Hands-on Learning versus Inquiry-based Learning

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My method of teaching science to children evolved over a period of 10 years, transitioning from hands-on learning to inquiry-based learning. As a teacher, I frequently tested my methods with children, finding that some worked wonderfully while others did not. Sometimes working in groups benefits a child, and sometimes working alone is better. Thus, as an Educator, it is essential to try different approaches and find the right balance. Trusting children, giving them ownership, or at least involving them as much as possible in the learning process is very important. While methodology is crucial, I believe the ambiance is equally important, such as displays, resources, or necessary tools. This is why I prefer to conduct my classes in the lab (I have written more about this later in this article)

My approach to teaching has mostly shifted from hands-on learning to inquiry-based learning. However, with senior classes such as 11th and 12th grades, I also used conventional methods like lectures. However, even while using the lecture method, I incorporated different resources such as simulations and experiments, and involved students as much as possible through discussions. I won't go into detail here, as the purpose of this article is to focus on the approaches I primarily used with students from primary to 10th grade.

First Approach: Hands-on Learning

At Anand Niketan, I mostly worked with kids on topics like light, electricity, force, and pressure. I would demonstrate an experiment or show a demo and ask them to brainstorm about it. For example, I would show them a beaker filled with water and put a pen into it, asking what they observed. Or I would connect two beakers, one empty and the other filled with water, using a cloth. We would leave it overnight and observe the difference in water levels the next day. I would then ask them to explain what happened.

Sometimes children would make statements that others wouldn't understand. My approach was to simplify everything to help them truly understand what happens and why. Such discussions might take hours or even days, and to keep curiosity alive, one must continuously provide fuel for it, which is what I did by asking probing questions.

For instance, when discussing the pen in the beaker, if they said the pen bends when it enters the water, I would keep it straight and parallel to the walls, so they noticed no bending. I would ask questions like what conditions are required to see this bending or use a laser to show the same experiment. During discussions, what one child says often provides clues for others, helping us move forward. The idea is not just to reach the known solution but to observe and appreciate the questions or statements that arise, even if they are not directly related to the main question.

Here, I did not consider writing work important and did not force children to write. However, I suggested drawing diagrams and writing points to remember the discussion. Sometimes, model or project making was purely for enjoyment, like making paper rockets on a thread or a parachute.

The thought behind all this was for children to have hands-on experience, as learning is more effective when the hand, heart, and head are involved. Therefore, I encouraged children to make circuits without giving them instructions, simply providing them with a bulb, wires, a bulb holder, and a battery or cells. As they connected the components in various ways, they figured out what worked and what didn't. This process was fascinating for both them and me. It led to a series of questions, such as why the cell must be connected a certain way, why a bulb doesn't work when touched anywhere on its body, or why a circuit doesn't work if rubber is used in between. These questions help us delve deeper and learn more. The role of a teacher or facilitator becomes very important here, guiding these questions in a way that leads to better understanding. This comes with experience and a lot of preparation before and after each class.

Some of the important skills involved with this type of method are observation, critical thinking and hands on practical skills.

Second Approach: Inquiry-based Learning

For years, I experimented with different methods, sometimes using hands-on approaches and other times using lecture modes with lots of videos, readings, and discussions. In each method I tried, there was an element of inquiry-based learning. Evoking curiosity and sustaining interest were common factors among all these methods. However, while working at Prakriti School In Noida, I fully implemented inquiry-based learning. Here, the ownership of learning was entirely with the students.

To understand this better, here are a few examples where I tried Inquiry based method in the class.

Example 1: Density

Density can often be misconstrued with weight. Inquiries such as why a ship stays afloat despite its heaviness can stimulate critical thinking. In my methodology, I present queries and encourage children to propose explanations, followed by collaborative discussions on each explanation. This method involves deduction, moving from numerous possibilities to fewer alternatives.

I devised two experiments and distributed written procedures with blank observation tables to students grouped accordingly. Subsequent to each experiment, we deliberated on the observations and the underlying reasons. This approach, which accommodates multiple correct answers, fosters holistic thinking in children. It is imperative to acknowledge all viewpoints without imparting any sense of bias. Occasionally, I deliberately highlight certain points to instill confidence. Errors and erroneous assumptions are as valuable in the realm of science and education. Indeed, progress in life mirrors this trajectory. We documented all viewpoints shared during discussions before transitioning to the next experiment. One experiment entailed determining the density of various items like vegetables, fruits, and stones. We noted that certain items did not submerge, prompting a discourse on buoyancy and its correlation with density. It became apparent that items with cavities or high water content tended to float. Conversely, some denser objects sank. This exploration elucidated the distinctions between mass and density. While students calculated density by applying the Archimedes principle to measure volume, a query arose regarding whether hollow containers displace the same volume when forcibly submerged. A student conducted the experiment and was elated to unveil the outcomes independently. Such experiential learning resonates with students in the long run. This impromptu experiment was particularly thrilling for me as well. The underlying principle is straightforward: when a child poses a question, they contemplate the answer and proceed to test it. Regardless of whether the anticipated outcome is achieved, firsthand learning is inevitable in all scenarios.

Example 2: Heat and temperature

My role in facilitating the sessions: To begin with, I started by asking opening questions and providing input only when the students were stuck or needed prompts to facilitate deeper inquiry. Opening questions not only help narrow down or guide the discussion but also reveal the students' prior knowledge. Sometimes they may not know the scientific terms but can still share their logical reasoning. And towards the end to wrap up the discussions highlighting major points that arose during the discussion.

For example, I introduced the topic of Heat and Temperature with the following questions:

- How would you increase the temperature of water in a beaker?
- Which of the following requires more thermal energy to raise its temperature by 10 degrees Celsius?
    1. A glass containing 0.25 kg of water
    2. 375,000 kg of water in a swimming pool

The students took around 15-20 minutes to discuss these questions. One group suggested that even though 375,000 kg of water is more, the area of the swimming pool is larger, and the sun would heat both the water in the glass and the pool in the same way, so there wouldn't be much difference. They reasoned that the larger surface area of the pool water would absorb more heat.

Another group argued that if we used a source like a Bunsen burner, we would have to heat the water in the swimming pool for more time to raise its temperature by the same degree.

We then discussed: What is heat? What is temperature? What happens when something is heated? What is the difference between heat and temperature?

I also asked them: If we have water in two beakers, one with less and one with more, and both initially have water at 20°C, which one would need more heat to increase its temperature by 10°C?

We discussed this question for hours before the students tested their ideas through an experiment. They used the same Bunsen burner as a heat source and observed which beaker of water took longer to raise its temperature by 10°C. They kept thermometers attached to stands, ensuring the thermometers were submerged at the same level in both beakers.

Then I asked: If we have water in two beakers at different temperatures, what does it mean to have different temperatures?

At the end we talked about the opening questions and statements given in the beginning again by children.

Feedback : I believe without taking children's feedback, moving to next topic is just another attempt to finish the syllabus without it making sense to the learners. So, before starting the next topic, I asked children about their experience of the previous chapter and working together in the groups was like. I noticed while doing the chapter density and not everyone was happy working in groups and some children were left all by themselves.

They shared both the pros and cons .

Pros: They said it took them less time to find the solutions as many minds were working on the same problem and we were complementing each other. They also enjoyed working together.

Cons:

- Some of them shared that they felt left out.
- Some of them were participating more giving less chance to speak to others
- Some of them were not interested at all and hence it was difficult to work with those in the same groups
- There was a lot of confusion regarding the work division. Even till the end they were struggling with who will do what.

Way forward: I then asked them if they would want to work in groups to which more than 95 percent of them said YES. I then asked them how could we move forward with these challenges knowing that working in group has its advantages. They shared different solutions. One person said that we must discuss and plan before directly jumping to the experiments. I observed that they worked well together in the next topic.

Norms : I believe setting norms is also an important thing to do even before the topic as it brings everyone to the same table to be able to work together better. Some of the norms we set together were as follows :

1. Valuing the tools or equipment that are taken from the lab and keeping it back at its place.
2. Respecting everyone in the class by listening to their points and not cutting them while they are speaking.

Example 2: Electricity Here is another example of how I tried inquiry-based learning with a different topic that was more practical. While we were covering other topics, children of class eight would often ask when we would be doing electricity, so the next topic we started was electricity, at their request. This is another thing I did: I let the children choose the topic they wanted to do next. Sometimes chapters need to be done in sequence to make more sense of the topics, but otherwise, we would do them randomly.

Preparation done before the topic: I went to different shops to buy the items I needed for the experiments. Now, one can assume that this topic can only be understood by doing, but since I was using inquiry-based learning, the idea was also to let children think more deeply about the questions to make sense of their learning. I made groups of 4-5 children in each group. We had about five groups. Each group was given a tray with all the materials, for example, bulbs, wires, cells with holders, switches, etc. I had done some pre-work, such as screwing wires into holders. I used plastic wires.

The idea was to ask questions and let the children find answers by working in groups. They would perform the experiments and then discuss. It was interesting to see the discussions and debates that happened in the groups. Children would then share their findings with the larger group, which would involve each member's thoughts.

For example, I asked the children how they thought the bulb in our lab was working. What things are required for it to work?

The children said we have wires running under the walls that connect the bulb to the switch. Another child said the switch provides the energy. Another child said no, it's coming from somewhere else. One child said it is coming from far away.
So, I then asked the children to use the materials given to light the bulb. I had told them nothing about how to connect it. Initially, there was no bulb holder or cell holder. They only had bulbs, wires, and cells. It was interesting to see how they kept trying different ways, helping each other, and shouting instructions. Obviously, there was a lot of chaos, but it was necessary chaos without which this learning couldn't happen. I also noticed that some children were left out, and even after trying, they wouldn't engage much with others. They were comfortable only with their friends, so I put them with their friends. Then I found them fully engaged and trying different things. Some groups found the way to light the bulb, and those who didn't would look at other circuits and try the same, while some would keep trying their own ways. This obviously needs time, and one has to be patient. Towards the end, each group was told to come and draw their circuits. Here we learned to use the symbols after a discussion, as we figured out that not everyone was comfortable drawing the components.

Many of them shared their findings, and while they were sharing, I also asked questions like: Could we connect the bulb at all points on it?
They said no and explained that the bulb will only light if we connect it at two specific points. Similarly, we talked about cells. This way, we discussed terminals. Then I told them to add a switch to their circuit after discussing the role of the switch in our lives.
We then talked about the ways we can connect bulbs and discussed series and parallel circuits. Here I first asked them to think, share, and discuss in the group what will happen if two bulbs are connected in series or parallel. It was interesting to first know their answers and then see what actually happened, and then think about why it happened. For example, the brightness of the bulbs reduces if we have two bulbs instead of one. Also, why do bulbs glow brighter in parallel circuits than in series circuits? We then tried to model electrons to understand the concept of energy in a circuit. There were many questions asked by children that obviously are not answered by this model, and this is when we also discussed the idea of different models or theories in science. We also talked about measuring current and voltage using the meters. Children were excited to measure to finally have a number to associate the term with.

At last we tried answering a few questions where children would first think and then answer and then we would verify using the PHeT simulation and discuss why was the answer different if it would be different. It took us a long time to finish this chapter(nearly 2 months) but the experience of learning would never be forgotten.

While electricity was being explored in the classes, I gave the children a project where I asked the parents to buy a few kits and then gave some puzzles for the children to solve using the kit. Many children developed interest because they were doing it at home with their parents or siblings and told me that their concepts were much clearer. This was also a way to involve the parents in the children's learning. Obviously, after a certain age, one might not think of involving parents in learning in this way, as children like to do their tasks all by themselves.

The **important skills** involved with Inquiry based learning were observation, critical thinking, taking ownership of their learning, collaboration and listening skills.

Hands on learning vs Inquiry based learning: My journey of going from hands on learning to inquiry based learning was natural and I developed it while working with children and not by reading about it somewhere and applying it. Hands on learning is very much part of inquiry based learning. However, it is much more than that. It is not to do just hands on but instead make the learning their own or experiential by engaging with the problem statement or the question and finding out the answers.

Other Elements of Learning: Children learn all the time whether or not someone else is in the picture. Hence it is important to talk about those spaces to emphasise this point. Such spaces which are not formally designed by anyone and yet how important they become in the learning of the child. Some of these spaces are where I was present while some where I was not present.

- Learning in the **Physics Lab:** I believe a physics lab or a science corner is an important space for learning, so I try to build it at the beginning. Doing science in a lab has a unique learning experience: first, it provides the right ambiance, and second, it has everything you may need while doing science. Children would often come to the lab and explore the items kept there. Sometimes, while playing, they would observe something interesting. For example, while playing with a slinky, one child observed that if we drop the slinky vertically, the lower part stays unmoved until the upper part touches it, and then they move together. He shared this with other children. We recorded it in slow motion and watched it together. This was his little discovery, and he then explained the theory behind it. Other children present argued with his points, and he took some time to think. A few days later, he came up with another explanation and shared it with others. Here, it is not important whether or not he got the right answer—after all, what is a right answer? The important thing is to understand the process and keep searching until you get a satisfactory explanation, which then can be considered the right answer.

- **Exploration outside the class:** Sometimes, children would come with observations or questions related to something being done in science class. For example, while discussing waves (progressive waves like sound waves and water waves) in class, a child noticed the waves formed with a rope of the curtains in the chemistry lab. He noticed that these waves started at the end of the rope he held but disappeared at the other end, unlike water waves. He shared this with me, and while discussing, he found it was a different kind of wave, which we call standing waves. He jumped with excitement, knowing he had discovered something new on his own.Science is not confined to the classroom; it is often taken outside too. For example, for a topic we were covering, we decided to do a treasure hunt prepared by the children of grade tenth. There were two teams and four moderators. The moderators prepared the questions and planned the hunt. Each team would get a clue to move to the next question if they answered the previous question correctly. The benefit of such an activity is that children get to learn a lot from each other. While playing the treasure hunt, since each child was involved in the activity very enthusiastically, they were all very attentive.Or the other time, to understand the idea of average speed with grade 9th, we did use the idea of race where children ran and we found their average speeds. The whole chapter of motion was done on the ground.

- **Projects:** It is a well-established fact that learning happens when you are involved and actively doing something to learn. This is why simply listening to lectures given by an expert will not help you learn unless you make an effort. Hence, I strongly believe that the role of facilitators should be small compared to that of learners. One time, I gave grade 9 students different questions on energy to explore. Knowing their interests, I asked one child to look at the historical aspects of energy use, another to find out about new resources, such as hydrogen fuel, and another child to perform an experiment and share his findings. They had the freedom to use any resource, conduct any experiment, and talk to any expert. It was fascinating to see that the findings the children shared had a broad perspective. The experiment of transferring energy (compounded pendulum) they demonstrated was done using cheap materials like rope, plastic bottles, and a table at home. Such opportunities give a child confidence not just in learning but in owning it by sharing it with others.

- **Connection of physics with the challenges humanity is facing:** Humans are facing problems that need thinkers who think out of the box and hence talking to children about these problems is essential. And hence I tried to integrate them wherever possible. For example, I conducted a debate on nuclear energy with class tenth students. Students knew about the debate weeks in advance, giving them time to prepare their points for the side they were advocating. Some were in favor of using nuclear energy as it is the future and we are nearly out of fossil fuels, while others were against it, arguing that it is harmful and produces waste that cannot be managed. During the debate, a few children who hadn't read anything about it or weren't prepared initially listened to the prepared students but ended up sharing their points as well. Often, students who haven't opted to join in the physics class and, while listening, share their points too. This kind of discussion not only enriches one's knowledge but provokes deeper thinking.

All these examples show that the children are relating science to their lives and seeing it around them. For me, this is what true learning is.

Hindi Translation Published in SANDARBH issue 156, January-February, 2025

Sandarbh is a bimonthly resource magazine published by Eklavya Foudantion