



A Problem-Solving Approach for Science Learning

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Abstract

Science education in schools is aimed at providing the knowledge of surrounding science, developing curiosity, scientific attitude and thinking skills. However, in terms of pedagogy, teaching science is limited in achieving the aim of providing knowledge, while the other aims require the use of methods for experiencing through hands-on activities, experimentation, etc. However, such activities are used as a supportive to the curriculum and are largely teacher guided for learning that takes away the possibility of developing thinking skills of children. The present project with children is a methodology that enables science learning from hands-on activities and practical experiencing that can take naturally and is not teacher-directed or have planned curriculum. It uses science based toys that are exciting for children and can be made from simple and easily available materials and work on science principles that one can experience practically. The idea is not to teach them the science behind toys but how things naturally motivate the child to know science relating it and how curriculum shapes by itself, simultaneously developing range of skills.

Arvind Gupta, a scientist turned toymaker in India, has designed hundreds of science based toys for children. For example, a well-known toy phone can be made from paper cups, a straw flute showing how sound is produced, a balloon car or a spinning straw that works on Newton's third law of motion, a fountain from plastic bottle and straws working on air and water pressures, a periscope from pencil box showing reflection of light, a simple DC motor and so on. In the present methodology, children are not instructed to make the toy models, but are allowed to do it independently through books/manuals gradually putting their own ideas. Rather teaching or motivating thinking as in a constructivist perspective, it helps learning through the natural thinking that occurs when one faces a problem. Making models is a process of working and reworking to make it better and better. Solving of problems in tasks asks to understand various science concepts in a conscious way. For eg: a balloon car may not run due to reasons like no smooth air flow, that help to discover that air provides the push that can further be framed in an organized way. It also asks to think on friction, surface-tension of balloon, behavior of air, pressure, effect of mass, etc. in order to make it better/faster. A single toy can cover concepts that are otherwise taught in separate lessons throughout the year. Problem-solving thus can be one of the important methods for science learning. Children use chart, write down problems, reasons, solutions, that reflect on the science learning taking place. Books on science then become meaningful and useful that finally structures their thinking. It helps cognitive development of children and solves many of the pedagogic problems such as application of knowledge, integration of theory and practice, etc. It is a process from experiencing to organized form of knowledge, rather finding a method to provide the organized knowledge.

1. Introduction

Science accounts to one of the important subjects in school education. However, recently the traditional teaching methods are challenged for their inability to foster critical thinking, cognitive skills and a holistic learning environment among children. Apart from knowing of facts the subject is expected to develop science process skills where children observe, measure, classify, process information, interpret, think on solving problems, formulate conclusions, etc.

A problem-solving method as the name suggests is a method where children learn by working on problems. This model enables the student to learn new knowledge by facing the problems to be solved, instead of burdened contents [1]. It asks them to observe, understand facts, analyse and interpret, find solutions and perform applications that lead to a holistic understanding of concepts.



Many researches have shown the effectiveness of problem-solving methods in science learning and process skills. According to the study by [2] both problem solving and traditional teaching methods have positive effect on students' achievement. But problem solving method is more effective than traditional teaching methods. It developed students' scientific process skills. Studies by [3] have shown that, in classes where the teacher adopted the problem-solving approach, there was increased use of brainstorming, an increase in time allotted to defining, sharing and presenting the problem, as well as more student-selected research questions and student-designed investigations. [4]

In spite of its identified advantages it is not a regular practice in schools. The methods under this approach are still teacher dependent who is responsible to present problems as per the curriculum needs and facilitate it towards a specific learning. It is time-consuming, requires rich material and asks teachers to change their teaching styles [1]. The present practice shows how the advantages of the approach can be achieved without the teacher or the curriculum being solely responsible to direct the problem-solving process and how it can be achieved in a free environment for children at their primary learning stage.

2. The Present Project

2.1 Field setting and background

The discovery of the present method have been a result of a one year project with around fifteen children of ten to twelve years of age in a rural area named Wada, in the state of Maharashtra, India. It aspires to develop an alternative to the traditional teaching methods that is based merely on dispensing of content information. It is founded on learning in a free environment where children feel free to investigate things on their own and engage in their interesting activities rather as per a specified curriculum. It believes such environment is necessary for genuine thinking to take place and have the required motivation in learning.

It has been found that children are interested in hands-on creative activities where there like to create things such as art and crafts, making models, etc. In the present project, making science based toy models have been one of the most interesting among children. Prof. Arvind Gupta, a scientist from India, has been working on designing science toys out of easily available materials from past 30 yrs. His activities are readily available on the internet [5] along with books in regional languages for children to have access.

The aim is not to teach the children the science behind toys and use such practical activities as supportive to the science curriculum which is widely used to enhance the teaching practices. The aim is to develop a method that enable learning without rigid planned curriculum and teacher directed processes and where the child is himself responsible for the learning, the teacher playing the role of a facilitator.

2.2 The Development of the Method

The project is experimented in a small village where it conducted regular sessions of two to three hours in a classroom of the village school. Initially the children were instructed on making the models, where they got introduced with the activities and generated required skills in making them. With the building of confidence, children showed the will to work independently through referring to books, manuals and e-resources gradually putting their own ideas.

Some of the toys included a toy phone that can be made from paper cups, a straw flute showing how sound is produced, a balloon car or a spinning straw that works on Newton's third law of motion, a water fountain from plastic bottle and straws working on air and water pressures, a water pump from pen, a periscope from pencil box showing reflection of light, a simple DC motor and generator and so on.

The making of the models isn't a smooth process so that one can make it in the first try. It is a process of working and re-working to make it better and better. Books do provide the guidance but ultimately also requires the child's skills in understanding it through common sense. Here the child is naturally engaged in a problem-solving process independently and therefore opens up doors for science learning. The problems that one encounter asks the need to understand many science concepts without which one cannot move to its solutions.

Table no. 1 is based on the problems children faced while making a balloon car toy which helps to understand how learning emerges naturally during the process. The toy is based on the simple principle that every action has an equal and opposite reaction which is Newton's third law of motion.



When one blows up the balloon and leaves it with its mouth open, the balloon travel to the opposite direction. In this toy, the balloon is attached to a straw stuck to the car body which can be made through various ways such as putting wheels to a paper cup. This simple structure is ready to run after the blown up balloon is released.



Fig 1. A Balloon Car

Table 1. A problem-solving chart of a balloon car

Problem	Reason	Science	Solutions
Slow Speed	Blocked air flow in straw	Air gives push to car (law of motion)	Check air flow
	Heavy weight	More energy for more mass, (Mass , energy, speed relation)	Reduce weight / add balloon
	Balloon not enough	Surface tension of balloon and pressure	Use thicker balloon
	Wheels stuck	Friction	Check wheels
Car tilting after blowing the balloon	Weight of air	Air properties and center of gravity	Balance the center of gravity through extra weight at rare side.

The table shows how working on problem asks to understand how things work together that actually forms the science learning. The slow or no speed of the car asks the child to find out its reason that is based on a particular science. If it is due to the blockage in the air flow, one understands the role of air in the motion of the car. Though it isn't directly possible to lead to the Newton's law of motion, it can be later understood through discussions and readings.

The working towards solution of the problem is a natural process done by the children. However the use of a chart systematizes the process giving the child a framework for thinking and reflects on the learning. The science rules thus discovered can become a subject for discussions among the group to arrive at final conclusions. Experiments can be quite useful to verify the science principles. The concepts can later be introduced through teaching or books that can then become meaningful. It is not only useful in understanding the concepts alone but working on it as well with its in-depth understanding. For eg: one can calculate on how much speed can be obtained with a certain air pressure and a given amount of weight and friction. Here one is also working on mathematic tools that generate maths learning simultaneously. Maths is a useful tool even in making of models for taking accurate measurements and geometric tools for a better one.

The activities of science toys primarily cover the physics area of the natural sciences. However, activities beyond the classroom walls open up opportunities for learning in biology, geography, etc. Activities like making a garden in the community or involving in agricultural activities would enhance learning in knowing about plants, soil, their growing processes, effects of climate on them, learning on climate, earth atmosphere, etc. that can again be structured through a planned format where problems can become the sources of learning. This is yet to be experimented in the project. The diverse activities children can involve in can become a learning experience in still wider areas that can



outstand the classroom teaching and lead to a holistic understanding of science and range of life-skills necessary for living.

The children's thinking on the problems and their understanding of the science behind is initially based on common sense. It doesn't start from books and understanding of organized concepts but through experiencing, gradually 'forming' concepts later through books. It therefore cannot take place through a pre-determined curriculum which shapes here by itself along the process. It is a process from practice to theory and not vice versa as in usual practices. Knowledge isn't a goal but a natural outcome of working on tasks. Children live in the real world and like to deal with concrete things where they can see, touch, feel and manipulate things. Knowledge as an abstract world therefore cannot directly influence children. The method is hence useful to ignite the process of science learning when the children being to understand the nature of science and learn concepts.

3. Conclusion

The method is an attempt to make science learning an active process for the child where he is himself responsible for his learning. Learning need not depend on the teacher who generally has the sole responsibility of learning. Many researches have found the benefits of a child-directed learning compared to the teacher-directed. However we haven't been yet successful to develop a method that can be implemented on a large scale and can replace the traditional practices. Many times the methods of teaching though are effective cannot be implemented at large scales due to their complex models and high degree of skills it asks on the part of the teacher.

The method have tried to achieve this by giving a very cost efficient model of learning that can be implement even in poor countries. Science is everywhere, and need not have expensive equipments and laboratories for learning at least in its initial stage. Science interest and curiosity has to be developed from the natural world itself which is an actual laboratory. By giving a less teacher dependent model it has tried to make it efficient by making learning an individualized process.

References

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