thuyết về giáo dục STEM và dạy học tích hợp giáo dục hướng nghiệp, chúng tôi xây dựng các hoạt động học tập trong bài học STEM bám sát công việc kĩ sư thiết kế tàu lượn siêu tốc trong công viên giải trí nhằm tăng cường hứng thú nghề nghiệp và bồi dưỡng năng lực định hướng nghề nghiệp của học sinh. Kết quả nghiên cứu thực nghiệm với 116 học sinh lớp 10 cho thấy bài học STEM tích hợp giáo dục hướng nghiệp* "Kĩ sư thiết kế tàu lượn siêu tốc" *đã giúp đạt được các yêu cầu cần đạt về năng lực vật lí thuộc nội dung động năng thế năng. Bên cạnh đó, kết quả khảo sát hứng thú nghề nghiệp STEM sử dụng công cụ STEM-CIS (STEM Career Interest Survey) cho thấy học sinh sau khi tham gia bài học cảm thấy tự tin hơn với các công việc trong lĩnh vực STEM, từ đó nâng cao hứng thú nghề nghiệp STEM để từ đó học sinh có định hướng lựa chọn nghề nghiệp. Kết quả đánh giá và phân tích biểu hiện năng lực định hướng nghề nghiệp cho thấy các em đã có nhận thức tốt về công việc kĩ sư.*

Từ khóa: bài học STEM; giáo dục hướng nghiệp; giáo dục phổ thông; dạy học tích hợp; dạy học khoa học