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A Case Study of Emerging Knowledge Building in Family Science Education

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Abstract: As a kind of informal learning environment, family is one of the main places for young children to perceive the world actively. But the potential value of family science education is often ignored or underestimated by family members. Knowledge Building opportunities as well as comprehensive science problems always emerge in family every day life. This study traced five cases of science learning activities of a 6-7 years old boy and his family emerged in the past 3.5 years, and every case was implemented about 2-4 rounds KB procedure. All of the original science problems were raised by the child spontaneously in every case and the continued inquiry activities were intentionally designed and iterated by the KB experienced mother who was supported by other family members. Data were collected from the mother's 16 stories records, the boy's 17 artifacts in family KB wall, 220 minutes audios and videos as well as 5 experiments reports. The quantitative and qualitative analysis indicated that the number and depth of the boy's problems obviously increased which involved more multiple domains, such as physics, biology and medicine. And the interesting thing is that he became more likely to refute and argue with others and actively adopted more diversified approaches to seek truth, such as self-designing of experiments, voice searching and so on. The preliminary findings also showed that home is a good place for KB where all of the family members could be involved and KB places could be extended from home to laboratory, museum, animal hospital, etc.
Keywords: Informal environment; Family; Knowledge Building; Science education; Emerging problems

Introduction

The present study was conducted in a family. The participants were a 7-year-old boy and his family members. The boy Stone, born on May 14, 2012, enjoyed asking questions since he was three years old. The family members were: the grandparents, the parents, and Stone's 2-year-old younger brother. To arouse Stone's curiosity, imagination and spirits of exploration, the family members often discussed with him to solve the problems. In addition, Stone's peers and their family members also participated in some activities. In June 2015, when we were dining together and ate eggs, he suddenly asked me "who lays eggs? Where do chickens come from?" I told him it's hens, Chickens hatch from eggs. Then he asked again: "Am I hatched from eggs, too?" I answered: "No. You were born by me, your mother. Everyone was born by his or her mother." He was very surprised: "really? Can cocks lay eggs? Are all animals born by their mothers? Is there an animal born by its father?". I was not sure, so I said "why don't we find out the answer together?" one day we found the answer in a book named "Mister seahorse", that is "unlike most animals, the baby seahorse is born by its father, the male seahorse". The discovery aroused his great interest. He then asked "Are there any other ways that animals are born?" Later, we found that starfish and earthworms can reproduce themselves.

Facing the boy's problems, we usually just tell him the answer directly or ignoring his problems instead. This had caused a lot of problems: For example, he was not satisfied with direct answers, and wanted to know more. Maybe I didn't know the answers either, Sometimes his grandparents and father or even his younger brother are involved in the activities. The dialogue took place once and again and a series of stories came out nearly every day until I knew about KB in Oct 2017 from professor Yibing Zhang. Therefore, I questioned myself: "Why not apply KB to family science education?" thus, there would be two problems: First, since science problems are aroused by the child himself, are there any differences of science problems between in the family and at school? Second, Can I apply this school education procedure directly? and how?

For this study, when comparing the problems in the family with that at school, I found they were different from each other in 6 dimensions (see Table 1), Family belonged to the informal environment, the problems proposed by the child were emerging. These were different from Scripted problems.

Table 1: Comparison between emerging problem and scripted problem

Dimension	Emerging problem (family education)	Scripted problem (school education)
Context	Rooted in the real context of everyday life	Based on artificial situation designed by teachers
Proposal	Emerging problems proposed by the child actively or spontaneously	Problems proposed by teachers or students based on curriculum objectives
Discipline	Complexity, synthesis, cross-discipline	A single discipline
Content	Dynamic, unpredictable, generative (Zhang J., et al. ,2009)	Static, predictable, with a syllabus
Organization	Unstructured, improvisational, opportunistic (Sawyer, R. K. ,2003)	Highly structured, sequential, scripted
Expert	Not prepared	Experts instructed

Research Questions

There were two research questions in this study:

1.Whether Knowledge Building can be carried out in family science education in informal environment? What is the procedure?

2.How KB influence the child? What are the changes of the child?

Methods

The present study was conducted in a family. The data was collected from one child about his science problems. This study traced five cases of science learning activities emerged in the past 3.5 years. Each case was implemented about 2-4 rounds of KB procedure. Variables included the number of problems; the depth of understanding; the extend of places and participants; the forms of activities; scaffolds.

Generally, there are five steps to conduct every round of KB activity in the family:

- Proposing the emerging problem. Initiated by children as the starting Point of KB.
- Capturing the initial problem. It is important to intentionally capture child's emerging problems for science KB.
- Extracting the focus problem. The children's statements are often vague and confusing.
- Improving the science idea. Adopt a variety of KB activities to promote the child's idea improvement
- Freezing the science problem. Freezing is not the end, but a pause when the problem develops beyond the current cognitive level of the child.

This study traced five cases of science learning activities from June, 2015 to January, 2019(see Table 2).

Table 2: Five cases of this study

Case	Period and age	Emerging problem
1 Chicken and egg	Jun, 2015-May, 2017 3-5 years old	Why chickens are hatched from eggs, but I was born by my mother?
2 Watermelon and buoyancy	Sept, 2016-Oct,2018 4-6 years old	In a summer, while washing a watermelon, Stone asked “Will watermelon float or sink when we put it in the water?”
3 Water and	Dec, 2017-Jan, 2019	One day Stone asked a question: “Which is more

fire	5-6 years old	powerful, water or fire?”
4 Fishbone and digestion	Dec, 2018-Jan, 2019 6.5 years old	One day his younger brother was gotten stuck by a fishbone. He asked “Why are dinosaurs not gotten stuck in their throats when they eat other animals, but we are easily gotten stuck by even a tiny fishbone?”
5 Bright and dark	Dec, 2018-Jan, 2019 6.5 years old	One night it was time to go to bed, he turned off the light and asked “Why I feel it is very dark when I just turn off the light, but not so dark after a while? I observed the phenomenon for several nights”

Data Sources

Data were collected from the mother’s 16 stories records, the boy’s 17 artifacts in family KB wall, 220 minutes audios and videos as well as 5 experiments reports.

1. The online log recording of the activities process (see Figure 1).

Figure 1. The online log recording(case4,case5)

2. Audios and videos

Some of the activities were recorded by audios or videos. For example,the video of watching a tooth model when we visited the veterinary laboratory.

3. Artifact

Because of Stone’s shortage of words, he often expresses his ideas through painting. Stone and peers were observing the bacteria which were magnified 1000 times through a microscope ,then they draw them on the paper. When solving the “Fishbone and digestion” problem, Stone asked one question “Are there more carnivorous dinosaurs or more herbivorous dinosaurs？”, Through the use of authoritative sources, we introduced the concept of the food chain to him. He then drew it according to his own understanding(see Figure 2).

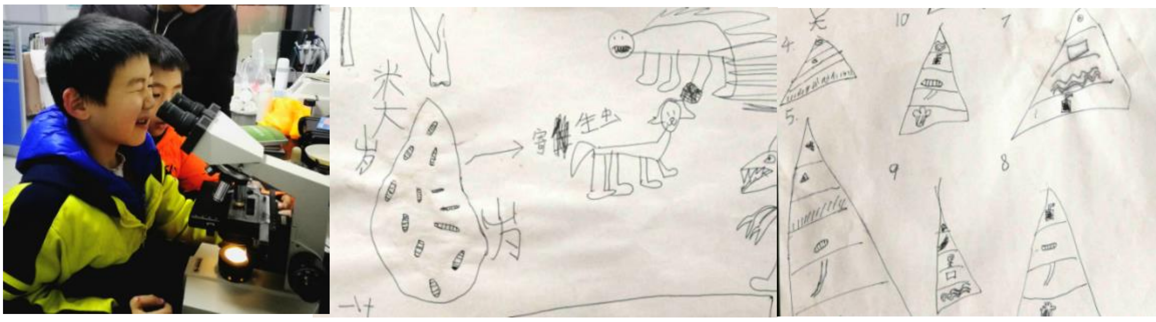

Figure 2. The artifacts drawn by stone

These are pictures which the children prepared for debate competition of "water and fire"(see Figure 3), The pictures above are obviously from children of higher grades (grade3 and grade4) who could express their ideas in words, While the pictures below come from children of lower grades (grade1 and grade2) who could only use painting and spelling to express their ideas.

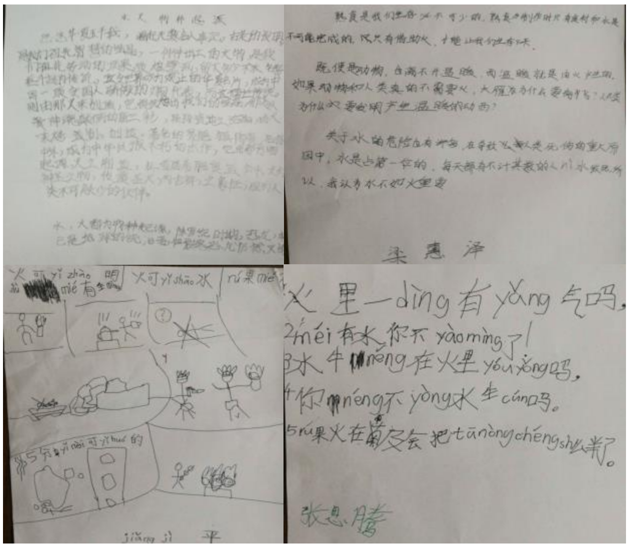

Figure 3. The artifacts of case3

4. Experiment reports

Experiment is a method that we often use in family science education. These are two experiments that we conducted "Bright and dark"(see Figure 4). The first experiment was to examine the effect of light on pupil size. These are 5 pupils drawn by stone, according to his observation. The second experiment was to test the brightness that was felt by eyes after the light was turned off. The father modified the experiment plan. The mother recorded the observations. The experiment process was recorded by audios.

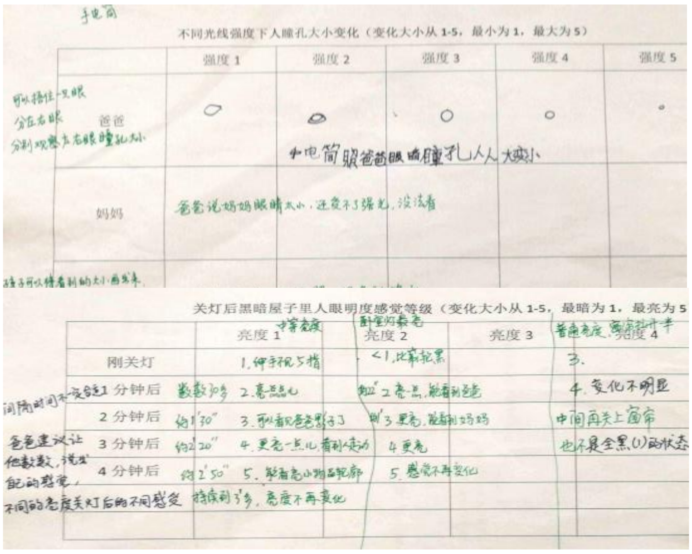

Figure 4. The Experiment plans

This is another experiment, about "Watermelon and buoyancy" (see Figure 5), We examined the floating or sinking of different fruits in the water. Stone himself designed an experiment to verify whether the hollow affected the floating or sinking of objects.

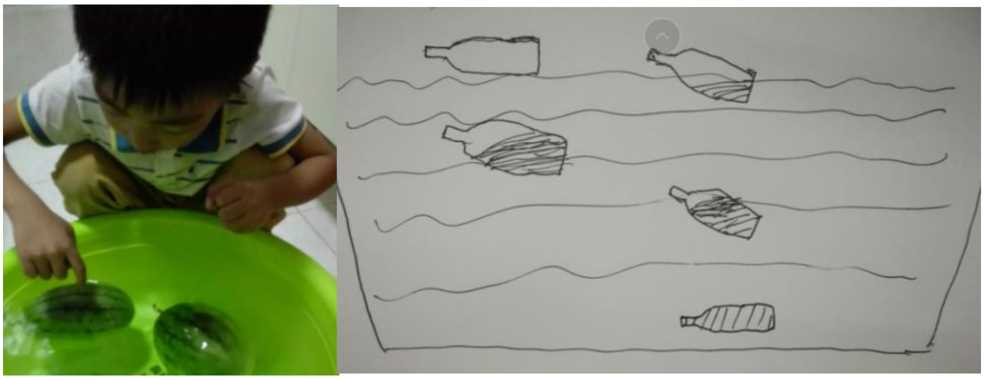

Figure 5. The Experiment process

Data Analysis

In October 2017, I consciously applied KB to family science education after I knew it(see Figure 6). there were only a few problems that were proposed by Stone. However, the number of problems greatly increased after I applied KB to family education.

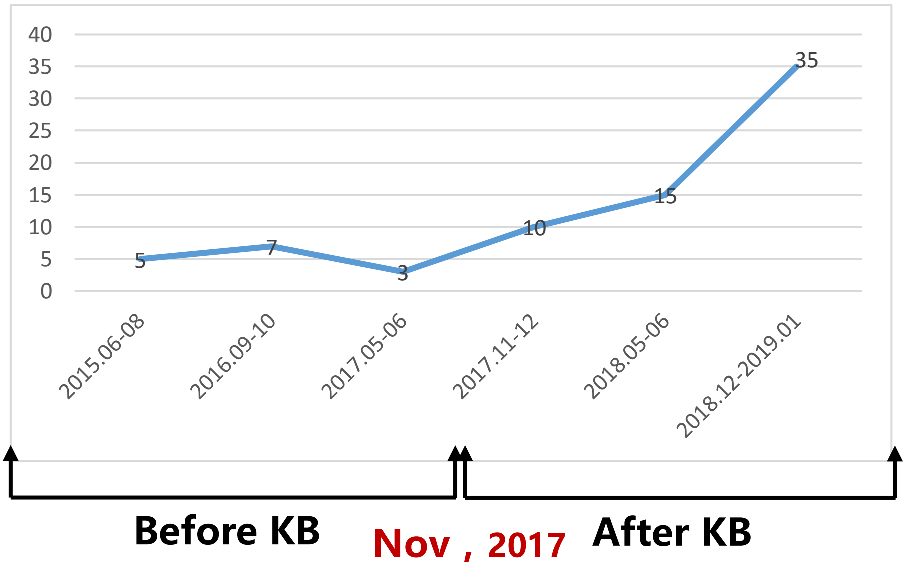

Figure 6 The number of problems

Note: The number in the diagram did not include problems raised by other participants.

The depth of understanding of science problems. In the beginning, most of his problems were factual or pre-scientific problems. For example, “Where do chickens come from? Who bore me, my father or my mother? Will watermelon float or sink when we put it in water?” In the second phase, he gradually raised more flexible or generative problems. Such as “What other ways are animals born? What are the factors affecting the floating or sinking of objects?” In the third phase, his problems were more comprehensive and complex, such as “Are all mammals viviparous? How do submarines apply the principle of buoyancy”.

The approaches we used in activities. He often question and refute the adults rather than regard them as authority. He learned to discuss or cooperate with others and search for information online.

The Participants and places. Participants ranged from mother-child to entire family members and even more children and more families. Places ranged from home to laboratory, museum, animal hospital, etc.

From the above five cases, I think that 12 principles of KB can be best embodied in family science education (see Table 3).

Table 3 Correspondence between five cases and 12 principles of KB

KB principles (Scardamalia, 2010)	Description
Real Ideas,Authentic Problems	The child's emerging problems come from everyday life, i.e., in the eating, bathing, sleeping activities.
Idea Diversity	Unlike subject teaching at the school, family science education has no definite instruction objectives, no fixed learning materials, no subject experts, therefore family members often generate diverse ideas. For example, the grandparents often have different opinions from the parents.
Improvable Ideas	Most of the original problems are superficial understanding or misconceptions, thus ideas needs to be advanced continuously with the help of the family members.
Rise Above	Each case goes through several rounds of iteration, and in the process of KB, the corresponding concepts are developed accordingly.
Epistemic Agency	He is eager to know the truth because the problem is raised by himself. He finds out the answer independently through internet searching, self-designed experiment, and so on.
Pervasive Knowledge Building	Family KB activities may take place anytime, anywhere, not limited to the classroom and campus only.
Constructive Uses Of Authoritative Sources	There are a lot of available authoritative sources about science problems, and the constructive use of the information is of great significance to the sublimation of the child's ideas.
Embedded,Concurrent and Transformative Assessment	The assessment of family science education is not external, but interest-oriented and self-reflected. For example, the child records the process and trajectory of idea improvement through paintings or discourses.
Community Knowledge, Collective Responsibility	The development of child is the goal of the whole family. Each member contributes to the family community knowledge.
Democratizing Knowledge	Parents are not like traditional teachers or experts, so it is easy for them to form a democratic atmosphere. Parents need to create knowledge with their children. For example, “Are all mammals viviparous?” It's hard for non-biology experts to provide a standard answer.
Symmetric Knowledge Advance	To give is to receive. Family members obtain knowledge through collaboration and the exchange of ideas. Some mistakes of adults'

	common sense have been corrected.
Knowledge Building Discourse	Science problems in the family often arise from discourses, and KB activities are often accomplished through discourse.

Results & Discussion

The number and depth of the boy's problems obviously increased which involved more multiple domains. The interesting thing is that he became more likely to refute and argue with others and actively adopted more diversified approaches to seek truth. The preliminary findings also showed that home is a good place for KB where all of the family members could be involved and KB places could be extended from home to laboratory, museum, animal hospital, etc.

This study is only a preliminary exploration and needs to be further studied and discussed. Whether need grandparents to participate more? How parents intentionally capture children's emerging problems for science KB? Family KB wall is very important. Peer participation can motivate the children to propose more problems.

References

Van Merriënboer J. (2016). How People Learn[M]// The Wiley Handbook of Learning Technology.

Sawyer, R. K. (2003). Emergence in creativity and development. In K. Sawyer, V. John-Steiner, S. Moran, S. Sternberg, D. H. Feldman, J. Wakamura, et al. (Eds.), Creativity and development (pp.12–60). Oxford, England: Oxford University Press.

Zhang J., Scardamalia M., Reeve R., et al. Designs for Collective Cognitive Responsibility in Knowledge-Building Communities[J]. Journal of the Learning Sciences, 2009, 18(1):7-44.

Oshima J., Oshima R., Murayama I., et al. Knowledge-building activity structures in Japanese elementary science pedagogy[J]. International Journal of Computer-Supported Collaborative Learning, 2006, 1(2):229-246.

Lin F., Chan C. K. K. Promoting elementary students' epistemology of science through computer-supported knowledge-building discourse and epistemic reflection[J]. International Journal of Science Education, 2018:1-20.

Huang-Yao H., Pei-Yi L. Elementary students enhancing their understanding of energy-saving through idea-centered collaborative knowledge-building scaffolds and activities[J]. Educational Technology Research and Development, 2018(6).

Pelletier J., Reeve R., Halewood C. Young Children's Knowledge-Building and Literacy Development, through Knowledge Forum®[J]. Early Education & Development, 2006, 17(3):323-346.

Cesareni D., Cacciamani S., Fujita N. Role taking and knowledge building in a blended university course[J]. International Journal of Computer-Supported Collaborative Learning, 2016, 11(1):9-39.

Goh A., Chai C. S., Tsai C C . Facilitating Students' Development of Their Views on Nature of Science: A Knowledge Building Approach[J]. Asia-pacific Education Researcher, 2013, 22(4):521-530.

Lossman H, So H J. Toward pervasive knowledge building discourse: analyzing online and offline discourses of primary science learning in Singapore[J]. Asia Pacific Education Review, 2010, 11(2):121-129.