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PHYSICS DIDACTICS: INNOVATIVE ACTION ORIENTED METHOD FOR TEACHING AND LEARNING PHYSICS

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Abstract: This study aims to propose a structure to work didactics of physics in teacher education program, based on research results obtained by conducting science activity classes with school students using 'Toys from Trash' (TFT) activity method. This phenomenological research design characterised the Didactics of Physics through activities, sociocultural sections, socio-scientific issues and interaction sections. It consequently designed and applied teaching methodologies. It was designed to analyse the impact and validate this dimensional proposal to serve as a physics educator to focus on enhancing students' conceptual understandings of physics concepts through various science teaching strategies such as learning by doing, discovery learning, active learning, hands-on approach, creating toys from trash etc. This research is based on the belief that knowledge is constructed in an on-going manner by learners as they engage with and give meaning to an activity, experience, or interaction. This research focuses on how to explain difficult science concepts using simple toys from the trash to school students and perspectives in the progressive teaching environment inside and outside the classroom.

Index Terms - Didactics, Effective teaching, Activity based learning.

I. INTRODUCTION

Didactic (Greek: didaskein) is a teaching method that follows a reliable scientific approach, educational style to engage, to encourage students minds and examines the teaching process as an interesting, effective one in a wider sense along with practical application of learning. 'Didactic competence is about the knowledge of how to teach and communicate

knowledge' (Kansanen, 1993). The main purpose of learning is to construct and induce critical thinking to understand the whole concept without any doubts. It lays emphasis on thinking power and understanding of the concept by his or her own connotation, not just memorising the concepts or answers in exam point of view.

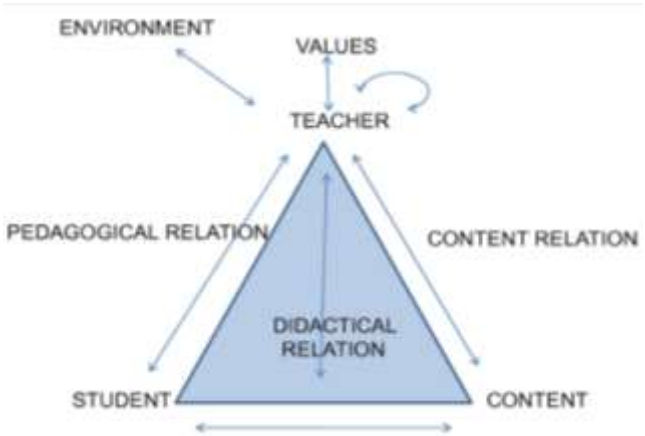

Fig. 1. Didactic Triangle

The theory of teaching and learning is mainly related to WHO should learn WHAT with WHOM, WHERE, HOW and WHAT FOR? 'This didactic triangle has three equal constituents: The Teacher, the learner, and the content'.

(Dr. A. Clement, Mr. Roland Rencewigg, December) As reported by a research work, knowledge of subject, enthusiasm and communication skills are the most enviable features of a good teacher. 'Didactics is a field of research that encompasses the collective knowledge of all teachers at the point where academic knowledge and practice intersects' (Christina Osbeck, Åke Ingerman, Silwa Claesson , 2018)

As for a teacher, we should keep in mind about the following things,

- How do teachers personally understand the content?
- How did they acquire knowledge about the subject to be discussed?
- How experienced/ well versed are they in a given topic?
- Where are their individual preferences and barriers in this subject?

For Content,

- How can the learners approach the topic?
- What prior experiences do the students already have with the topic?
- What interests, assumptions does the topic raise in students?

For Student,

- What is the objective/connection among people present here?
- How do we define our roles?
- What do we know from each other?
- How to develop more?

The importance of learning outside the classroom found that school children's learning about their local environment influenced the way they treated it. 'During the past few decades, physics educators and researchers have accepted the idea that students bring to the science classroom alternative or misconceptions that must be changed to the scientifically accepted concepts'. (Miriam Lemmer and Nico T. Lemmer, 2008)

We found that not only was this the case, but high-quality, out-of-classroom learning also influenced how children behaved and the lifestyle choices they made. It shows the potential for school trips to change not just individual lives but the lives of whole communities. Learning must start with the issues around which students are actively trying to construct meaning. Meaning requires understanding the whole concept as well as its sections. Categories must be understood in the holistic context. So it is important that the learning process focuses on major concepts and not isolated truths.

II. Project Objective

This action research has the following precise objectives:

- How to teach difficult concepts of science in easy way to students.
- Improve creative thinking of the students.
- Develop the importance of activity-based learning.
- Increase students' active participation in science class.
- Analyse the challenges faced by teachers during activity class.
- Easy hands-on experiments for teaching complex science concepts
- Know the importance of creating toys from trash to learn science through fun and enhance learning outside the class.

According to Holt (1989), science is continious wondering, finding out, and knowing. Science experiences also help young students to develop their abilities to solve problems, acquire scientific knowledge and information, keep an interest in and appreciation for science happenings around them, and develop positive attitudes towards science.

2.1 Effective Physics Teaching and Learning:

Effective physics learning in formal way involves three main steps,

- Pre reading
- Active learning Review &
- Problems with an Active Physics Course

In general, for an active physics course, focus on making connections between facts and fostering new understanding and critical thinking in students, we can use strategies that encourage students to analyse, interpret, and predict information.

Students are asked to read portions of the text books before coming to class. They are expected to take notes and to write out questions on things they do not understand. For active learning classes, every student must engage in some special method of practical activity. Activity sheets involve guided and reflective questions. 'This method enhances the critical thinking of the student and is also helpful in finding links between theoretical and experimental analysis. During the learning process, learners are motivated to obtain knowledge through the usage of student worksheets'. (Faye Joy Ferrer Delos Reyes, Dennis G. Caballes, 2021)

For effective teaching of development of conceptual knowledge, teachers start from known to unknown phenomena, clarify misconceptions, use a variety of approaches and contexts, and develop a technical approach.

Some basic didactic teaching strategies can include:

- Demonstration: A teaching strategy in which the teacher demonstrates a concept. The demonstration method can be especially effective when combined with visual aspects like writing on a whiteboard.
- Explanation: A strategy in which the teacher explains the concept. This can occur independently or along with demonstration to enhance learning.
- Observation: A method in which students make observations to learn more about topics. Students can observe a teacher's demonstration to help them better understand a concept.
- Group discussion: It is very important that teachers discuss the lessons with students to analyse their understanding level.

- Home activity: Teachers can help their students learn new skills and knowledge by assigning them home activities to complete to practise concepts and strengthen their understanding.

III. CONSTRUCTIVISTIC DIDACTICS METHODS

'The concept of using simple, everyday objects to trigger interest in physics was established by Vittorio Zanetti at Trento University, more than 20 years ago'. (Grzegorz Karwasz, Anna Kamińska, 2020). The purpose of this study is to investigate the changes in students' learning experiences, especially in terms of learning comprehension and learning motivation, after they sequentially participate in three different teaching stages.

It unveils new knowledge on how activities can affect the learning environment as well as impact learners in the education system today. During the past few decades, physics educators and researchers have accepted the idea that students bring alternative ideas or misconceptions to the science classroom that must be changed to the scientifically accepted ones.

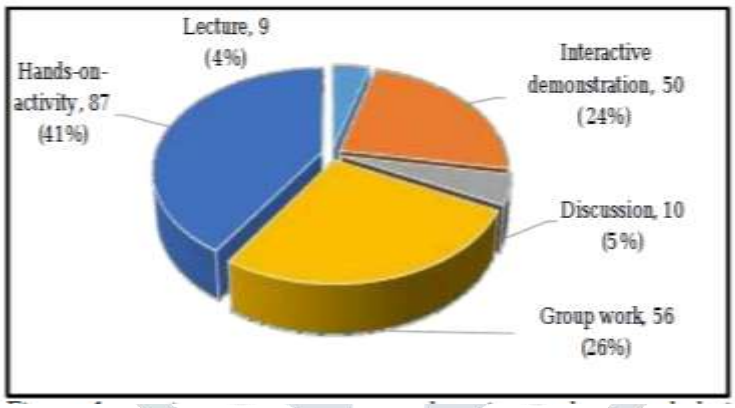

Fig. 2. Students' responses diuring practical classes.

Above all, the best didactic method of teaching physics to school students is "Teach Science with Fun Activities." 'Majority [87 (41%)] of the students asserted that teachers used hands-on activity as the main pedagogical method during practical lessons'. (Yao Asamoah, Godwin Kwame Aboagye, 2019)

For the past two years, I have conducted a science activity class, for school students, by doing various fun-based activities to demonstrate various science topics (such as viscosity, surface tension, magnets etc.) and basic science terms by making toys from trash.

3.1. Teaching hypotheses and highlights of my science activity class:

The highlight of this class is that students were asked not to bring any books, notes, etc. They came to class with a fresh mind set only because they were very eager to learn the concept through lots of fun activities. It's was challenging for me to imagine a class without

notes. However, I succeeded in that method and reached a class's enthusiasm level, which was very high.

Presentation of the project was necessary. Before starting my innovative experience used in physics teaching classes, I had formulated the following working hypothesis:

Step: 1 Introduction to the Topic

Step 2: Demonstration and explanation of main activity

Step 3: Teamwork and Project

Step: 4 Asking typical questions about the activity and group discussion

Step 1: Introduction to the Topic

Giving an introduction about the topic and showing pictures in a PowerPoint presentation improves students understanding of the corresponding physics phenomena. The duration of the science activity class is one hour. But due to the interest level of the kids, it extended beyond one hour. I introduced the topic by asking simple questions. For example, In the activity class of the subject "object",

Me : What are the names of the objects available in the class room?

Students : chair, pen, desk, glass, water bottle, cloth, laptop

(They immediately answered by looking around the class.)

Me : Are all of the objects made of the same material?

(This was my second question)

Students : NO (This time they replied a few seconds later because they were thinking.)

Students : wood, glass, paper, plastic, etc. (Without expecting my question, they immediately responded with the names of materials which indicates their eagerness to learn more about the objects.

Me : Okay, so now you classify the objects based on their softness and hardness?

Students : Wooden materials are hard. Glass is soft. (This time only some students replied. Hence, I explained it in detail (starting point of the class))

Usually the class starts with lots of questions, which stimulates their thinking ability and also allows them to ask many questions.

Step 2: Demonstration of Main Activity:

Scientists would know that the best way to "learn science is to do science". Students were randomly assigned to either the action or observation roles. Overall, the action group earned quiz grades that were about 7 % higher than the observation group. (https://news.uchicago.edu). It seems to be the only way to get down to the business of asking questions and conducting investigations. Children need to have the chance to ask and answer questions, do investigations, and apply them to problem-solving skills. 'Nearly 90% of teachers agree that students interact positively with practical activities and few indicated that many students consider lab as a place for fun and relief from the stress of learning in traditional classes'. (Ziad Said, Heather Friesen, 2014).

After successfully explaining the theory, it is very important to demonstrate it with an explanation. As demonstrated in class, some activities require a lot of technique. For example, we demonstrated a candle seesaw (which required a lot of practice and technical knowledge). Candles were attached in the middle of the needle and placed on a freely rotating stand. The candles began to melt as soon as I lit them. So the weight of the candle got reduced. Hence, it moved in an upward direction. Now the other side of the candle was in downward motion. But the flame length was high. So again, it melted fast. It continuously changed its weight and moved in both an upward and downward direction, just like a seesaw.

Sometimes the main activity was a very interesting one and created lots of joy in class. For example, 'the pressure inside the glass activity' made the students happier. The boy sucked the air inside the tumbler, which created high pressure inside the cup. So pulling the cup out was very difficult. Students enjoyed the activity and understood the concept in an easy way.

The choice of the main activity depends on enjoyment of the class and also facilitation of easy understanding of challenging concepts. Kids may ask lots of questions during this period because they observe things very keenly. For example, kids asked why a balloon made a sound when it was deflated. So I explained in detail by creating various sounds by making different-sized holes (pressure variation) in a balloon. Children learned a lot through hands-on experience. Explaining difficult concepts in a simple manner is one of the qualities required in didactics.

Step 3: Teamwork and Project

Table 1: Schedule of Activities

Subject Name	Activity Name	Materials Needed	Procedure
Objects	Find the centre point of an object.	Paper thread scissors scale pencil	• Poke the paper at one side and inject the thread through it. • Tie both ends of the thread and suspend them freely. • Now you draw the vertical line from the hole towards the ground. • Repeat this method by changing the hole. • Now all the vertical lines join at one point, which indicates the centre of the object. • Repeat this activity for irregular shapes, too.
Moon and Eclipse	Eclipse of moon	card boxes pen cutter coin gum	• Draw a circle using a coin on the flap and cut it. • Remove it • Attach a cardboard stand to the disc. • Fix the disc in front of the hole inside the box. • Cut off four small flaps. • Punch 15 holes 1 cm apart on the opposite flap. • View the light progressively through 15 small holes to see the eclipse of the moon.
	Phases of moon	Plate oreo biscuit spoon	• Split the Oreo biscuit. • Using a spoon, arrange the cream as if it were waxing and waning. • Order it as regular phases in plate.
	day cycle of the moon	Stapler scissors paper	• Draw 28 circles using a coin, and colour them to represent the waxing and waning moon.

		coin	• First 14—waxing (remaining 14—waning) • Staple each strip together to make a booklet that indicates the phases of the moon.
Candles	Candle Seesaw	Match box long candle Needle paper cup	• Using a knife, sharpen the candle to expose the wick on both sides. • Poke the needle at the centre of the candle. (The weight of the candle is equal on both sides.) • Place the needle between two cups and light both ends of the candle. • Wax drops from both ends, shifting weight, and the seesaw is set in motion.
	Candle pump	bottles-3 scissors candle glue match box long tube	• Make holes at the bottom of one bottle and on the sides of the two bottles. • Make a hole in one lid. • Join bottles with short pieces of tube. Now close one bottle with a lid. • Take another bottle (inverted position) and join with the lid. • Joints should be tight and sealed with glue. • Pour coloured water into one bottle at a time until the water level in both bottles is the same. • Now light the candle and invert the bottle onto it.
Colour Chroma	Colour Wheel	plastic bottle chart paper pin needle colors thread	• Cut the chart paper into a circle shape and make a small hole at the centre of it. • Draw different colours. • Insert the needle into the chart and insert it through the bottle hole. • Tie one end of the thread at the centre of the needle and pass the other end through the bottom hole.

			• Now Pull the thread downward and let the flywheel rotate; it will become colourless.
	Colour Pattern	Filter paper colour sketch pen water glass straw or toothpick	• Stick strips of paper on a straw or toothpick. • Make different-coloured dots on the strips. • Place straw on glass (gently pour water so that the end of the strip touches water). • It will create beautiful patterns.
Spiral Illusion	CD illusion	Old CD spiral card disc glue marble	• Apply glue to the CD and stick the spiral on it. • Stick the marble at the centre and wait to let the glue dry. • Spin the disc clockwise, not too fast. • Focus on the centre of the spinning disc for 20 seconds. • Now look at the object near it. What do you observe? • Now try it in the anti-clockwise direction.
	Disappearing coin	transparent glass two coins water	• Take a coin and place a glass on top of one coin. • Place another coin inside the glass. • Fill both glasses with an equal amount of water. • One coin is visible, and the other disappears. Why? • Place water on the coin that is outside. • Now the disappearing coin will appear. Why?
	Multiple images	match box candle two mirrors protractor	• Place a lighted candle near the protractor. • Place the mirror at 180. • You can see that there is only one image.

			• As the angle between the mirrors decreases, so does the number of images. • Place two mirrors in opposite directions. How many images do you observe?
Action reaction	Balloon-rocket reaction	Balloon cello tape plastic straw thread	• Insert the thread inside the straw. • Tie the ends of the thread together and hold it tightly. • Blow up the balloon and tape it to the plastic straw. • Now release the balloon. • It shoots like a jet and goes from one end of the thread to the other.
	Bouncing ball-action reaction	solid, heavy ball light-weight ball	• Case 1: Drop the small ball from a particular height. The ball bounces back. • Measure the height. • Case 2: Drop the big ball and repeat the same • Case 3: Place a light ball on a heavy ball and drop it vertically from height • What is the difference?
Shadows	Coloured light shadows	light source-3 paper strip-3 scissor, cello tape screen (paste paper in the card board) colour sketch (blue, yellow, and red)	• Colour each paper strip separately. • Paste it into the source light. • Place three coloured light sources at some distance from the screen. • Now place any object between the source and screen. • Now switch on the first source and observe the shadow; repeat for the second and third colours. • Try it with different colour combinations. What do you observe?
	Shadow pattern	Mirror comb	• Fix the comb with paper using tape. • Also fix the mirror at some distance from the comb in the paper.

		light double-sided cello tape screen (paste paper in the card board) white paper	• Place the light on the opposite side of the comb-mirror arrangement. • Now rotate the paper. What do you observe?
	Object-Shadow-Length	pencil source screen double-sided cello tape scale	• Fix the pencil straight using cello tape. • Measure the length of the pencil using a scale. • Place the source at a distance. • Now you measure the length of the shadow on the screen. • Try it with different angles and distances. • What will you do with the maximum shadow length?
	Light Direction	Candle old CD-3 clip match box	• Light the candle and place it • Fix the old CDs with the clip. • Place them one by one in a straight line. • You can see the light passing through all the CDs. Now increase the distance and angle of the CD.
Pressure	Pressure inside and outside the balloon	balloon plastic bottle straw scissors or (a pin and candle)	• Place the balloon in the bottle's mouth. • Stretch the balloon on the bottle mouth. • Make a small hole near the base with scissors or a pin or candle. • Blow hard to inflate the balloon, and air will escape from the hole. • Seal the hole with sticky tape. After sticking the tape, even though the balloon mouth is open, it does not deflate. Why?
	Vacuum Lift	Match box water	• Burn a piece of paper and carefully place it in an empty glass.

		glass balloon Paper pinch	• Dip the half-inflated balloon base in water. • Wait for a while and place the wet balloon on glass. Now the balloon was sucking in. • Now, the hot air inside the glass, after cooling, will contract and suck the balloon tightly in.
	High Pressure in Deep Ocean	Bottle pin match box	• Make three holes at the bottom, centre, and top of the bottle. • Pour water into it. • Place the entire arrangement into the vessel. • Just observe the variation in the water flow. • The bottom hole has high pressure. So the speed of flow is at its maximum.
Human body	Creation of the human body	Scissors Stapler chart paper	• Draw body legs shoulders on paper • Cut all body parts on the outline. • Overlap two body parts and staple them. • Staple all body parts • Use your imagination to make many figures
	sound from where?	flexi tube Funnel	• Fix the plastic pipes in the funnels. • Tape them together and place the ends near the ears. • Close your eyes and place flexi-end pipes close to your ears. • Ask your friend to make some sounds. • It will be difficult for you to tell the direction of the sound. Why?

Step: 4 Asking typical questions about the activity and group discussion

Interacting with the school students through talking is the key factor; it helps children internalise their observations and start to involve themselves in a higher or more complex level of thinking.

Children will be curious enough to ask many questions. They will begin to understand the scientific method, how to develop hypotheses, and ways to test, record, and compare the data. Through exploration and discussion, students learn that science is both part of their lives and fun.

IV. HOW TO DESIGN THE NOTES FOR KIDS

Designing notes for kids is an interesting and challenging one because we have to think their knowledge level and also the conceptual level. I prepared the science class notes for the year 2019 that were easily understood by the students. They consisted of lots of pictures that were attractive to the kids and which facilitate understanding of different difficult concepts. This must satisfy students' natural curiosity by designing activity lessons that motivate them to use their inquiry skills.

- It is different from a normal text book. Textbooks contain definitions, problems, explanations, etc. But this note contains all the activities and the key points, which are easy to remember.
- Ensure that the assessment activity is directly and explicitly tied to the stated objectives.
- Science activities only need things that are easily available at home.

4.1. Research Findings:

- It was indeed a good sign that students need to be thinking about and discussing conceptual questions. Learning through play is a perfect opportunity for these kinaesthetic and tactile learners to experiment with simple scientific processes such as cause-and-effect.

- I found that students were excited about this teaching method, interested in examining knowledge and applying it to solving situations in life, narrowing the gap between theory and practical life that enhances students' ability to solve critical problems.

- A clear and organised presentation by the instructor is not at all sufficient. It is essential to find ways to guide students towards creating concepts in their own minds.

- I do hope that these activities will positively change the students' attitude towards physics and that they will be much closer to everyday life.

Table 2: Learning Outcomes of students in an active class room environment

From	To
Being passive recipients of knowledge	Active and participatory learners
Focus on answering questions	Asking questions
Being 'spoon fed'	Taking responsibility for their own learning-reflective learners
Competing with one another	Collaborating in their learning
Wanting to have their own say	Actively listening to opinions of others
Learners of individual subjects	Connecting their learning

4.2. However, in the teaching method that I proposed in the research, there were certain challenges, specifically:

The activities can be done outside the school environment. Projects lead to teamwork; students learn to work as researchers with various tools, technologies, and materials. 'Accordingly, out-of-class learning is a contextualised learning method that brings the student into a particular environment to learn'. (Wan Idros, 2011).

4.2.1. Challenges of the Physics Activity Class

- It requires teachers to invest a lot of time and effort. Teachers must have good pedagogical ability to think, create many problem-solving situations and guide students to explore, to detect and solve problems.

- Class control is a challenging aspect because students are very eager to know the concept and ask lots of question randomly.

- Teachers are not able and willing to prepare interdisciplinary projects and collaborate. 'Teachers must have good pedagogical ability to think, create many problem-solving situations, and guide students to explore to detect and solve problems'. (Nguyen Thi Thu Ha 2021)

- The organisation of teaching takes a long time. Moreover, only certain knowledge and operating methods that are cleverly selected and well-grounded will become the object of this proposed teaching method.

V. CONCLUSION

The goal of teaching science to young children is to help them develop their ability to apply scientific knowledge and learning processes that they will continue to develop throughout their lifetime. In addition to a good demonstration such as audio visual presentation, the teacher lectures need to be effective. To plan and prepare adequately for a demonstration, we are required to first determine our goals, the materials we need, our steps, and rehearse. The teaching method (with guided discussions) should enable students to understand new information, encouraging them to associate the said science concepts to day-to-day life. This research has manifested an improvement in the students' thinking ability and concept recognition. This activity method project should be adopted by all grades in school and colleges since resources are easily available and cost effective. Furthermore, it creates interest among both students and teachers. Future research based on activity method using Toys from Trash seems to be highly practical and can potentially become a world-wide phenomenon.

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