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Perspective

Innovation event model for STEM education: A constructivism perspective

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Abstract: STEM education aims to cultivate innovative talents by improving students' ability to comprehensively apply interdisciplinary knowledge in solving practical problems. This paper first develops an innovation event model through the analysis of 50 historical innovation events that can be traced back to whole human history. The model divides the realization process of those innovation events into four steps: 1) pointing out a problem, 2) proposing solutions to the problem, 3) concrete implementation of those solutions, and 4) iterative modification process. And then, the relationship between innovation event model and STEM education is established from the perspectives of subject integration and constructivism of STEM education. Based on this model, we can understand some key issues in the implementation of STEM education from a top-down view, including the nature of STEM education, the knowledge integration model, and the relationship between subject-specific education and integrated education. This will help to gradually improve our cognition and understanding of STEM education, so as to achieve its initial goal of integrated and innovative education. This article will contribute to a holistic rethinking about how to renovate STEM education in different levels of schools and colleges, equipped with such an innovation event model.

Keywords: STEM education, innovative event model, knowledge integration, constructivism

1. Introduction

Education should keep pace with the development of the times, meanwhile being a booster of social progress. In the 21st century, dominated by knowledge and globalized economy, "what kind of person to cultivate" has become the focus of all nations' attention, which is directly related to the future of a country's comprehensive strength and power of voice at the world stage. In this context, many countries have carried out educational reform one after another, and STEM education, which is committed to integrating subject knowledge and cultivating interdisciplinary and innovative talents, stands out. In 2017, National Institute of Education Sciences of China released the White Paper on STEM Education in China and launched the "2029 Innovation Action Plan on STEM Education in China", marking that China would raise STEM education to a new level[1].

The acronym "STEM" comes from the initials of Science, Technology, Engineering and Mathematics. It emphasizes cultivating students' ability to use various disciplines to solve problems in the real world [1]. Research on STEM education has been increasing exponentially since 2000, reflecting that this topic has gradually attracted attention of worldwide scholars. Different literature has anatomized the connotation and critical issues in the practice of STEM education from different perspectives. But undeniably, STEM education is still immature in theory and practice. As STEM education aims to cultivate innovative talents, this paper will conduct research to shed insights on how to achieve this goal. Concretely, the paper first traces 50 typical innovation events in history to draw up an innovation event model, and then clarifies the essence and critical issues of STEM education from a top-down view based on this model.

The remainder of this paper is organized as follows. Section 2 will introduce how the prior studies model the innovation events based on the innovation cases. The methodologies on establishing the relationship between the innovation event model and STEM education will be demonstrated in Section 3. Then the enlightenment of the innovation event model to STEM education will be discussed in Section 4. We will conclude this paper in Section 5.

2. Modelling the innovation events based on innovation cases

Schumpeter, an economist, was the first person to elaborate on the concept of innovation. He believed that innovation was referred to the establishment of a brand-new production function, which was capable of recombining various factors in the production sector [2]. This new production combination could be: 1) a new product or a new characteristic of the product; 2) a new production method, which does not need establishing on new scientific discoveries; 3) the opening-up of a new market; 4) new materials or sources of supply; 5) a new industrial organization [2]. In addition, Schumpeter distinguished innovation from invention, arguing that invention represented a less sufficient condition for innovation. Only the invention that could create new value, was exactly what he called innovation. Certainly, in this sense, innovation inherently contains the economic value and promotes positive social development.

Based on the concepts mentioned above, this paper traces the direct cause and process of every innovation, as for which we call it an innovation event. Given that the occurrence of innovation events is often intertwined with personal subjective consciousness and intangible inspiration, so far, we still cannot use formulated methods to demonstrate how to produce innovation. There have been countless

[1] White Paper on STEM Education in China (Essence Edition), http://www.ict.edu.cn/uploadfile/2018/0507/20180507033914363.pdf

innovation events in human history. In other words, the history of human civilization can be translated as that of continuous innovation and progress to follow. This paper sorts out 50 innovation events (as seen in the appendix at the end of the paper). Compared with the whole history of human development, the examples here are only a waterdrop in the ocean. However, from the analysis and research of these innovation events, we can still have a glimpse of the typical conditions and characteristics related to the occurrences of innovations, and thus draw the model diagram of innovation events. As shown in Fig. 1, it divides the process into four steps, namely: 1) pointing out a problem; 2) proposing solutions to the problem; 3) realizing the solutions concretely; 4) testing those solutions iteratively by feedback in practice.

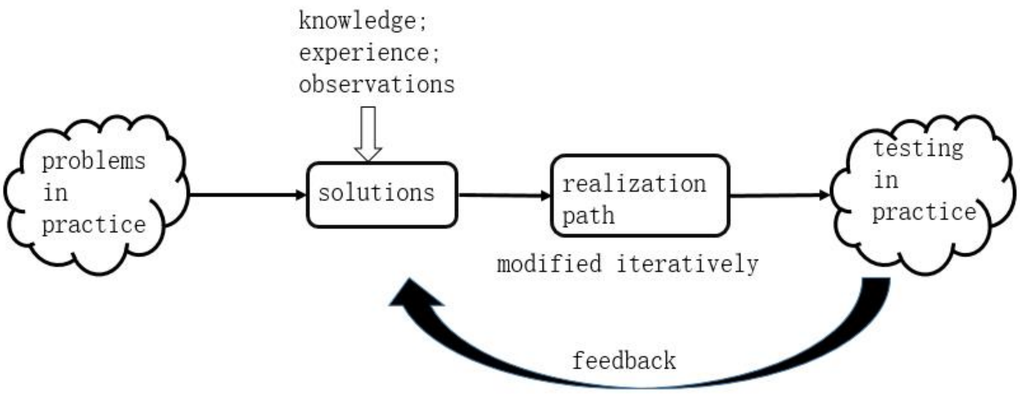

Figure 1. The Innovation Event Model

Step 1. Finding problems is the key factor for innovation.

First of all, it is the key factor for innovation to point out problems in practice. If none of the problems can be raised, we will lose direction for any innovation. In the list of 50 innovation events, only five events were based on accidental factors and the rest were all driven by certain problems, which were inspired by the difficulties or deficiencies encountered in the working or living practice of innovators. For example, to accurately measure the body temperature of patients, a French man named Brio invented the mercury-in-glass thermometer. However, due to the lack of a unified method to measure the temperature change at that time, it was still very inconvenient. Warren, a Dutch scientist, formulated the Fahrenheit scale to get rid of the snags [3]. Also, the stethoscope was invented by Rene Linnac to examine a patient's heartbeat [4]. Thus, it can be seen that problems in practice play a driving role in innovation. It is under the drive of the perplexity of these problems that innovators take the initiative to fill the knowledge gap, constantly observe various phenomena in life, and try various possible solutions.

Some innovations were truly resulted from an accidental happening. For example, aniline purple, a chemical dye firstly synthesized in human history, was accidentally discovered by British chemist William Perkin while he was extracting quinine, a specific drug for malaria treatment [5]. Although it was an unexpected discovery, he immediately realized that it could be applied to fabric dyeing.

In the face of the accidental phenomenon, people with a strong sense of innovation would not hastily neglect without further contemplation, but they would seriously analyze the scientific principles behind it, and quickly apply it to solve other existing problems. Therefore, it is reasonable to conclude that these problems have long resided in the minds of innovators.

Step 2. Proposing solutions to those problems.

For the second step, a solution should be formed to solve the problem. On the one hand, the formation of the scheme is based on the experience and knowledge of the innovator or innovation team. On the other hand, it is inseparable from the various phenomena observed by the innovator or innovation team during this period. For example, the idea of PageRank algorithm originated from, then a university student, Page's intention to exploit the value evaluation method of academic papers to evaluate the importance of websites [6]. Clarence Birdseye observed that the fish caught under the ice were extraordinarily delicious after defrosting, which inspired him to study the related techniques of quick-freeze [7].

Step 3. The Concrete realization of the solution

The third step is to implement the scheme. Compared with the period of making a proposal, there are many engineering and technical elements in the realization of innovation. Especially for the innovation presented in the form of product, the innovator must be capable of transforming ideas into reality, and administering various means of production, including manpower, materials, funds, equipment, etc. For example, in the 19th century, Frederick Reed had a whimsical idea of selling ice in the West Indies, which meant that he had to overcome a series of the core issues presented in the technology of collecting, storing and transporting. In fact, after reusing three almost free materials: sawdust, ice cubes and empty ships, problems were solved, and ice trade was turned into a profitable business [7]. In another case, Bi Sheng invented movable type printing around 1000 A.D., but there were many matching technical problems to be overcome if it was intended to completely replace the blocking printing. At that time, Bi Sheng used clay movable type, which had many disadvantages, such as difficult to be arranged and easy to be damaged, so that the whole printing effect was not as good as block printing. The lack of effect and efficiency disable it to be popularized on a large scale. Instead, several hundred years later, the greatest contribution of Gutenberg movable type printing, was not to invent the movable type itself, but to implement a whole set of printing technology and equipment, including lead-tin alloy to make movable type, so as to make the rapid and low-cost mass production of books become true [5].

Step 4. Testing those solutions iteratively by feedback in practice

Finally, the innovation is not something which can be achieved overnight. Final achievement must bear on the mark of iterative processes, the repeated attempts and the adjustments over the years according to experimental results. For example, in order to improve the quality of filament, Edison and his colleagues had tried more than 1600 kinds of heat-resistant materials [5]. Curie, during her study in France, discovered a radioactive element stronger than uranium in pitchblende. In order to find out what this element was, she spent five years refining dozens of tons of ore through tens of thousands of times. Finally, 0.1g pure radium chloride was obtained [5]. There was another similar case. Before Watt, Newcomen steam engine had been already invented, but its efficiency was not satisfactory. In order to improve this device, it took Watt 36 years, during which period he first added a condenser, then an epicyclic gear, an inert flywheel and centrifugal control valve etc. Finally, the steam engine was invented [5].

3. Establishing the relationship between the innovation event model and STEM education

From the analysis of the first section, it is not difficult to identify the relationship between STEM education and the innovation event model.

3.1. Analysis of the Relationship between the Innovation Event Model and Constructivism Learning Theory

It is generally believed that the guiding ideology of STEM education represents the core ideas of constructivism learning theory [8]. In essence, any learning theory is based on the theory of the nature of knowledge and how human beings perceive it [9].

Constructivism learning theory is widely divergent from the traditional teaching view, mainly from these two aspects:

Firstly, it is widely believed that the knowledge can be abstracted from the concrete situation. From the abstract and generalized knowledge, we can still come closer to the nature of the things around us. Also, it has another advantage because it can independently operate beyond realistic situations. However, the constructivism learning theory emphasizes the different situations of learning, which have the characteristics of being concrete and changeable. The constructivism advocates that there is no universal rule among different situations and the abstract concepts and rules are often unable to adapt to the changes of specific situations.

Secondly, the traditional teaching theory is greatly influenced by objectivism, which emphasizes the effect of external teaching elements on learning outcomes, and heralds teaching as a one-way process of knowledge transferring from one side to the other. In contrast, the constructivism learning theory emphasizes the subjective initiative of learners. Learning is a process in which learners actively utilize their experience and existing knowledge to construct knowledge system through active interaction with the environment.

In the innovation event model, the observed phenomenon counts as one of the important reasons for creating innovation schemes. This paper analyzes 50 cases listed in the appendix, among which innovative solutions of 25 cases are direct or indirect results out of the phenomena observed by innovators, such as the creative birth of radar, stethoscope, Apgar score table and frozen preservation technology, etc. In fact, the emergence of many innovations in human history can be formulated as the following procedures: deeply rooted itself in phenomena, then summarizing principles, applying principles and drawing inferences from one instance, inventing new methods and tools. Different knowledge backgrounds and cognitive styles, and even the same person in different periods, may have different interpretations of the same phenomenon. For example, when Karel and the textile female workers saw the triangle weaving method, due to their different knowledge structures, the presentation could be totally different in their mind [4].

The one with innovative spirits who always has questions in mind will try to interpret all the phenomena he sees from problems. This is exactly what constructivism is inclined to expresses that "cognition is a process in which learners can enhance, enrich and transform their knowledge and experience through the interaction of new and previous knowledge and experience. Learners will actively interact with the environment to a certain degree based on their own unique experience and worldviews, as a way to construct their own unique understanding of the world" [9].

Therefore, problem-based learning (PBL) becomes the main teaching method of constructivism teaching theory, which advocates project-based learning driven by problems in reality [10]. Also, it would promote the construction and understanding of knowledge through project practice. In that way, its learning pattern is consistent with the innovation event model. As shown in Fig. 1, every innovation event can be categorized as a PBL process. In order to find solutions and specific methods of the solutions, innovators explore the problems in practice, and comprehensively employ the knowledge and experience in different fields. In the repeated interaction, they succeed in improving the solutions, again and again, to finally solve the problem and promote the innovation.

Through the above analysis, this paper argues that in essence the innovation event model conforms with the constructivism theory in terms of the knowledge nature and cognitive views.

3.2. Analysis of the Relationship between the Innovation Event Model and Inter-discipline Knowledge

Discipline integration can be considered as a typical feature of STEM education, and almost all of the innovation events in the list cover the content of multi-domain or multi-discipline. This integration of different fields and disciplines mainly manifests itself in three aspects: 1) applying the methods and techniques of certain fields and disciplines into other professional aspects.

For example, Alexis Carrel improved the method of embroidery and then applied it to the suture of blood vessels, which was named after three stay sutures end-to-end anastomosis [19]; 2) promoting the innovative products in one field to other fields, such as the widespread use of steam engine in manufacturing, textile and navigation, and sonar system in gynecology; 3) the process of realizing innovation itself involves multidisciplinary knowledge. For example, the invention of the telegraph was involved in applying electromagnetic theory. In the meantime, how to manufacture and package the wires belongs to the knowledge of engineering. As for how to convey the information about electricity as the carrier is more relevant to the contents of linguistics [5]. It should be emphasized that the multidisciplinary integration characteristics of the cases in the list have nothing to do with any deliberate screening from us. Instead, the occurrences of innovation all come from the problems in life or production practice, and these problems naturally have the characteristics of disciplinary integration. For example, how to manufacture light and warm clothes involves hylology, art design and production techniques, and even market analysis and other disciplines also play different roles. Once human started practice, there would be no abstract subject. Also, thanks to the phenomenon research, abstract knowledge comes into existence, together with the assistance of summary of experience and secondary practice-based processing. Dividing knowledge into disciplines can help us complete the systematic teaching of knowledge, but it does not conform with the facticity and complexity of real-life [11].

As we all know, STEM is the acronym of Science, Technology, Engineering and Mathematics. Why should it be emphasized here the integration of these four disciplines? We can approach to this issue from the innovation event model. Innovative solutions are generally based on the scientific principles behind certain phenomena. Such as, the research and invention of radar started when Watson Watt observed the phenomenon of high-rise buildings reflecting radio signals. Science plays a guiding role in clarifying the causes of problems and providing the solution. To realize the innovative scheme, it is necessary to solve a series of engineering and technical problems where engineering is responsible for process management, technology takes the charge of generating specific functions, while mathematics becomes an indispensable tool for all other disciplines. Only when a principle or method is transformed into a formal mathematical language, can quantitative analysis find its place. In the innovation event model, around the problems in reality, science, engineering, technology and mathematics are combined to form a unified entity.

4. Enlightenment of the innovation event model to STEM education

The way we human beings recognize the macro objects resembles that of blind people feeling for objects. Different people study objects from different angles, get different information, and then integrate the observed information into an organic entity mainly by scientific thinking methods, including deduction and induction. STEM education aims to cultivate innovative talents to meet the needs of productivity development in the future. In exploring how to achieve the goal of talent cultivation, scholars first normally depict some typical characteristics of the feasible education model, from different angles, such as inter-disciplines, real situation, the experiential, etc. However, it is not sufficient to simply focus on the surface level, because it cannot solve the problem of the essence of STEM education which is otherwise highly related to the development direction of educational practice, such as how to build the curriculum system, what the relationship between integrated curricula and subject-specific curricula is, and so on. From the innovation event model, it can give us a top-down perspective to re-examine these issues.

4.1. The Enlightenment of the Innovation Event Model on the Nature of STEM Education

As soon as the concept of STEM education was introduced, its essence has been discussed by many scholars. From the literature review, we can see the key to STEM education mostly lies in the integration of interdisciplinary knowledge [12-14]. However, in the innovation event model, there are two significant steps in the process of achieving innovation, one of which is to put forward problems and the other is the application of comprehensive knowledge of various disciplines to solve problems. These two steps both revolve around one's life and production experience.

1)The driving problem must come from life and production practice of the innovator

As the analysis in the first section, the innovation event model lays its foundations on certain driving problems and each problem must come from the life experience of innovators. If there was no need to improve efficiency in production, there would not be Spinning Jenny and Watt Streamer. Without experience in practice and meticulous observation on phenomena, innovators will not have the capability to find and put forward problems and there will not be one innovation after another.

2) Interdisciplinary knowledge forms an organic whole around innovators' practices

First of all, knowledge comes from our practices. It is highly relevant to the experience and laws of the external world that human beings have summed up in practice. For example, heat engines were very popular in the 18th century, but the improvement of its efficiency was still rare, and there was no background knowledge to rely on. In the process of generating power, there must be heat transfer from high temperature to low temperature. After noticing the situation and summarizing the principle, the relationship between heat engine efficiency and temperature difference was discovered by Carnot.

However, Carnot did not figure out whether heat was matter or energy. Eleven years after the death of Carnot, Joule further measured the mechanical equivalent of heat, confirming that, heat is an energy rather than a substance. Clausius, a German scholar, further explained why temperature difference was needed for heat work by mathematical method, thus laying the foundation of the scientific system of thermodynamics.

Secondly, to realize innovation, it is necessary to make knowledge return to practices to solve practical problems. In the innovation event model, the knowledge of each subject forms an organic whole around the part of "iterative problem solving". Innovation cannot be realized without multiple interactions between innovators and the real world, and according to the feedback, repeatedly adjusting their schemes. This is also the reason why STEM education advocates the experiential. For example, the invention of the steamboat and steam locomotive in the early 19th century could not illustrate the idea completely. Even though Watt steam engine gradually became sophisticated at that time, when it was applied to other fields, it was still confronted with many failures and needed to repeatedly explore solutions in practice. It is better to act rather than to talk. No matter how well you can remember the recipe, it does not mean that you can cook a good meal.

It can be concluded that the knowledge of one specific subject is not in an abstract form outside the world, but in a certain structure embedded in the real world, as shown in Fig. 2. It is in one's experience that an individual forms his cognition of the external world. In one's experiences knowledge connects with each other, forms a huge network and a unified whole. For subject-specific education as in the universities, on the one hand, it is conducive to the systematic teaching of knowledge within the group, and such process beefs up the rapid development of human society. On the other hand, subject-specific education extracts knowledge from the real world, and cuts off the relationship among people, knowledge, and the world, which results in a serious consequence that people do not know where knowledge comes from and how to use it.

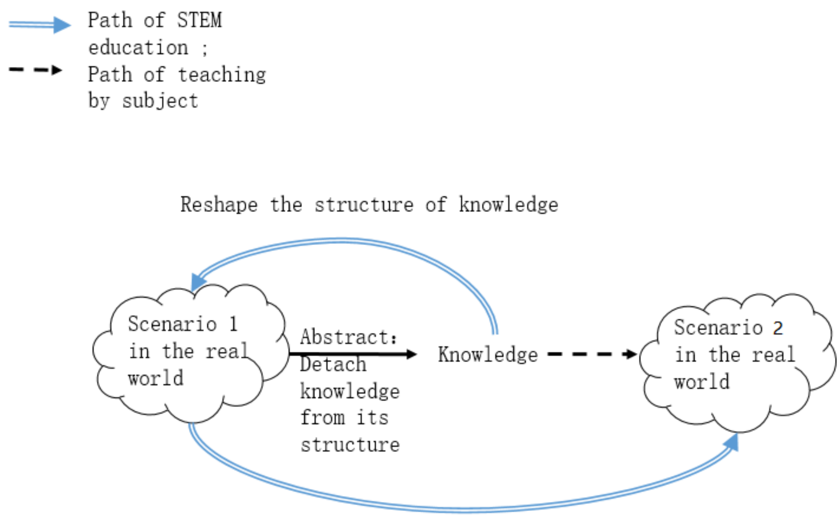

Figure 2. A schematic diagram of the structure of knowledge

To sum up, this paper argues that discipline integration is an external manifestation of STEM education while its core should be one's life (and production) experiences (or practices). Knowledge is not abstract but structured. Rather than learning and mastering interdisciplinary knowledge, the purpose of STEM education is to reconstruct knowledge in the real world, i.e., to anchor the abstract, one-sided and fragmented formulas, theories and concepts in textbooks into the real world, to transform from the abstract into the concrete, and from the fragmented into the whole. The knowledge should come from our life and finally be applied to our daily life, so that it can really act as the bridge between learners and the external world.

4.2. Enlightenment of Innovation Event model to Inter-disciplinary Integration in STEM Curricula

How to organically integrate the subject-specific knowledge emerges as another key issue in the implementation of STEM education. The literature review shows three orientations of interdisciplinary integration: 1) integration based on subject knowledge; 2) integration based on life experience; 3) and learner-centered integration. However, no matter what kind of orientation, they all lead to a specific characteristic of integrating the knowledge of various disciplines around a center (problem or project), which is relatively difficult for teachers, especially those with a background of subject specific education. Based on the conclusion in Section 4.1, we will find that the core of STEM education lies in one's experiences, which can provide an easier operation of knowledge integration, that is, to center on learners' life experiences. As shown in Fig. 3, teachers first would select a typical situation or activity in students' daily life. Then, teachers with different disciplines background would gather together to have a brainstorming, interpret the possibly existing knowledge points in the situation from different views, and then draw a mind map. Maybe, after combining the knowledge points, they will put forward a number of questions, as a way to guide students to further make an observation and explore an inquiry. And they can also design some experiments for students to conduct from one of these points. The specific implementation steps are illustrated in Fig. 3.

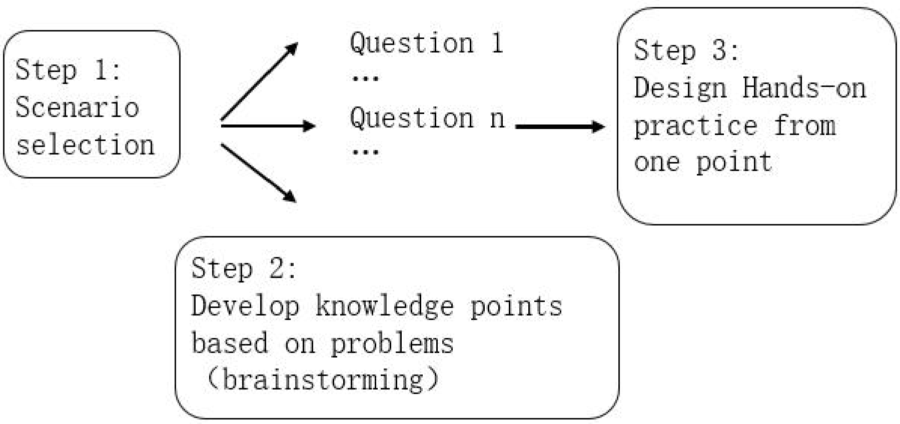

Figure 3. Design STEM curricula around students' life experiences

For example, the case of "The Crossroad" has been designed specifically for the fourth grade of primary school. It selects a crossroad near the school. At first, teachers specialized in different disciplines in the school STEM curriculum teams provide their different knowledge points, as shown in Fig. 4, including science, mathematics, information technology and so on. Then, specific questions for these knowledge points, will be proposed, such as Q2 (Why the duration of traffic lights at different sections and periods is different?). The question would encourage the students to view different aspects and phenomena by their independent observations, and connect the "duration of traffic lights" with the traffic situation, commuting time and other life scenarios together. Q3 (Is it clearly seen at the red light or the green light in the distance?) leads to the related concepts and experiments of light in science. Finally, through Q4 (How to know if a vehicle runs a red light?), the discussion, exploration and electronic design can be carried out. This knowledge integration method, on the one hand, is closely bonded with the daily life of students; and on the other hand, it organizes a wide range of materials in a much more diversified way, which greatly reduces the difficulty of curriculum design, thus it is very suitable for the currently popular "School-based STEM curriculum development". In this process, some points deserve more attention and they are fully explained as follows.

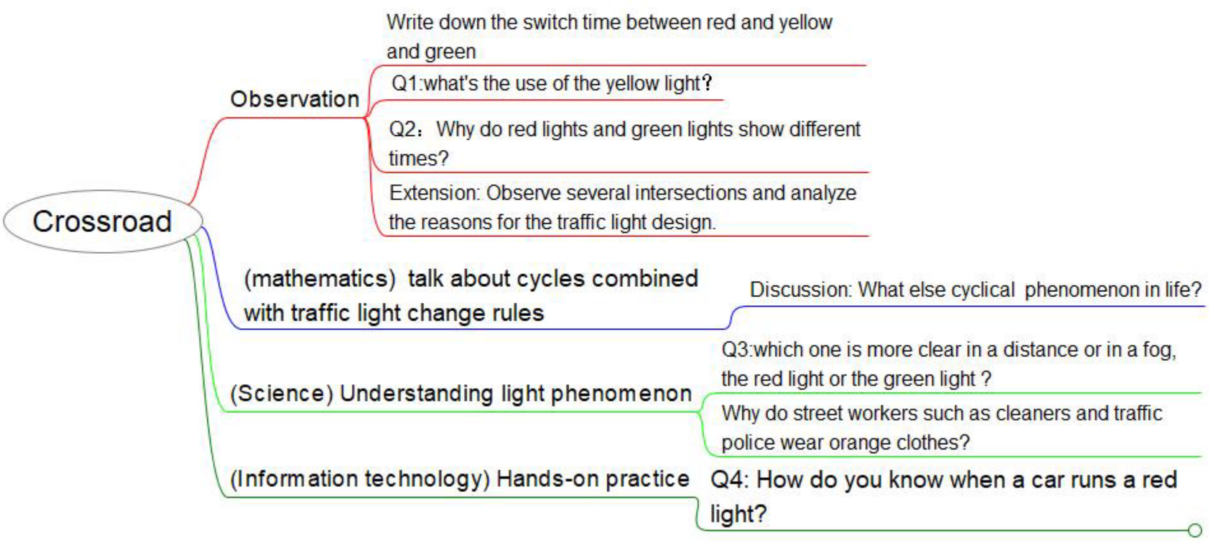

Figure 4. The mind map of "The Crossroad"

1) STEM curriculum design should focus on cultivating observation ability of students.

From the perspective of innovation event model, the problem cannot be solved without the meticulous observation ability of innovators. Observation is not only the key to innovation, but also an important part of scientific research. Therefore, teachers are obliged to design cases from the students' life practices, to increase the observation and comparison part on purpose as a way to guide students to see the difference around and the details of life. For example, it is plausible to add hints like "to observe the switching time of traffic lights" as shown in Fig. 4, and explore the design of "why the traffic lights at different crossroads are varied in duration".

2) It needs to be close to life when it comes to the choice of situation.

The choice of the situation in the course must be based on the students' daily life, and the virtual, fantastic and inexperienced scene is off the list. This is consistent with the concept of "phenomenon teaching" in Finland, which champions the idea of "starting from life needs, covering multi-disciplinary elements, analyzing life phenomena and returning to life application" [14]. On the one hand, it can systematically, comprehensively and truly reflect life, come closer to life, and respond to such problems as "why to learn", "what the function of learning is" and "how to use it after learning". On the other hand, it helps guide students to form a practice route featuring "continuous interaction with the real world and continuous correction based on feedback". [15]

From this point of view, the currently popular STEM cases, such as "designing residence suitable to human beings on Mars", are quite distinguished from "STEM education concept based on life experience". Certainly, Mars exploration would arouse the curiosity of the children. However, choosing Mars as the typical situation seems a relatively empty idea. It cannot assume that participants have a direct and concrete touch. It is not in line with the experiential characteristics of STEM education, either. On the other hand, there is no way for students to experience the process of "repeatedly revising and exploring solutions in the continuous interaction with the external environment" [15].

Similarly, another STEM case introduced from the United States for the lower grades in China comes with the same fault. For Chinese children who do not have the practice of camping as North American peers, the questions such as “what should we prepare for camping", would be unrealistic. As a result, the content of the course will be transformed into introducing the functions of the goods, while lacking the experience process of testing and adjusting in practices. Furthermore, the learning outcome of the course will be greatly reduced.

3) Diversity of STEM education

If STEM education activities center on the life scenes and life experience of students, it is natural to assume that the variance of life experience scenes contributes to the difference of arrangement of STEM curricula in different regions and even in different schools at the same place. The reality determines that STEM curricula cannot adopt a unified top-down approach or unified implementation, or directly copy foreign cases. Instead, it indicates a more difficult task. That is to combine the actual situation of various schools in various places and make great efforts to develop a STEM curriculum of school-based development, which means to take the local conditions into consideration and integrate elements reflecting local cultural characteristics [12]. During this period, teachers should have an awareness of switching from "executor" to "designer and practitioner" [17]. We should also make active use of urban resources, including museums, science and technology museums, hospitals, enterprises, etc., to build diversified STEM education extracurricular classes. Only through the combined effort, can STEM curricula broaden the scope of school activities, and increase the interaction between schools and the whole society.

4)The relationship between subject-specific curricula and integrated curricula

The STEM education idea concentrates on "life experience", which is consistent with the core concept advocating "Phenomenon-based Learning" idea of Finland [16]. In reality, given the population size and population characteristics of a big country like China, they cannot directly and simply copy Finland’s curriculum model. At present in China, it is still reasonable to give priority to subject specific education and its weakness can be supplemented by integrated education. Subject specific education stands out by the attributes of being systematic, logical, independent and simple. Above all, it pays close attention to the learning of basic knowledge and skills.

Therefore, in the case of a large population, it ensures the quality of education in primary and secondary schools. In economically developed areas and schools with excellent staffing resources, as well as in the lower grades of primary schools, the proportion of integrated education can be appropriately increased. Students in primary schools have weaker practical ability, and the theme design of STEM curricula should better focus on life scenes and priority should be given to experiential education. When it comes to the middle school stage, we can increase the proportion of practice. If conditions permit, we can set up innovator workshops. Especially for the knowledge points closely related to practice in junior and senior high schools, such as force, torque, pulley, etc., we can design STEM courses to help students build knowledge structure and change knowledge from abstract to the concrete, so as to improve their ability to solve problems in the real world.

5. Conclusion

The proposal of STEM education is a reflection on the traditional view of knowledge and teaching. Based on the innovation event model, this paper attempts to re-examine some problems in STEM education from a macroscopic perspective, and argues that the main reason why traditional subject-specific education cannot realize the cultivation of innovative talents lies in the fact that it separates knowledge from the real world, and thus cuts off the relationship among people, knowledge, and the world. In order to realize the flexible application of knowledge in real problems, we should take the world as the carrier and reconstruct the knowledge. Therefore, the core of STEM education is not problem-based learning (PBL) or subject integration, but to enable students to interact with the environment through practical activities so as to construct their own unique understanding of the world. From this point, STEM education can refer to "the phenomenon education" model of Finland, but different countries have different specific conditions, so it cannot be copied totally.

Some scholars believe that STEM education should be combined with artistic elements and it becomes "STEAM education" [18]. The core of STEM education is "knowledge built-in practices". Science, Technology, Engineering and Mathematics are just four representative types. Therefore, as long as it can reflect the educational concepts of STEM, we need not tangle in the name.

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Appendix:

LIST OF INNOVATION CASES

Order	Invention	Driving problem
1	Kay Shuttle technology [4]	To improve efficiency of working
2	Jenny's Loom [4]	To improve efficiency of working
3	Microscope [4]	**By accident**
4	Barcode [4]	To collect product information automatically at checkout
5	Television [4]	To transmit images electronically
6	Internal combustion engine [4]	To improve thermal efficiency
7	Ultrasound diagnosis [4]	To detect the pathological changes of organs in the human body
8	Mercurial thermometer [5]	To measure the patient's temperature accurately
9	Fahrenheit [5]	To get the temperature exactly
10	Echometer [5]	To improve the method of auscultation
11	U-shaped mercury manometer [5]	To get the patient's blood pressure
12	Compass, quadrant, spinnaker [5]	To solve the problem of positioning in navigation
13	Watt steam engine [5]	To improve performance of older steam engine
14	Using steam engines in manufacturing [5]	To improve performance of that field
15	Steam driven vessel [5]	To improve performance of that field
16	Steam Locomotive [5]	To improve performance of that field
17	LD process [5]	To improve performance of that field
18	Cotton gin [5]	To improve performance of that field
19	Music box [5]	**By accident**
20	Typewriter [5]	To page a book automatically
21	Edison's Light Bulb [5]	To improve performance
22	Telegram [5]	To realize long distance communication
23	Telephone [5]	To realize long distance transmission of sound
24	Radio [5]	To transmit information wirelessly
25	Movable type printing(Bi Sheng) [5]	To improve efficiency of printing
26	Movable type printing (Gutenberg) [5]	To improve efficiency of printing
27	Penicillin [5]	To kill bacteria
28	Fessenden oscillator [5]	To detect underwater objects
29	Aniline violet dyeing technique [5]	**By accident**

30	Porcelain glazing technology [5]	**By accident**
31	Fiberglass [5]	To make glass threads
32	Plastics [5]	**By accident**
33	Maxim's machine gun [5]	To load the bullet with the force of the gun after firing
34	Radiotelegraph Communication (Marconi) [5]	To send a telegram by wireless
35	Radar (Watson Watt) [5]	**By accident**
36	Aspirin(Felix Hoffmann) [5]	To relieve his father's pain
37	Plane [5]	To fly like a bird
38	Transistor [5]	To overcome the limitations of the vacuum tube
39	Google [6]	To improve efficiency of finding information in the Internet
40	The internet [6]	To share the computing resources
41	WWW [6]	To connect information from different computers
42	Computer [6]	To compute automatically
43	Integrated circuit [6]	To reduce the size of the circuit
44	Disinfection of drinking water [7]	To effectively curb waterborne diseases
45	Ice market [7]	To explore new market
46	Artificial ice making technology [7]	To make ice cubes to help patients cool down
47	Freeze preservation technology [7]	To keep the taste of food
48	Three-point suture [19]	To achieve vascular suture?
49	Artemisinin (Tu Youyou) [20]	To treat malaria
50	Apgar Score [21]	To reduce neonatal mortality effectively