Elementary School-university Collaboration towards Extracurricular STEM Education

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Abstract. Through the author’s two-semester extra-curricular STEM education activities for elementary school pupils, this article introduces the preliminary preparation content, the development process, and the summary and experience of this activity. Through a detailed introduction to one of the activities about the production of hydraulic excavators, the application of STEM in the activities was explained. It shows that pupils participating in extra-curricular STEM activities not only improve themselves in terms of confidence, interest, ability, and discipline, but also help their parents balance work and family.

Background

As early as the 1970s, the report of the international commission on the development of education was discussed about the general tendency of education around the world, which stated that "education has expanded beyond the scope of schools; primary and secondary schools are being supplemented by various extra-curricular and auxiliary activities outside the school"[1].

It has been proven practically and by facts that not only has this trend been verified in the past 50 years, but also the extra-curricular education has become more professional[2]. It cannot only meet the students’ needs, promoting their overall development, but also enhances young people’s learning interests. The mission of promoting lifelong education awareness and forming of habits and improving young people’s comprehensive ability, helping young people to cope with the challenges of survival and development are clearly increasing. The research[3] shows school-university collaboration to pilot a professional development framework for integrating STEM in mathematics classrooms.

China also clearly proposes[4]: “enriching students' auxiliary and extracurricular activities”, "using social education resources to carry out various auxiliary and extracurricular activities”, and “strengthening the construction for extracurricular activities in primary and secondary schools”.

Science, technology, engineering, and mathematics (STEM) education is becoming more prevalent at the elementary level[5-6]. As a university teacher, I took my two semesters to lead the college students to directly participate in this practical experience of extracurricular education in a certain elementary school. Practice in this paper shows that the ability, interest, learning kinetic energy and other aspects of the participants have been greatly improved, and their parents have more time to work and better balance the family and work.

Preparations

Many interested and capable college students have been recruited in my college and been trained on their experimental abilities, the way of teaching and managing with primary school pupils. Other special preparations include:
Venues and Equipment

**Venues.** Fortunately, the elementary schools’ head teachers are very supportive of our project, giving us nearly 30m² of event venue from their very limited teaching space. The venue is an empty room with no table or stool. This is the basis for our STEM activities.

**Equipment.** Adapting to the conditions, let’s start by refurbishing an empty room into a STEM activity space. So, in addition to the manual instruments required for STEM activities, the purchased equipment also includes woodworking instruments and wooden boards, such as table saws (with vacuum cleaners), woodworking U-saws, woodworking clamps, wire strippers, diagonal pliers, and other manual tools. Ruler and hot melt glue gun and stick, electric iron and solder wire, glue are also included. It also includes some electronic components and small motors. It is worth mentioning that the equipment also needs safety-related items, which include protective goggles, gloves, fire extinguishers, alcohol, iodophors, and band-aids.

**Activity Cost**

One of the aims of STEM extracurricular activities is to use readily available items, processing and transforming them into works, which is based on the pupils’ knowledge and ability. Therefore, in addition to the cost of the above equipments, the rest of the activity’s funds almost do not need to be added.

**Student Organization**

The registration is organized by elementary schools, and the interested pupils are invited to participate voluntarily. The participants of this activity are agreed to be in the fourth grade of elementary school. It is specifically pointed out here that the only criterion for selecting participants is that pupils are willingly interested, not the parents’ requirements, and irrespective of their academic performance. Also, they would be given a chance to try and decide. If they don’t feel satisfied with the activity after participating, they can decide to quit, and the vacant position will be replaced by other pupils still waiting.

**Signing an Agreement with Their Parents**

Children’s extracurricular activities can’t be executed without their parent’s permission. The main contents of the agreement include: (1) Hoping to get the parents’ support to continue participating in activities; (2) Though, we will be responsible for ensuring the children’s safety, it is unavoidable that the children will have minor injuries; (3) Purchase of insurance or not, etc. After signing an agreement with the parents, pupils will come to the activity room weekly on a fixed afternoon.

**Activities**

This program is to engage the pupils in fun and challenging activities, cultivate their practical abilities, creativity and imagination, and process their own ideas. Through hands-on production, pupils can also develop their mathematical thinking, spatial thinking, measurement and calculation abilities, and experience the fun of hand crafting from the scratch (Fig.1).
When designing these activities, the rules about emphasizing the STEM concept, following the principles from easy to hard, safety and self-responsibility are considered. Examples of the activities of the first semester are shown in Table 1.

Table 1. Activities of the first semester are arranged in sequence.

| Number | Content                     | Remarks                                                                 |
|--------|-----------------------------|-------------------------------------------------------------------------|
| 1      | Rules and safety            | Identifying all unsafe factors of the studio, participate in the         |
|        |                             | formulation of the studio's rules, and establishing emergency            |
|        |                             | systems and measures.                                                   |
| 2      | Workbench Installation      | Installing, polishing and painting                                       |
| 3      | Usage of hammer / power tool| Realizing the importance of tools for human development,                 |
|        | / electrician tool          | Learn to recognize and use                                              |
| 4      | Standard parts              | Understanding of fasteners screw nuts; iron nails; motors and motors   |
| 5      | Topical works               | Under the guidance of the teacher, completing several works, such as    |
|        |                             | radio-controlled trucks, stereo speakers, micro                        |
|        |                             | generators, wooden football tables, etc.                                |
| 6      | Creative works              | Making hydraulic mechanical arm                                         |

Establishing Rules for the Activity Room

The first activity carried out is to make activity guidelines for the activity room (under the supervision of the teacher and college students) which become rules that must be followed by everyone during the weekly activities.

Based on the rules established by the pupils themselves, factors such as safety and environmental hygiene have been considered. But as an extracurricular activity, I think the teacher’s instructions should be minimal and we should let the children express their creativity while ensuring their safety.

Build Their Working Environment by Themselves

As mentioned above, the activity room is still empty. This is the opportunity that allows pupils create their own working environment. Teachers and college students prepare wooden boards as desktops, and K-shaped brackets to be fixed on the walls, ahead of the fixed day, and college students have fixed the desktops on the brackets. But the wooden board is still a bit rough for a work desk.

The pupils start to pick up the sand skin. After a simple training, they put on masks, put on gloves, deburred with coarse sand skin, rounded the corners, and then polished the desktop with fine sand skin and very fine sand skin. The children didn’t feel tired after all the hard work, and yet they
performed an excellent job. Everyone is busy for him/herself, not for others. That feeling and sense of belonging is totally different from what they feel when they’re asked to do something.

At the same time, these are real activities, and the results of labor are immediately shown, and these labor results depend on the laborer himself, independent of other partners. Whether the sanding work is careful or not, whether each area on the desktop is equally taken care of, whether it is strictly in accordance with the sanding sequence from coarse sand to fine sand, etc., are directly reflected in the smoothness of the desktop. This is in line with an old Chinese saying: “one work and one reward”

Examples of Hand-made Activities

This article takes the hand-made projects of hydraulic mechanical arms as an example to introduce the process of STEM practical activities. The hydraulic mechanical arm's manual activity is to use folded cardboard as the raw material, build the mechanical body of the excavator through cutting and hot melt adhesive bonding, and then use the infusion syringe as a hydraulic device, which is installed in various parts of the excavator and acts as the excavator's rotation, lifting of the robotic arm and excavation. This topic is highly comprehensive and a test of pupils’ comprehensive abilities in engineering, craftsmanship, and creativity.

Observation and Analysis of Works. By watching existing works videos, the working principles of physical hydraulic excavators and model machines are analyzed separately, leading pupils to discuss in detail the structural characteristics of model machines, their mutual positions, and the connection methods between parts, etc. Instruct primary school pupils to draw sketches to deepen their understanding of the structure.

Production of Parts. The dimensions are marked according to hand-drawn sketches, and are easy-to-obtain. THE basic materials used are the wasted folded cardboard. The measurement and drawing are used to stake out, and the steel ruler and the art steel knife are used in cutting to obtain various designed parts.

Assembly and Construction. The various cut parts are constructed and assembled according to their respective hand-drawn design drawings. Toothpicks, hot melt adhesives, 502 universal adhesives, etc. are used as assembly tools.

Installation and Debugging of Hydraulic Device. The injection syringe is used as a hydraulic device, fixed at certain positions of the excavator body, filled with clean water as a hydraulic medium, and is used to draw pressure to rotate, lift, excavate. The equipment used here includes syringes, cable ties, hot melt adhesives, rubber tubes, etc.

The entire STEM process is reflected in this special practice. For instance, in the cutting and production of parts, it involves the training of engineering (“E”) capabilities such as drawing and measurement. In the drawing, it involves the calculation (math, “M”) link, and the production of folded parts. The use and cutting technology (“T”) of utility knife and steel ruler, during the construction of the body structure, involves the construction of the space and the processing of the project, including stability, stiffness, rotation axis and other issues. In the technical part, when the syringe is used as a hydraulic component, the principle of hydraulic pressure will be involved. The comparison between hydraulic pressure and pneumatic pressure, that is science (“S”) and engineering (“E”) considerations in the installation process, and imitation will also involve creativity and other artistic abilities.

The actual hands-on ability of the fourth grade primary school pupils has exceeded our adult imagination. After the fifth class, a few pupils have already built hydraulic excavators to take shape, and they can achieve basic movements. Finally, the teacher's comments on the work, the pupils’ self-reviews, the mutual evaluation between the pupils, etc. were carried out, and the work was further improved.

Summary and Experience

This project carried out extra-curricular STEM education activities in a primary school for two semesters, and the pupils who participated completed all the courses once a week. The frequency of once a week for two semesters have a certain result on primary school pupils and their parents.
(1) Safety

As said above, this activity is carried out in the elementary school’s premises, pupils go directly from the classroom to the activity room, eliminating the need for parents to pick them up, so parents and pupils feel safe. The pupils created the entire activity room by themselves, including the activity guidelines, activity room cleaning, etc., which also gives them a sense of belonging and makes them feel very safe. Furthermore, there is no standard answer for the activities here, failure is allowed, the children do not have to fear failure because this failure will become the cornerstone of the next success, this makes them feel safe.

(2) Happiness

Basically, no step-by-step instructions and no duck-filling education are involved during these fun activities. Just the child’s personal experience, encountered problems, and finding ways to solve the problem. It can be seen that the children are happy because they rarely miss classes, and they are in a state of euphoria and are always humming. According to parents’ feedbacks, the children cry in anxiety when they are unable to participate in this activity due to illness, which shows that children really enjoy this activity and are happy.

(3) Self-growth

This activity conforms with the process from 0 to 1, including the establishment of a common activity room for everyone and each work at hand. The process from 0 to 1 have increased the confidence of the children, and the work challenges from easy to difficult have stimulated the children's interest. Small injuries that are inevitable during the activity, such as fingers bleeding, the fingers 502 glue stuck, all have a positive impact on children's self-protection awareness and emergency treatment.

(4) Improvement of ability

The STEM training lasting two semesters has greatly improved the children's science, engineering, mathematics and hands-on skills. Not only that, the concentration that is improved through training, the ability to solve problems, in turn, promotes the children's academics; the good work habits established in the activity room also promotes the discipline of the children in the classroom.

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