Research Article in Physics Education Research

Exploring STEAM Education Activities Based on Project Production—A Case Study on “the Changeable Road” Project

Yan Fan[1], Yuxuan Yang[1], Wei Li[1], Chao Gong[1], Li Xie[1*]

School of Physics and Optoelectronic Engineering, Yangtze University; Jingzhou 434023, China

[*] Correspondence: shirlyxieli@yahoo.com

(Received: 09/16/2019; Accepted: 04/17/2020; Published: 04/21/2020)

DOI: https://doi.org/10.37906/real.2020.1

Abstract: STEAM education is a new concept in the field of education that focuses on fostering students' critical thinking, creative problem-solving skills, and corporation skills, which are all essential for students to succeed in the modern workforce. The integration of STEAM concept into the physics curriculum can help students solve practical problems using interdisciplinary knowledge, which helps students form core discipline literacy. This paper takes the friction in "Motion and Force" in high school physics course as an example, takes "the Changeable Road" as the project theme, based on the 6E Design Learning Model including the process of "Scientific Inquiry" and "Engineering Design", and incorporates the concept of STEAM for the production of physics curriculum projects. The concept of the physics curriculum project is designed to provide a reference paradigm for the implementation of STEAM education in secondary schools.

Keywords: STEAM education; 6E design learning model; curriculum project design

1. Introduction

STEM is an abbreviation of four disciplines, namely Science, Technology, Engineering, and Math, which were collected by the American Science Foundation in the 1990s. In the field of education, STEM focuses on Mathematics and Science (Bybee & Rodger, 2010). The U.S. government proposes to use STEM as the core of education to ensure that American science and technology is in the leading position internationally (Beering, 2009). STEM education focuses on the direction of mathematics, science, and technology, and ignores the all-round development advocated by educational concepts such as the Balanced Personality Development and the Theory of the Multiple Intelligences. Therefore, STEM has caused heated discussions in the education community. The President of Rhode Island School of Design John Maeda proposed: "STEM + ARTS = STEAM" (Maeda, 2011). He believed that the unique creativity, flexible thinking, and problem-solving ability of art in the creative process are the keys to the development of STEM education. Professor Yakman (2008, 2012), an American educator, saw STEAM as a developing educational model of how the traditional academic subjects (silos) of science, technology, engineering, arts and mathematics can be structured into a framework by which to plan integrative curricula. It is a mathematics-based interpretation of science and technology through engineering and art, emphasizing the extensibility of classroom design, embodying the important position of artistic humanistic innovation education (Richter & Kuester, 2014) and design thinking in interdisciplinary education, allowing students to be in real problem situations. Learning, applying multidisciplinary knowledge-solving education models in project-based activities, aimed at developing students' potential for exploration, creativity, interaction and development (Yew & Goh, 2016).

With the rapid development of science and technology innovation, the internet makes all information extremely easily accessible to the public. As a result, the modern workforce must have the ability to use the internet and other modern tools to acquire and internalize knowledge (Piaget, 1957). For teachers, the teaching objectives should be clearly identified according to the curriculum standards. The instruction design should not only focus on the development of students' high-level skills such as knowledge transfer and problem-solving ability (Jeon & Lee, 2014), but also build students' characters such as critical thinking and innovative spirit. However, although the middle school physics classroom in China is actively reformed in accordance with the requirements of the curriculum reform, most of the classroom still focuses on the teaching of knowledge (Shi, 2017). Therefore, it is high time to promote the STEAM concept to be used in physics teaching, so as to promote the development of students' innovative thinking and problem-solving skills in real-life situations.

2. Analyze the Suitability of the Combination of Curriculum Standard and STEAM Concept

Curriculum standard is the first element of curriculum content, and a central guide to curriculum development. Morrison and Raymond (2009) pointed out that dividing knowledge into discrete subjects does not promote an in-depth exploration of nature, nor does it reflect the authenticity and complexity of the world we live in. The goal of STEAM education is to break the boundaries between different disciplines, synthesize interdisciplinary knowledge. It advocates students to think creatively, solve real-world problems in their own way (Pinkel, 2016).

Nowadays, the concept of STEAM education is gaining more popularity in the world. Schools in the United States, Canada, Israel, and other countries have put more emphasis on the "experience" of science since primary school, the "learning by doing" in the field of science and technology, as well as the improvement of innovation ability in the "experience". More specifically, the development of STEAM education in the United States is relatively mature, has developed into a national strategy. In 2010, the United States promulgated the country's first primary and secondary school curriculum standards, the Common Core State Standard (2010), which defines the knowledge and skills that K-12 students should possess in terms of communication skills, use of multimedia technologies, and information processing. Although high school physics curriculum standards formulated by Australia, the United States, Canada, South Korea, and other countries have slightly different formulation for the requirements of student abilities, they all focus on developing students' scientific inquiry skills (Anggraini & Sani, 2016) and scientific thinking skills (Erman, Wasis, Susantini & Azizah, 2018), the ability to analyze and solve physical problems, etc. In 2016, the Ministry of Education of the People's Republic of China released *Core Competencies and Values for Chinese Student* (2014), which showed the vision of Chinese education for future talents, defined the vision of the STEAM curriculum. Under the new round curriculum reform in China, *The National Physics Curriculum Standards for general High School* (2017) also explicitly states that the high school physics curriculum should cultivate students' core literacy (Hill, 2013), including Physical Concepts, Scientific Thinking, Scientific Inquiry, Scientific Attitudes and Responsibilities, so as to lay the foundation for future students' employment and lifelong learning.

3. STEAM Course Project Design based on 6E Design Learning Model

Developing and designing STEAM courses is the key to practicing the STEAM philosophy, which is an effective way to cultivate students' innovative technological literacy and implement curriculum reform. The United States, the main promoter of STEAM curriculum reform, has developed some related courses and accumulated a lot of theoretical and practical experience for reference, such as Project Lead the Way (2015), Engineering by Design™ (2011). Educators have proposed different curriculum design models, especially, 6E Design Learning Model is a popular course design model that was introduced by International Technology and Engineering Educators Association in 2014, which integrates "Scientific Inquiry" and "Engineering Design" (Burke, 2014). Therefore, based on the 6E Design Learning Model, this section explains the physics curriculum design that can integrate the concept of STEAM.

3.1 6E Design Learning Model

6E Design Learning Model, proposed by ITEEA in 2014, has been a much-respected curriculum design model in recent years. It is a teaching model that emphasizes "engineering design" and "student engagement". The main task of teachers is to assist students when they need help. In the teaching process, teachers take the Socratic Method to students and encourage discussions among students to guide students to explore the subject of the course and build a knowledge framework. During the learning process, the students propose a design plan after group discussions, and propose improvement plans based on the test results of the work during the subsequent project implementation process. Students first identify problems in real-world situations, and then use interdisciplinary knowledge to solve these problems. 6E Design Learning Model proposed by Barry (2014) includes six progressive learning stages of Engage, Explore, Explain, Engineer, Enrich and Evaluate. The brief description and their relationship are shown in Figure 1 (Burke, 2014):

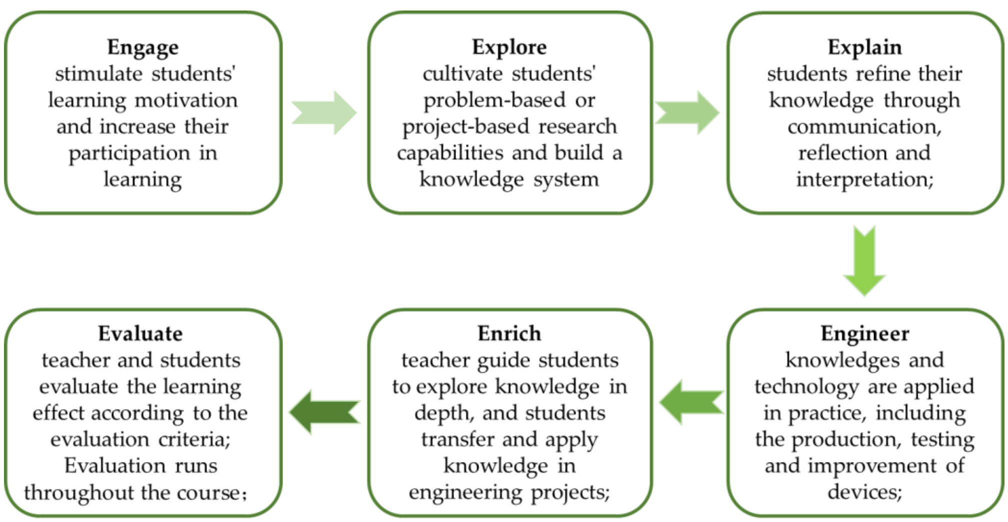


Figure 1. The contents of 6E Design Learning Model

3.2 Friction and "the Changeable Road" Project

In daily life, students often come in contact with various phenomena and problems related to friction. Most of them have some initial knowledge of friction from middle school, but some still have a limited understanding of friction with a great number of misconceptions (Zhu & Zeng, 2019). *The National Physics Curriculum Standards for general High School* (2017) has clearly pointed out that students should have learned the basic knowledge of friction in middle school, and put forward higher requirements in high school, where they study friction in combination with force analysis. To study friction, one must first study the conditions under which it occurs, and understand the concepts of motion, relative motion, and relative motion trends. From that, students can judge whether there is friction, the magnitude, and the direction of friction, which can cause difficulty among students. Teachers need to correct these students' misconceptions through experimental demonstrations and case studies, so that the students can fully understand the friction force. In teaching, some teachers use multimedia to help students understand friction, whereas some schools with better hardware facilities use frame by frame analysis.

As the concept of friction can be challenging for students to understand and apply in real life, it is worth using the 6E Design Learning Model to create a STEAM curriculum that helps students contextualize this concept. In the process of engineering manufacturing, students can use scientific knowledge, mathematical calculation, and other abilities to learn the concept of friction and solve practical problems, which will further extend students' understanding of related concepts and improve students' core literacy of physics. This article takes the friction in "Motion and Force" in high school physics course as an example, takes "the Changeable Road" as the project theme, based on the 6E Design Learning Model, and incorporates the concept of STEM for the production of physics curriculum projects. The main contents are shown in Table 1.

Table 1. Integrating project production and STEAM concepts in the creative design of "the Changeable Road"

STEAM	Set Course Objectives	Involving 6E process
S（Scientific Knowledge）	Concepts of friction, pressure, etc., factors affecting the magnitude of friction, the contents and conditions of equilibrium.	Engage; Explain; Evaluation;
T（Application of Technology）	The geometry sketchpads, 3D printing technology, computer programming, 3D computer graphics, information retrieval, and application, sensors, assembly ability; use of hand tools or machines, creative design, product testing and correction, energy and power, 2D computer graphics;	Explore; Explain;
E（Engineering Manufacturing）	Structural design, computer graphics, material use, component assembly, engineering design, product testing and optimization, problem raising and solving;	Explain Enrich Evaluation
A（Art Embodiment）	Aesthetic ability, structural aesthetics, design, color matching, hand-tooling operational capacity, handicraft ability, material assessment and application, statistical contents and methods;	Engineer Evaluation
M（Mathematical Thinking）	Data measurement and calculation; geometric concepts, angle conversion, unit conversion, reading, geometric concept, algebra and analytic geometry;	Engage Explore Engineer

3.3 STEAM-6E teaching procedures

3.3.1 Engage

Before the course, the teacher shows the students a video of a car braking in the snow before and after installing the anti-skid chain, so that the students have some intuition that friction is ubiquitous in daily life. Through the situational setting, the students are guided to review knowledge of friction they have learned, and to understand the research theme of the course—Friction. The teacher raises the student's guess through the setting of the problem group, asks the students to verify by manufacturing the product. After reviewing prior knowledge on friction and group discussion, the students have some preliminary understanding of the topic. The design framework for the initial construction of the activity can be based on the problem sets provided by the instructor. On the basis of the students' existing knowledge and experience, the teacher proposed the learning task of making "the Changeable Road ", requiring the students to make products that could explore the relationship between friction and pressure and roughness of contact surface respectively, and could accurately measure the magnitude of friction force on the object.

Note: the raw materials for this course are provided by the teacher. Students can only use the raw materials provided by the teacher to design and make experimental devices. Qualified materials and tools are shown in Table 2:

Table 2. List of materials provided

Name	Quantity / Size
Computer	5
3D Printer	1
Sensor	1
Date Display	2
Caterpillar Tread	3 (tracks with different roughness)
Hot Glue	Several
Planks	6 （150cm*100cm*1.5cm）
Utility Knife	5
Spring	Multiple springs with different stiffness coefficients
Pulley	Several
Traverse	Several
Screwdriver	Slotted, Phillips, Pozi, Torx and other types;
Nail	Several
Weights	10*50g
Power Supply	2
Crank Handles	2
Towel	Several
Rubber sheet	Several
Glass	4(15cm*8cm*0.2cm)
……	……

3.3.2 Explore

Students are asked to review the knowledge of friction through different channels to answer the following questions more accurately: What is the concept of friction? What are the different types of friction? What is the definition of each type of friction? Can you give some examples of these frictions in real life? What are the factors that affect friction? Can you explain the factors related to the braking distance of the car? The teacher then introduces students to the concepts and processes of modeling. Students construct scientific knowledge models of physics through scientific inquiry, which includes three stages: asking questions, collecting evidence and explaining communication. Next, the students begin to design the project plan. The teacher guides the students to build the model step by step through a series of questions. For example: what components are included in the project plan you designed? What are their functions, and what is the size of each component? Is the part size setting reasonable? Where is the basic location of these components? How to connect each component, and how to design to make the whole device more presentable and artistic? How does the finished product work? Can you describe the principle of the design scheme? What is the specific method of operation? In addition, the teacher asked the students to draw a schematic diagram of the model of the project design scheme. The above specific content is shown in Figure 1. See Appendix I for details.

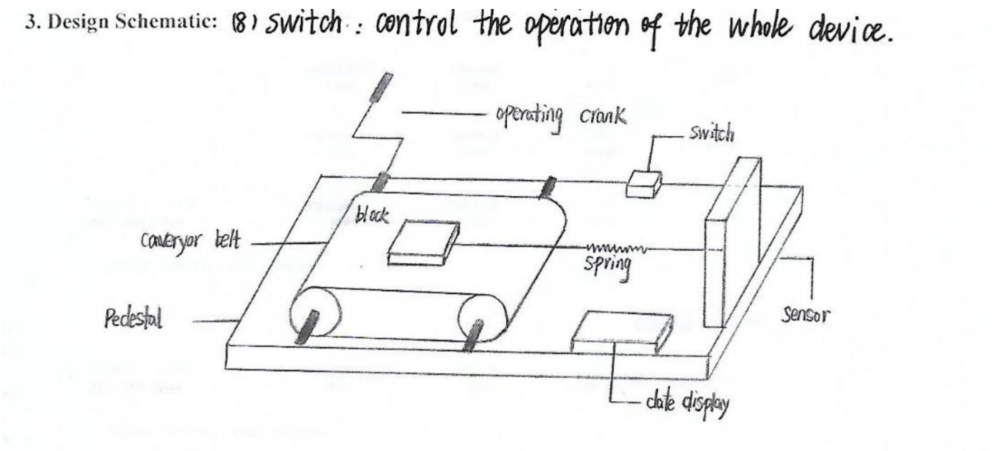


Figure 2. Some contents of student design plan about project design sketch

3.3.3 Explain

Students explain the design of the product from the perspectives of design principles, appearance, display devices, and data measurement. Students need to solve the problem of fixing the conveyor belt to the base in the design. After understanding the students' final design, the teacher asks the students to answer the following questions: How to fix the conveyor belt on the base? How to ensure the uniform transmission of a conveyor belt? Why do you think the conveyor belt can be approximately considered to move at a constant speed? How can the mass on the conveyor belt and the force sensor be connected to more accurately study the impact of friction on contact with different roughness levels? How does the display connect to the sensor to work properly? How can the relative position of each component make the whole product more attractive and durable? Students in other groups listen, question, and evaluate other students' designs. Next, students use Geometer's Sketchpad or other drawing tools to draw a schematic structure of the "the changeable road". This design drawing is required to clearly mark the basic location of the conveyor belt, sensor, block, switch and other parts, as well as the size of each part. In addition, students will explain how the entire product works.

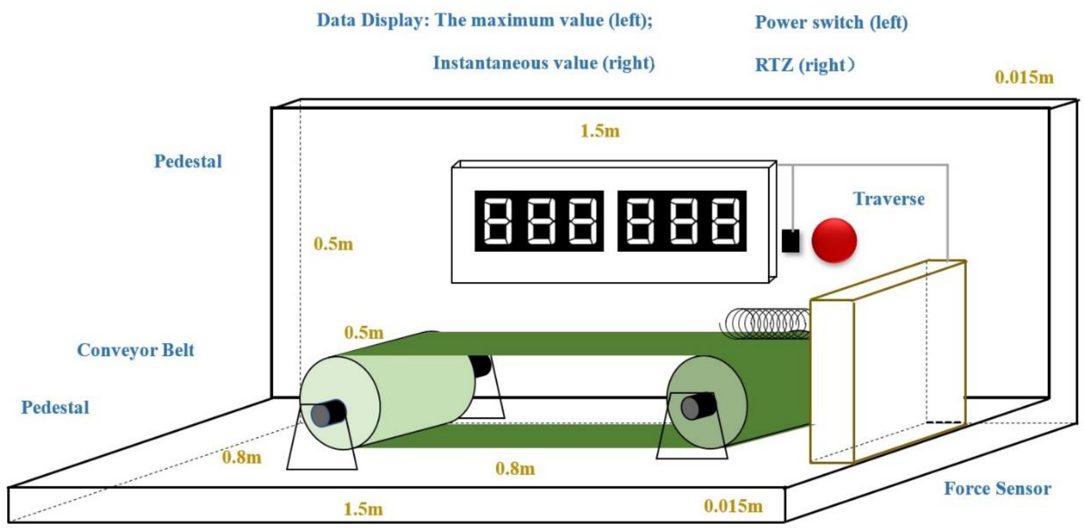


Figure 3. Schematic diagram of "the changeable road" structure modified by students

3.3.4 Engineer

Students' technical ability and practical ability are essential in the project production process. (Grady & Michael, 2012). The teacher restates the design process to the student, provides the student with the materials needed for the product design, and assists the teams to start building the product using the given tools and materials according to their design. The teacher checks the quality of the production process. The students complete the production of the various components in the design, including the entire base, the assembly of the conveyor belt, the data display, the force sensor, the power supply, and the switch. After the completion of each component, other students questioned and evaluated the manufactured parts, and whether the product's specifications and quality were problematic, whether the part was not suitable for the content of this course. After many improvements, the students assembled the components together as a team. Based on the data obtained from the debugging, the design of the entire product is optimized from the perspective of the stability of the entire device, the rationality of the position of each part, and the aesthetics.

Figure 4. The picture shows the students' production equipment.

3.3.5 Enrich

The teacher encourages the students to think about how to use this device to explore the relationship between the friction and the roughness of the contact surface and the pressure on the contact surface of the object. In the process of exploration, the teacher explained that when the object moves on the contact surface, the friction force in a certain range is constantly changing. Therefore, the experiment explores the relationship between the pressure, the roughness of the contact surface and the maximum static friction. Then, the teacher encourages students to control different variables in the process of exploration. Under the premise of being able to solve the existing problems, students' products can expand from the original design scheme, and test the impact on friction by designing different contact surfaces that can be attached to the track. The students can also change the mass of the object (by adding different numbers of weights to the object), and then measure the relationship between pressure and friction. After getting the data from the experimental device, the teacher asked the students to analyze the data. Students use Excel and Origin to plot the relationship between the maximum static friction and mass, as well as the relationship between the maximum static friction and the roughness of the contact surface. According to these plots, the students will conclude that the maximum static friction force on the object is proportional to the pressure when the roughness of the contact surface is constant; when the pressure is constant, the coarser the contact surface is, the greater the maximum static friction force on the object is.

Table 3. Experimental data table

	A(X)	**Mean(Y)**	**SD（yEr-）**
Long Name	Pressure/N	Maximum Static Friction/N	
Unite			
Comments			
1	1.50	0.87	0.06
2	2.00	1.17	0.10
3	2.50	1.53	0.05
4	3.00	1.73	0.07
5	3.50	2.04	0.07

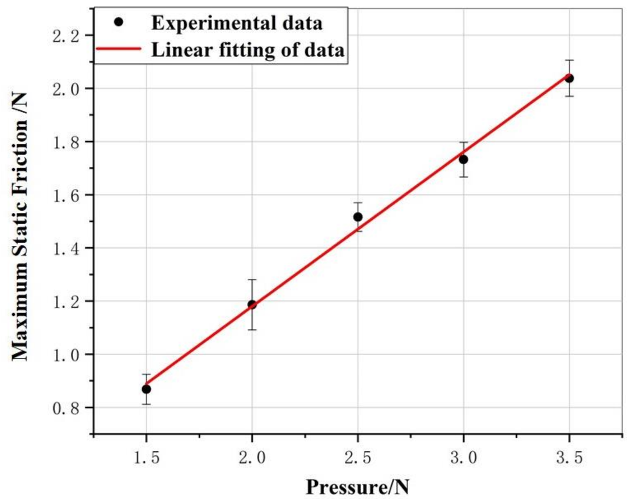


Figure 5. Experimental data

3.3.6 Evaluation

Evaluation is an important part of the education system. At this stage, a variety of methods such as self-evaluation, student mutual evaluation, and teacher evaluation, innovative thinking evaluation, and achievement display evaluation are used to comprehensively examine students' abilities. During the project design and production process, students' self-evaluation and mutual evaluation were used to record student participation and contribution. The teacher evaluates students from the perspective of their knowledge, creative thinking, and practical skills. After the product construction is completed, the students will display their works and vote for the best design. The teacher finally expanded the "Changeable Road" project, such as trying to use a speed-adjustable motor to make the moving belt move at a uniform speed.

Table 4. STEAM-6E Project Evaluation Scale

Evaluation Index	Weights	Comment Contents
Self-evaluation	20%	Students actively participate in the project production; carefully record and summarize research content during the course; flexibly use interdisciplinary knowledge to solve practical problems when creating works;
Mutual Evaluation	20%	No absenteeism, team awareness, good communication with others, division of labor and collaboration during the course;
Teacher's Evaluation	20%	Students are proficient in the basics of the operation of various tools, use computers to collect information reasonably; they can properly connect displays， sensors, and other components, proficient in drawing software, and correctly assemble various parts; The students' design themes are artistic and fit the theme of the times.
Creative Thinking	25%	Students have the enthusiasm for creating works, the ability to find and solve problems, and be able to solve problems in different ways of thinking; they can propose multiple solutions to problems that arise;
Practical Skills	15%	The structure of the work is complete, clearly showing the operation process of the entire device, the use of standardized and organized language to explain the operation principle of the device, and relevant conclusions can be concluded from the experimental data.

4. Conclusion and Reflection

The physics curriculum project production is a practical activity for students to understand the principle of the device and explore the essence of physics. It is an effective way to meet the needs of students' design research, hands-on practice and innovation creation. In the engineering learning activities that incorporate art, students not only completed the theoretical exploration of "the Changeable Road", but also used the knowledge of sciences such as physics and mathematics to understand engineering and technology such as information technology, software, and modeling. Combining art, design and other artistic content, students continue to interact with real-world situations, constantly solving problems and forming a conceptual understanding. In this process, thinking patterns and inquiry skills are gradually formed, and interdisciplinary knowledge and skills are continuously structured (Helle & Olkinuora, 2006). Through project design and product production, students experience the process of scientific inquiry and engineering design, experience the correlation between physics and other disciplines, and fully grasp the knowledge related to friction. The production process of physical experimental instruments is a process of deepening understanding and flexible use of relevant physical knowledge by students. In the design of the physics course "Changeable Road" project, the conversion method is used to use static friction and sliding friction in different regions. The numerical value is presented to clearly demonstrate the phenomenon, which can attract students' attention and help students understand the essential laws of static friction and sliding friction.

Limitations of this study include limited diversity in student participants (use of one school, with the same teacher). It is unclear whether these results can be replicated in different schools or in different geographical areas. Another limitation of this study is that there is no evaluation standard for STEAM projects, and no corresponding evaluation tools, including questionnaires and tests. Another limitation to the study is not comprehensive enough, no more systematic and in-depth investigations have been made, no evaluation criteria for the STEAM project have been established, and corresponding evaluation tools, including questionnaires and tests, have not been established.

We need creative talents to establish productive collaborations with scientists, educators, and technical experts to advance STEAM education. (Hunterdoniger & Sydow, 2016). It also requires artists, architects, designers, planners, and innovation writers to find new ways to look, feel and create meaning in our world (Connor & Karmokar, 2015; Kang, Jihyun, Yuna, 2012). The purpose of this paper is to provide a reference paradigm for the development of physics courses that contain the STEAM concept. The development of physics courses based on the STEAM concept also requires new physics educators to be innovative and advance with the times basing consolidating the knowledge of the subject.

Funding:

This research was funded by Humanities and Social Sciences project of the Ministry of Education of China, grant number 18YJC880094 and Educational Science Planning Project of Hubei Province, grant number 2019GB024.

Acknowledgments: Firstly, the authors would like to thank the teachers and students of the relevant middle schools in Jingzhou City for their support and cooperation in this physics course, which is an important cornerstone for carrying out this research. And thank the professor Xie for her comments and suggestions on the author's research.

Conflicts of Interest: The authors declare no conflict of interest.

References:

Anggraini, P., & Sani, R. A. (2015). The effect of scientific inquiry learning model and creative thinking ability on science process skills of student. *Jurnal Pendidikan Fisika, 4*(2), 47-54.

Barry, N. (2014). The ITEEA 6E Learning by DeSIGN™ Model. T*echnology and Engineering Teacher, 73*(3) 14-19.

Beering, S. (2009). Actions to improve science, technology, engineering, and mathematics (STEM) education for all American students [Letter from the National Science Board STEM education outlining recommendations for the President-Elect Obama administration]. Retrieved January 1.

Burke B.N. (2014). The ITEEA 6E Learning by DeSIGN™ Model: Maximizing Informed Design and Inquiry in the Integrative STEM Classroom. *Technology and Engineering Teacher, 73*(6), 18-19.

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher, 70* (6), 30-35.

Common Core State Standards Initiative. (2010). Common Core State Standards for Mathematics,4-8.

Connor A.M., Karmokar S., & Whittington C. (2015). From STEM to STEAM: Strategies for Enhancing Engineering & Technology Education. *International Journal of Engineering Pedagogy, 5*(2):37-47.

Erman, E., Wasis, W., Susantini, E., & Azizah, U. (2018). Scientific Thinking Skills: Why Junior High School Science Teachers Cannot Use Discovery and Inquiry Models in Classroom. *In International Conference on Science and Technology (ICST 2018)*. Atlantis Press.

Grady, O., & Michael, J. (2012). Practical problem-based learning in computing education. *ACM Transactions on Computing Education (TOCE), 12*(3), 10.

Helle, L., & Olkinuora, P. T. (2006). Project-Based Learning in Post-Secondary Education: Theory, Practice and Rubber Sling Shots. *Higher Education, 51*(2):287-314.

Hill, R. A. (2013). Narrative nonfiction for STEM (science, technology, engineering, and math) reading: One option for Common Core literacy. *Teacher Librarian, 40*(3), 31.

Hunter-Doniger, T., & Sydow, L. (2016). A journey from STEM to STEAM: A middle school case study. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 89*(4-5), 159-166.

International Technology and Engineer Education Association. (2015). The Engineering by Design. https://www.iteea.org/STEMCenter/EbD.aspx

Jeon, S., & Lee, Y. (2014). Art based STEAM Education Program using EPL. *Journal of The Korea Society of Computer and Information, 19*(4), 149-158.

Myunghee, K., JiHyun, K., & Yuna, K. (2013). Learning Outcomes of the Teacher Training Program for STEAM Education. *Korean Journal of Chemical Engineering, 7*(2), 18-28.

Maeda, J. (2011). STEM to STEAM.

http：//www.core77.com/posts/20692/getting-steamy-in-rhode-island-20692.

Ministry of Education of the People's Republic of China. (2014). Core Competencies and Values for Chinese Student s' Development. Beijing Normal University Publishing House.

Ministry of Education of the People's Republic of China. (2017). The National Physics Curriculum Standards for general High School. Beijing Normal University Publishing House.

Morrison, J., Bartlett, R., & Raymond, V. (2009). STEM as curriculum. *Education Week, 23*(19.03), 28-31.

Piaget, J. (1955). The construction of reality in the child London Routledge & Kegan Paul.

Pinkel, S. (2016). STEM, STEAM, STEAMS. *Leonardo, 49*(1), 2-2.

Pltw programs overview. (2011). http://www. pltwcalifornia.org.

Richter, A. M., Petrovic, V., Kuester, F., Seracini, M., & Angelo, R. (2014). From stem to steam: Towards aerospace partnerships with cultural heritage diagnostics. *In 2014 IEEE Aerospace Conference*, 1-11.

Shi, Y. J. (2017). Research on Junior School Physics Course Design Based on STEAM Concept (Master's thesis, Guangxi Normal University).

Yakman, G. (2008). STΣ@M Education: an overview of creating a model of integrative education. Pupils Attitudes Towards Technology. *2008 Annual Proceedings*. Netherlands.

Yakman, G., & Lee, H. (2012). Exploring the exemplary STEAM education in the US as a practical educational framework for Korea. *Journal of the Korean Association for Science Education, 32*(6), 1072-1086.

Yew, E. H., & Goh, K. (2016). Problem-based learning: an overview of its process and impact on learning. *Health Professions Education, 2*(2), 75-79.

Zhu, Q., & Zeng, X. (2019). The Teaching Design of "Friction" from the Perspective of Core Literacy. *Middle School Physics, 37* (23): 42-45.

Appendix I.

Friction Course Project Production

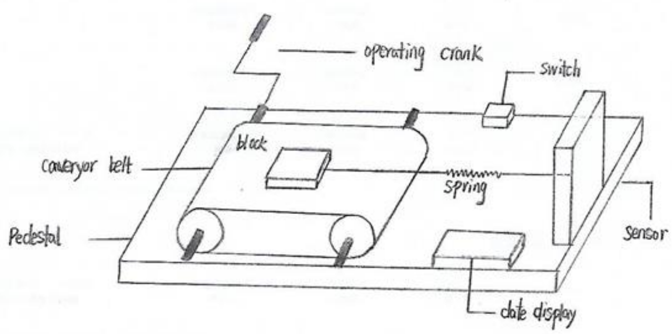
Group: 5th group; Fill in the date: 2019. 10. 15;

1. Project Name: " Changing Roads" Project Production

2. Experimental Equipment: (fill in the required materials in the form)

(1) pedestal : it is composed of two mutually perpendicular broads connects by Angle iron connects ;
(2) conveyor belt: composed of track and roller;
(3) force sensor: used for measuring the force on the blocks ;
(4) date display : it is used to display the force size of the object ;
(5) spring : used for connecting the block and force sensor ;
(6) crank : rotate the crank to drive the movement of the conveyor belt;
(7) power supply : it is an essential component for the normal operation of the force sensor and date display ;
(8) switch : control the operation of the whole device.

3. Design Schematic:



4. Device Operation Instructions:

When you start the test, please hold the instrument with one hand and rotate the shaft with the other hand to make the conveyor belt and the object move to left. When the ~~conveyory~~ conveyor belt and the object move for some distance, the block and the belt move relative to each other. At this time, the static friction force changes to sliding fiction force. At this point, you can stop the rotation axis to record the value displayed by the date display, and then know the maximum static friction force on the object. After, measuring a set of data, restart the power, reset and read the next set of experiments. again