A Study of Strategies and Assessment for Teaching Physics: An Action Research

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Abstract **- Although physics is one of the core subjects of science and technology, many students find it to be a mentally exhausting subject with a dearth of fun that demands complex analysis for mastery (Tamang, 2004). So, in offering quality physics education, a teacher needs to keep this complexity in mind when developing teaching strategies. This paper investigates the teaching strategies that can be employed to impart physics lessons effectively. Within a short span of time (six weeks of Teaching Practice), this research was carried out at Karnataka Middle Secondary School, Karnataka under K.E. Board with 24 class IX students. Data were gathered using three methods: observation, class tests and questionnaires. The findings were validated using diary notes, feedback from a critical friend, the researcher's observation, and data triangulation. The findings from these multiple sources reveal that students developed interest in learning physics after the intervention. More interestingly, their much-improved score in the class test after intervention shows the propensity of how crucial a teacher's way of teaching is in imparting physics lessons effectively. The improvement in students‟ physics performance overwhelmed our colleagues and critical friend, and they would like to model our strategies in their future prospects of teaching physics.**

Index Terms **- Teaching strategies, Physics, assessment**

INTRODUCTION

In this globalised world, the need for fundamental scientific knowledge is a major component of education. India's curriculum handbook for schools (1996) clearly states the rationale behind science education: "Science in secondary school level should cater to equip the students who want to pursue higher studies in the field of science and technology. For others, this course should enable them to understand the natural and physical environment and in particular the technological environment". The science curriculum at the Higher Secondary School level offers advanced courses of science studies with physics as one of the elective subjects. However, science subjects still have a hard time winning the mindset of India students. Physics is the study of nature and natural phenomena. Tamang (2004) noted, "Physics remains as one of the knotty subjects for the majority of our students with its many derivations, definitions, formulae, laws and most importantly its unending calculations". He also opined that a great many students find it rather a dry subject with a dearth of interesting activities which demands an aggressive memorization for its mastery in examination. So, the physics teacher's role in the improvement of students‟ performance in physics is crucial.

Research is the means of finding solutions to problems. More interestingly, action research is the process of finding solutions to a problem in which both the respondent and researcher aim for improvement. According to Maxwell (2003), the key idea of action research is the systematic collection of data in order to answer a research question for the purpose of improvement. So, this action research was undertaken to improve student performance in physics using new strategies. Different teaching strategies were used in the intervention programs to bring about improvement in the teaching and learning of physics. To find the impact of teaching strategies, observations, evaluation, and questionnaires were used as data collection tools.

RECONNAISSANCE

Reconnaissance is a diagnostic phase that requires insight to identify the most critical point of attack from which a positive impact can most likely proceed. Maxwell (2003) conceptualized reconnaissance as consisting of three parts, namely, situational analysis, analysis of competence of the researcher, critical

friend and participants and review of related literature. The objective of reconnaissance is to come up with an action research question that will lead to improvement as detailed below.

COMPETENCE

Whitehead (2002) posit that to ensure action research is an educative practice, it is essential to remember that "I" remain at the centre of enquiry as a potential influence for good in the lives of others. Also, the participatory nature of action research makes it a social process of collaborative learning realized by groups of people who join together in changing the practices through which they interact in a shared social world (Kemmis & McTaggart, 2005). So, in our action research, I‟ (first author) as an educator was at the center, and the students as participants were collaborating in examining the strategies for teaching physics.

The first author graduated with B.Sc. physical science (physics and chemistry), from Sherubtse College in 2013. He has an innate predisposition towards exploring in the field of research. To this date, he has published one research paper and attended several seminars as an observer and media reporter. He served as an assistant researcher to the Dean of Research and Industrial Linkages and helped to run research conference and in the publication of college research journal at Sherubtse College. At Samtse College of Education (SCE), Introduction to Research Methods in Education (EDU503) module further equipped him with how to carry out educational research in general and action research in particular. He has also attended several workshops on research.

The second author is a faculty member at SCE and a mentor to the first author. Our critical friend has good research knowledge as he has attended a research module at SCE, written papers for journals and presented research papers at the conferences.

LITERATURE REVIEW

Physics is a fundamental science which is concerned with the basic principles of the universe (Wang, 2005). It is the foundation for other physical sciences. Teaching science to young learners is a challenging task for teachers as the subject has to be made very interesting. Unless motivated to "do science" learning a science will be a mundane activity for a student. The teacher has to make changes in the teaching of science because the world is changing (Wang, 2005). Teachers must not only teach students knowledge but also develop their problem-solving skills and lifelong learning skills.

Many teachers use a traditional approach to teach science. Traditional physics instruction relies heavily on the use of drills and practice for solving numerical problems, requiring routine application of formulae and equations for the solutions (Tao, 1999). The teachers have to follow the texts designed by Department of Research and Curriculum (DCRD), and carefully prepare and present lectures. Assessment, testing, and feedback are used to support this process. This is known as the behaviorist's style of teaching. For most of the teachers, it is the preferred way to teach and learn science. However, to fulfill the insatiable desires of most students, teachers must employ new sets of strategies to teach. The authors believe that the use of these contemporary teaching strategies as an intervening measure should be useful in improving teaching in physics.

Teaching strategies can be defined as plans of action to use teaching tactics, in which a teacher selects, coordinates, and applies teaching techniques/teaching procedures in order to make the learning effective. In his research on "Strategies for Teaching Physics," Tamang (2004) lists ten strategies to teach the subject effectively: use of double-paged lesson recipes; use of simpler words and relevant examples; frequent demonstration and investigation; use of humorous questions and explanations; using diagrams to solve questions; using acronyms of statement to learn the longer ones; application-based approaches; using simpler explanations and questions; assessment and evaluation of students work and achievement; and evaluation of our teaching. Most of the strategies listed by Tamang are aligned with imparting constructivist education. Moreover, Wang (2005) in his paper, "Using new strategies to improve teaching and learning in Fundamental Physics course" lists four strategies in teaching physics: problem-based learning, concept mapping, team work and mini-lecture and assessment.

In this action research, certain unavoidable circumstances pertaining to time and resources did not permit the authors to do thorough research on all the strategies for physics as uncovered in the literature review. Nevertheless, selected strategies examined are

listed in the intervention section. Systematic and logical data analysis was undertaken.

ACTION RESEARCH QUESTION

Based on the literature of strategies for teaching physics and situational analysis, this research study posed the following question:

What do I do to enhance class IX students' proficiency in physics?

Research Design and Methodology

For the successful conduct of this research, authors used a multi method approach to data collection and analysis, employing the three tools of observation, test and questionnaires as discussed in turn below.

Observation- One of the prominent means of collecting data was through observation. We observed students‟ response during class hours and the effectiveness of a particular strategy used. Our critical friend also recorded some observations. Since action research itself is a change directed towards improvement, we examined the degree of improvement in learning and attitude towards learning provided. The first was general observation of how students take part in the learning process. This method of data collection involved recording a tally of evidence. As mentioned by Rinchen (2009), "a tally was used to record the frequency of number of questions raised, frequency of clarification sought, volunteering to answer the question, taking initiative in the group work, any sort of misbehavior, peer interaction and interaction with the teacher". Two rounds of observations were carried out during the entire period of action research study.

Test results- This data collection tool was to see the improvement in students‟ performance in physics. A well-structured question set was designed and verified by the critical friend. It encompasses all the levels of questions from Bloom's Taxonomy. However, for the baseline data, we used the mid-term examination score for physics since the research was carried out within a short period of time.

Questionnaires- The third set of data was collected by administering questionnaires. Questionnaires were framed on three-point Likert scale with the following ratings: Agree = 1; Agree to Some Extent = 2; and Disagree = 3 (Appendix A). The questionnaires were designed with the intention to find students‟ interest towards learning physics. The questionnaires were administered twice, one before the intervention and once after the intervention.

BASELINE RESULT

The first data source was the observation of how students participate in the classroom learning process. During the first two weeks, five out of 24 students (three males and two females) voluntarily took part in responding to questions and seeking clarification. The frequency of participation was five times by one male student, three times by one female student, and the remaining three students participated only once. The students who participated in the class were those who are confident and fluent in English. Most of the students were shy and hardly participate in class discussion unless forced by the teachers.

The second method of data collection involved reviewing their physics mid-term exam papers. Their marks revealed that 60% of the students failed in the physics midterm. The highest mark was 64 out of 100 and the lowest mark was one. As a subject teacher, the first author felt the need to improve students'‟ performance in physics.

The data from questionnaires revealed that 59% of the students disagreed the statement: "physics is a very interesting subject" while 37.5% agreed to some extent that "physics is a very interesting subject." Only 29% agreed that the "teacher's way of teaching determines their understanding of physics." The majority of the students (70%) agreed that "they are feeling bored when the teacher lectures throughout the period." Other extended supporting questions and ratings revealed that almost all the students (91.7%) agreed that "learning takes place when they are given a chance to investigate." Moreover, 70.8% of the students agreed that "using diagram to solve questions makes problem solving in physics easy." Close to half (45.8%) of the class population agreed that the "teacher's fair and just assessment let them to develop likeliness towards the subject taught." Further, majority of the students agreed that "knowing the application" (50%) and "using acronyms will help them to learn physics better" (70.8%). In sum, the baseline data revealed that majority of the students have poor interest in the subject (59%) and dislike lecture-driven classes (70%) as reflected in Table 1 below.

SCORE OF STUDENT'S PERCEPTION LEVELS ON EACH INDICATOR OFTEN INTERVENTION

S. No	Physics interest indicators	Disagrees	Agrees to some extent	Agree
1	Physics is a very interesting subject	59	37.5	4.1
2	Teachers way of teaching determines my understandings of Physics	21	50.0	29
3	I am feeling bored when I listened to teacher lecture thought the period	4	26	70
4	I learn more when teacher demonstrate and give opportunity to investigate it	4.2	4.1	91.7
5	Using diagram to solve questions make the problem solving in physics essay and interesting	0.0	29.2	70.8
6	I can remember important laws and equations for longer time by framing on acronym	16.7	37.5	45.8
7	Knowing the daily life application of the topic encourage me to pay more attention	0.0	50.0	50
8	Teachers fair and just assessment let me to develop like line towards the subject thought	8.4	20.8	70.8
Note	D= Disagree ASE= agrees to some extent, A= agree			

The upper main send baseline data where you are used as a comparative benchmark.

INTERVENTION

The baseline data revealed that students showed less interest in physics initially as evident from Table one, where only one student (4.1%) agreed to the statement "Physics is a very interesting subject". Moreover, it was clearly discernible from the small number of classroom participation (21%) and poor performance (50% average) in the mid-term examination. These data posit the need for intervention if we want the students to develop interest in physics as a subject and excel in it.

The existing literature review suggested myriad of strategies to be used to teach physics lessons. As proposed by Jean Piaget and Vygotsky, constructivist approaches to wards teaching and learning were taken into consideration. For instance, Vygotsky's description of scaffolding instruction as opined by Raymond (2000) that the "role of teachers and others in supporting the student's development and providing support structures to get to new level" was well thought-out. The following strategies were deployed and their effects on student learning were observed. Researchers stayed mindful of the importance of observing students‟ responses to the specific strategy used.

- Frequent demonstration and investigation: Physics is a subject that needs a systematic learning process. It requires step by step explanation and demonstration. Demonstrating the skills and letting students' practice will have a lasting impact on student learning. Hence, we delivered some lessons using the demonstration method and investigated student reactions.
- Using diagrams to solve questions: This method is helpful to solve numerical questions as well as for explanations during any lesson. The use of diagrams helps students to visualize the questions and numerical letters. It also provides them more clues and ideas to comprehend and solve problems.
- Using acronyms to improving speed of learning and retention: Those students who face difficulty in grasping and understanding long statements learn faster and better when shorter forms of statements are used. This strategy could be used to teach various laws, principles, hypotheses, equations, and explanations. Researchers constructed interesting acronyms to teach some important laws and statement and inspect its impact on the students‟ performance.
- Application base approach: Physics is a subject which has an all-round application in daily life. This intervention induces the students to learn physics by appreciating the applications of the subject matter that will allow them to think about the significance and technological uses of difficult subjects to their everyday lives. To boost student interest and encourage wider participation in the class, we related the concept taught in the class with everyday practice.

- Assessment and evaluation of students' work and achievement: The way teachers evaluate the work of the students and provide feedback influences the way they learn. Moreover, Gibbs (1999) noted assessment as the most powerful lever that teachers have to influence the way students respond to courses and behave as learners. We employed giving feedback and fair assessment and then recorded its effect in students‟ performance and interest towards learning physics.

POST RESULT

As an apprentice during the conduct of intervention programs, the first author was bit apprehensive about the improvement that he could foster. Yet, the conductive learning environment that he managed to create was amazing. It was a moment of achievement and, more interestingly, our critical friend's comment during his last observation in the sixth week of the class was amazing. He expressed,

In the beginning, physics class used to be most dull and boring class. Whatsoever be the effort from teacher, students were always silent. Student's participation in the class activity is very low and they have to be forced to respond or take part in their learning. However, after the execution of the plan commenced, I saw the lively and interactive teaching and learning taking place. Students were very alert, responsive, and always ready to take part in learning. I was amazed by the shift in student's interest towards learning physics.

Observations showed that students who were apathetic in learning physics prior to the intervention were very supportive about their learning during and after the intervention program. Except for a few naturally introverted students, almost all the students took part in classroom discussion voluntarily. Fourteen students (eight male and six female) were regular participants. They became proactive, responsive, and more open to classroom discussion. Some students even started to clarify their doubts with each other during free hours and after school. This finding coheres with those of Rinchen (2009) in a similar study who observed that after intervention: "the students became supportive of each other when their response did not make sense or when they fail to understand some concepts". The standard question paper similar to that of the mid-term test was used to collect the post data. While framing the questions, the concepts of a bell-shaped curve and Bloom's Taxonomy were taken into consideration. The class test marks revealed a drastic improvement in students‟ performance in the physics test compared to the base line test. The pass percentage was 100%. The highest score was 86 out of 100 and lowest was 43. The mean mark of mid-term exam (base line data) was 40 while the post class test mean mark was sixty-two. We were quite relieved and excited to see a major shift in the data collected from the questionnaires. Our main focus was on developing students‟ interest in physics by using relevant teaching strategies during the intervention program. All the students (100%) agreed that "physics is an interesting subject" and the "teacher's way of teaching determines their understanding of physics." However, 4% responded in disagreement in terms of listening to the teacher's lecture throughout the period compared to 41.6% in the base line data. And amazingly the ratings for all the teaching strategies used at various sessions were in agreement, indicating the relevance of those teaching methods in physics (See Table 2).

TABLE 2: SCORE OF STUDENTS PERCEPTION LEVELS ON EACH INDICATORS OFTER INTERVENTION

S. No	Physics interest indicators	Disagrees	Agrees to some extent	Agree
1	Physics is a very interesting subject	0.0	0.0	100
2	Teachers way of teaching determines my understandings of Physics	0.0	0.0	100
3	I am feeling bored when I listened to teacher lecture thought the period	41.6	16.7	41.6
4	I learn more when teacher demonstrate and give opportunity to investigate it	4.3	4.3	91.3
5	using diagram to solve questions make the problem solving in physics essay and interesting	0.0	8.7	91.3
6	I can remember important laws and equations for longer time by framing on acronym	4.2	16.6	79.2

7	Knowing the daily life application of the topic encourage me to pay more attention	0.0	25.0	75
8	Teachers fair and just assessment let me to develop like line towards the subject thought	0.0	8.7	91.3
Note	D= Disagree ASE= agrees to some extent, A= agree			

TRIANGULATION OF MULTIPLE DATA SOURCE

To authenticate the data gathered from multiple sources, data triangulation was used. As for the observational results, the students who initially needed to be called upon to take part in class activity or respond to questions volunteered to do so after intervention. The rise in the number of regular participants from five in the beginning to 14 in the end was impressive as reflected. Their class test score also gives more illumination to the success of the intervention programs. Assessment as a means of gathering information on how much a student has learned gives a wider meaning for those strategies used as intervention. The class pass percentage increased from 40% in the beginning to 100% after the intervention programs.

DISCUSSION AND CONCLUSIONS

The data collected from three different sources revealed that after the intervention programs, students‟ interest towards the physics subject had developed. A majority of the indicators in the questionnaires indicated the relevance of different teaching strategies used. The demonstration method and use of diagrams to solve physics problems gave students enough opportunity to acquire knowledge.

The term acronym‟ was new to students until our intervention. After intervention, a majority of the students strongly agreed that they can remember important laws and equations for a longer time by framing an acronym. For instance, one of the respondents said, “Sir I will remember three primary colors throughout my life. The acronym RGB ‟which sir used to represent Royal Government of India will not be forgotten cannot for a long time to come” (Researcher’s diary notes). RGB actually stands for three primary colors (red, green, and blue).

The teaching strategies used were relevant to teach physics lessons. The findings can be related well to Tamang’s research (2011) on “strategies for teaching physics” where he noted that demonstration and investigation; using diagrams to solve questions; using acronyms of statement to learn the longer ones; application-based approaches; assessment and evaluation of students work and achievement as some of the strategies for teaching physics.

As a physics teacher in the making, the first author was glad about the success of our action research. As mentioned by Rinchen (2009) the positive aspect of our research was that the study was contextualized; the goals were realistic and could cater to the needs of both students and teacher. Despite weeklong disturbances in the teaching learning process due to the K.E. Board Sport Meets, we remained optimistic about the flexibility of our plan. We rescheduled three lost periods to other days.

The outcome of this action research not only gratified us, it overwhelmed our critical friend and some of our friends too. Most of the physics post graduate friends wish to model our strategy in their class in the immediate future. Despite many obstacles, we are fully satisfied after the completion of this study. It not only enhances our proficiency in the area we chose to study but we have strengthened our competence in action research. In the words of Maxwell (2003), “action research is such a flexible process, amenable as it is to a wide variety of questions and situations”. It is not highly resource dependent but depends upon the capacities of the people involved. We were amazed by the drastic improvement of our students in learning physics. We would highly recommend the teaching strategies that we used to adopt in physics classes.

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