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A Study on the Performance of STEAM Education on 5 Essential Abilities for Middle-Aged Children in China

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Abstract: The ongoing 4th industrial revolution has caused some nerves for Chinese government. Its intention in catching up the world's fast-paced development leads to the implementation of STEAM to nurture more compound talented individuals to create and innovate. This paper observes Chinese current primary school education system and methods in delivering STEAM. While it being observed, one of the core problems in STEAM delivery in China is the educators' general confusion in what type of person STEAM hopes to bring out to middle-aged children. The paper aims to list 5 essential abilities that are necessary for young children in China to develop under the concept of STEAM. It will also evaluate the efficacy and provide some feasible recommendations in delivering STEAM concept. It is recommended to carefully encourage adopting 5 essential abilities in designing teaching methods.

Keywords: STEM, STEAM implementation, essential ability, STEAM performance, middle-aged children

1. Introduction

In 2013, a new idea of the 4th industrial revolution was launched and caught the world's attention during Hannover Messe held in Germany [1]. The 4th industrial revolution is a composite of artificial intelligence, life science, Internet of Things, robotics and intelligent manufacturing to realize a world of physical, smart and biological space. Along with this rising idea, the Chinese government was eager to keep up the pace and unveiled its 10-year strategic plan 'Chinese Manufacture 2025' in 2015 [1]. The government encourages people to innovate and to enterprise. Under the pressure of the 4th industrial revolution and having this national-wise atmosphere in innovation and entrepreneurship, the educational field is bond to revolutionize. To cope with the change, STEAM system (Science, Technology, Engineering, Art, and Mathematics) was adopted by Chinese government for middle-aged children. They believe that abilities to generate compound talented personnel should be nurtured since young, specifically start from age 6. This article aims to point out the 5 core abilities that are necessary for young children in China to develop under the concept of STEAM, evaluate the efficacy and provide some feasible recommendations.

To understand the importance of STEAM, it is compulsory to know the origin of STEAM system. In 1986, the US National Science Committee released a report on 'Science, Mathematics and Engineering Education for bachelor's degree' and it was regarded as the beginning of STEM development. It itself was not simply a mixture or combination of several subjects. Instead, it aimed to dynamically apply knowledge from different areas (Science, Technology, Engineering and Mathematics) to tackle real-world problems more sophisticatedly. In October 2005, a strategic report was composed by various authority departments for continuous emphasis on STEM and brought STEM to a higher level of importance nationally [2]. In 2014, President Obama activated a STEM National Plan which includes STEM Innovation Networks Program, STEM-focused School and so on. The

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plan gave children a lot more convenient and effective way to understand STEM from an early stage of education. As STEM constantly evolved, Yakman from University of Virginia pointed out that art should also be included for it is vital to bring artistic sense into science so STEM then became STEAM [3].

2. Essence of STEAM

Deep down the STEAM concept, it hopes to carry out open-minded and insightful individuals with integrity for the betterment of human race. This leads to think what whole person is. In today's world, individuals with the following 5 abilities are more likely to achieve it: critical thinking ability, problem-solving ability, innovation ability, interpersonal skill and social responsibility. The former 3 conclude one's mind shaping and the latter 2 include interaction with peers and society.

Critical thinking is a thinking that accesses, analyzes and transforms one's own or others' thought more comprehensively and systematically. With tremendous amount of information now, it is important to see beneath what has been shown and think more deeply. By obtaining this ability, it allows students to build a more rigorous system of cognition. A clear mind quickly generates categorized information, sharpened evidence and deepened understanding when any idea is flawed or superficial. Li et al points out that STEAM develops this ability under the context of Problem-Based Learning (PBL) [4]. They found a significant positive relationship between critical thinking ability and PBL based on 843 literature reviews. A good STEAM teacher should raise good questions to promote critical thinking. For instance, with respect to waste disposal, general instruction includes how waste is sorted while 'is it the only way to sort, why, how can it be more effective' could further be asked [5].

Problem-solving ability is inclusive of realizing the problem, designing a feasible plan to tackle the problem as well as evaluating the solution. Since STEAM education calls for teachers to put students in the center of classroom, learning should be facilitated on students' own. After tasks are handed out to the students, they should be able to understand the question so then to brainstorm in what way, by how, and why things should be done. This leads them to put hands on researching online, conducting field trip, performing experiments, testing hypothesis or building models. Certain results may come out and sometimes at this stage, critical analysis joins to evaluate the solution. The whole process will be recorded by the students and drafted into presentations or posters [5].

Innovation ability is now weighted as the most important ability for the development of a country since it decides technological and economic power. STEAM education is now world-widely famous for cultivating this ability by encouraging using 3D printer, coding to make APPs, robotic design and so on. Zhao and Lu demonstrated an US case that students' creativities are maximized when artists and professionals being in the STEAM Labs to corporate and communicate with them [6]. Fu and Wang indicated that more and more Chinese students are able to make innovative work under teachers' inspiration [7]. They can build a model between IOT and Smart Home by using S4A and construct APPs by using simple coding programs like ArduBlocks or AppInventor. Looking into the cases, students are not only equipped with technological and engineering abilities, but also emotionally satisfied with their work or inventions. They could further start entrepreneurial businesses if interested.

Interpersonal skill is one of the core qualities that students must have for it decides mental wellbeing. STEAM creates abundant opportunities for students to cope with each other. Most of the STEAM topics assigned could be big and complex. Students are asked to work in groups to break down topic and assign each member's workload, or discuss the topic together to formulate a more comprehensive understanding [5]. This gives students the opportunity to present themselves to their peers as well as absorbing information from others. Du also mentioned that group basis gives the chance for students to review each other, providing a real-world experience like at work [5].

Social Responsibility implies the care and love for the world. Even though this quality is barely discussed under STEAM areas, it is still necessary to reinforce in the class. Compared with people holding no care and love for the world, individuals with social responsibility brings more possibility to realize certain real-world problems. Having this in mind encourages one to think critically, to solve the problem, and to create new tools.

3. Current Status of STEAM in China and Discussion

The concept of STEAM has been advocated by the Chinese National Bureau of Education back in 2015 and it was later formally established in 'Standard Science Curriculum of Elementary Public Schools' in 2017 by the authority. It's important to note here that the following discussions are strictly restricted to public-school education track, exclusive of private schools and international schools in China. There have been various evident compliments with positive statistics after implementing STEAM concept from a wide range of Chinese-education-based

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teachers. Compliments include 81.79% of teachers believe that STEAM can nurture children's willingness to innovate, 75.42% of teachers agree that STEAM has helped children put their thoughts into practice and 69.52% of teachers think that STEAM equipped students with scientific analysis methods [8]. Nevertheless, numerous problems also arise. The current most significant problems of implementation of STEAM in China, with respect to 5 abilities will be discussed in the following section.

According to Yuan et al, public schools and outside-school institutions are the two primary channels in applying STEAM for public school students in China now [8]. Problems with respect to two different types are discussed separately below:

Problems of STEAM implementation in school:

- Instead of students solely sitting there and listening to the teachers like the traditional way, teachers tend to think that children physically getting their hands on making things is considered as STEAM implementation;
- The management teams in many schools rely STEAM heavily on generating coding ability for future competition, but coding ≠ STEAM;
- Some teachers tend to think that STEAM encourages students to do experiments voluntarily and no need from teacher's help. This, therefore, results the process of delivering STEAM remains stagnant.

Problems of STEAM implementation outside school:

- Likewise, outside-school programs also like to stress the importance of coding ability.
- Some institutions base their educational methodology on guiding the children to do lab experiments.
- Lego is another stream that institutions like to do because Lego itself is systematic and easy to deliver.

Below are two radar charts that evaluate the effectiveness of current 2 educational STEAM methods corresponding to the 5 core essential abilities:

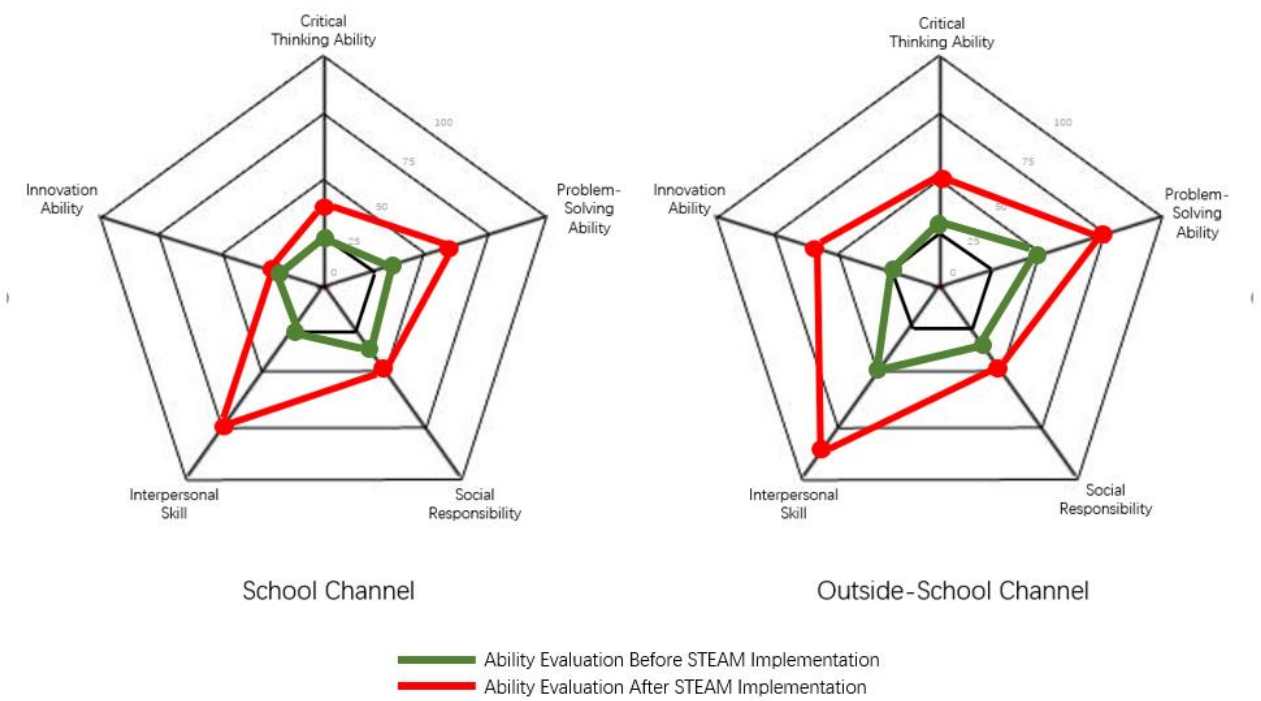

Figure 1: Radar Chart of Two Channels.

To rate the STEAM performances of different channels on 5 essential abilities, two radar charts are made above. Green radar represents the ability evaluation before STEAM implementation and red radar represents the ability

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evaluation after STEAM implementation. Each essential ability of the two channels forms individual axes radially around the center point. The outer the radar stands, the better STEAM performance that one channel operates.

From the school channel radar chart, it can be seen that these 5 essential abilities are very little trained to the students with an average of 30th percentile successful delivery chance on the abilities. Interpersonal skill, innovation ability and critical thinking ability are rated with score of 25, and meanwhile problem-solving skill and social responsibility have the score of 35. After implementing STEAM, interpersonal skill goes sharply from 25% to 75% which is highly likely resulted from the more group work time assigned to students. Problem-solving ability also increases fairly from 37.5% to 65% with more tasks being allocated to students. The effects on critical thinking and social responsibility both rise slightly and innovation ability demonstrates the least increment to one's digit. Innovation ability, critical thinking ability and problem-thinking ability are three core abilities compulsory for a whole-person development one would face internally. The result of school channel on STEAM delivery is not so satisfying for these three core abilities have not been cultivated enough.

As for outside-school channel, the pattern of innovation ability, critical thinking ability and social responsibility before STEAM implementation are quite similar, maintaining 25%, 30% and 37.5% chances respectively. Problem-solving ability and interpersonal skill are in around 50th percentile successful delivery range. After the STEAM methodology involved, most essential abilities with the exception of social ability strengthen greatly. Innovation ability moves up from 25% to 67%, problem solving skill going from 50% to 75%, critical thinking ability changing from 30% to 50%, and interpersonal skill varying from 50% to 85%. STEAM influence of outside-school channel on social responsibility has a relatively smaller scale of 15% increment, from 35% to 50%.

Comparing the red radar from both channels, it could easily be seen that outside-school channel performs better than school channel in every aspect. Other than social responsibility part remaining the same from both channels, all other 4 abilities differ. Innovation ability elucidates the greatest gap for outside-school institutions tend to have more time on intuitively guiding children in mind. Critical thinking, problem-solving ability and interpersonal skill differ in the same scale from both channels. They improve in the same way as outside-school institutions have smaller class sizes and more time to generate more critical questions and guidance methodology.

Generally speaking, there is nothing wrong with working with LEGOs, cultivating coding ability as well as doing laboratory experiments in delivering STEAM. However, what really matters is how to bring a new perspective of view into a student's life through the process of STEAM. This therefore comes to a serious point that requires teachers who committed to STEAM to work harder on delivering STEAM more inspirationally and intuitively. To improve the STEAM efficacy of both channels, one feasible tackling method is to break down each step of STEAM delivery mode and scrutinize into each step. During the process of delivery, 4 steps are diagnosed below:

- teachers should spend more time on designing more valuable and inspiring questions. Questions are subject to the topic but could bring wider imagination to the students so that they could study more on their own initiatives.
- Teachers should help students alongside without straightly giving the answer. Let students solve their own problem with a little hint only. They could find their own answer out and build their own logic tree.
- Teachers should assist students to realize their own talent and therefore encourage them to do more or learn more. This is a matter of helping them choose their focuses or future paths. Bearing a bright and clear goal, they would work harder and along this, school or teachers could provide more opportunities or advice if possible.
- It is recommended to evaluate student in a routine basis through these 5 abilities. With these helps, students, their parents, and teachers are able to know which part the student is particularly weak and strong at and therefore to modify.

4. Conclusion

Throughout the past 6 years of experiencing STEAM education in China, it is important to acknowledge the fact that China has done well in a way that positive feedbacks are seen. However, it is also crucial to understand that there is a wide gap to fully facilitate the concept as well as the 5 core abilities. Bearing this in mind, teachers and authorities should make more efforts on constructing a more adaptable and comprehensive way of delivering STEAM to meet students' full capacity. When students are truly inspired and emersed in the cross-field world of science, technology, engineering, art and mathematics, they would better have themselves ready for the new era of human being – the age of intelligence. Meeting this enables them to serve their nation and therefore the world more socially responsibly.

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