CONSTRUCTION OF KNOWLEDGE AND DEVELOPMENT OF MULTIPLE INTELLIGENCE TEACHING AND ASSESSING THROUGH PBL

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In this paper, we shall discuss constructivist method that is tried successfully to teach students physics using problems. We shall discuss how such a method can help to develop multiple intelligence of students and can also be used for dynamic assessment, that is assessing the students while they learn.

Introduction

In Taxonomy of Educational Objectives, Bloom talks about six major classes:

1. Knowledge;
2. Comprehension;
3. Application;
4. Analysis;
5. Synthesis;
6. Evaluation.

At present, in our academic set up, our teaching-learning and assessment over-emphasises transfer and assessment of surface level knowledge to a great extent. Most of our school/college system has examination which achieves first of Bloom's objective well but higher order objectives are ignored to a great extent due to various reasons in spite of its acceptance as a policy.

In the words of Gardner, "*It is of the utmost importance that we recognise and nurture all of the varied human intelligences, and all of the combinations of intelligences. We are all so different largely because we all have different combinations of intelligences. If we recognise this, I think we will have at least a better chance of dealing appropriately with the many problems that we face in the world.*"

In what follows we suggest one such method which is constructivist, it is based on problem-solving and also enhances intelligence level of student. We show that it is possible to have our assessment based on such a method that is integrated with learning. This method can be easily adopted in our educational set up.

Constructivism and Problem-Based Learning (PBL)

Three ways of constructivist teaching/learning methods are suggested in the literature:

1. Situated learning;
2. Cognitive apprentice;
3. Problem-based learning.

In an educational institutional set up, problem-based learning (PBL) seems to be a good candidate as a remedy for the existing situation. Although need to include problem-solving in science is being realised in India now, none of the efforts made so far has come up with any strategy to actively engage students. It is almost left to students' initiative and interest.

In any case, how much of knowledge that students acquire is needed to be used in real life and needs to be on fingertips? In real life, whatever careers student take up, they would be required to solve problems. These may be from the subject they have learned or otherwise. At the same time, due to explosion in the amount of scientific knowledge, it has become difficult for students to learn everything in their field of interest. It is not possible for any curriculum to cover such a large amount of scientific knowledge. The need is to equip students with necessary skills needed to learn and understand independently. Thus, it is important that education focusses on problem-solving skill and let students learn to construct their knowledge through problems. This way we are teaching learners how to learn. As mentioned earlier problem-solving is also considered as one of the constructivist teaching–learning methodology.

According to Tan, it is not how much content we disseminate in our classrooms, but how we engage students' motivation and independent learning is important. For science teaching he has noted that, *"breakthroughs in science and technology are often the result of fascination with problems. Great learning often begins with preoccupation with a problem, followed by taking ownership of the problem and harnessing of multiple dimensions of thinking. Problems and the questions associated with them when strategically posed can enhance the depth and quality of thinking. What is often lacking in education today is the effective use of inquiry and problem-based learning approaches."*

The problem-solving is an activity which involves stimulating purposeful, reflective thinking in students when they attempt to arrive at rational solution. The teacher creates learning opportunities through properly selected problems and leads the learner through the environment of learning. In the process, which can be termed as cultural mediation, a student internalises and becomes integrated with, the culture of the subject. Thus, teaching students through problem-solving becomes a constructivist activity.

This also involves: (i) guiding students to create appropriate visualisation or mental picture; (ii) pointing to them the precise auxiliary problem/activity; (iii) creating cognitive conflict with their misconception; or (iv) involving them in a reflective metacognitive discussion, so as to arrive at a strategy to solve the problem.

Vygotsky has introduced a concept of Zone of Proximal Development (ZPD) which is an intellectual space where learner and teacher interact. The teacher can gauge intellectual development of the learner and provide the necessary support to advance the learner's thinking. With teacher support, learner can achieve more than they would unaided. More knowledgeable peers can also perform the same function as teachers.

Multiple Intelligence Theory

As mentioned by Armstrong, Gardner provided a means of mapping the broad range of abilities that humans possess by grouping their capabilities into the following comprehensive categories or "intelligences":

Linguistic: The capacity to use words effectively, whether orally or in writing.

Logical-mathematical: The capacity to use numbers effectively and to reason.

Spatial: The ability to perceive the visual-spatial world accurately and to perform transformations upon those perceptions.

Bodily-kinesthetic: Expertise in using one's whole body to express ideas and feelings and facility in using one's hands to produce or transform things.

Musical: The capacity to perceive, discriminate, transform and express musical forms.

Interpersonal: The ability to perceive and make distinctions in the moods, intentions, motivations and feelings of other people.

Intra-personal: Self-knowledge and the ability to act adaptively on the basis of that knowledge.

Naturalist: Expertise in the recognition and classification of the numerous species—the flora and fauna—of an individual's environment.

According to Gardner· "An intelligence is a capacity, with its component processes, that is geared to specific content in the world. A person with high intelligence in my sense of the term is one whose computational capacities are very effective with a particular form of information or content."

In Gardner's words, *"I define understanding as the capacity to take knowledge, skills, concepts, facts learned in one context, usually the school context, and use that knowledge in a new context, in a place where you haven't been forewarned to make use of that knowledge. If you were only asked to use knowledge in the same situation in which it was introduced, you might understand, but you might not; we can't tell. But if something new happens out in the street or in the sky or in the newspaper, and you can draw on your earlier knowing, then I would infer that you understand."*

When we refer to problem/s, they are not merely plug-in numbers but expect them to have one or more of the following characteristics:

(i) A problem which incorporates basic principle/s.

(ii) A problem which is attractive enough or is rich in context.

(iii) The problem should be sufficiently difficult but not too difficult to put students off.

(iv) Should require steps that are not of repetitive pattern and at the same time should involve some decision-making.

(v) The problem should have a reasonable goal.

(vi) The problem should guide students to comprehend the topic and/or application.

In order to design problems for the course, the following is the strategy that has to be adopted:

1. Area of the subject has to be identified keeping in mind students' familiarity with the subject, their background, strengths and weaknesses, e.g. we chose basic physics as weakness of students and thus developed a course based on problems from basic physics.
2. For designing problems from a particular area/sub-area, underlying concepts and key points have to be identified that we need to address and highlight, e.g. we may identify mechanics as sub-area and kinematics of motion as concept and velocity, acceleration, displacement, frames of reference as key points.
3. Once this is done, identify the goal of a problem in accordance with why a particular problem is to be set up (learning objectives) as already discussed. This may involve some application (preferably one that students can relate to) and its interrelation to equation. We may have a problem that involves description of motion involving motion that has these key-points to be addressed and may involve calculation using relevant equations that students have to identify.
4. Problem may involve some goal that may involve concepts from different areas/ sub-areas to highlight interconnection between different areas/sub-areas of the subject.

Care needs to be taken that the goal in the problem should not be too obvious, e.g. as in some plug in problems, that there is no challenge involved in solving the problem.

Example

Let us consider an example from Class VIII, NCERT Science textbook of reflection at a plane surface to illustrate how to employ dynamic assessment.

Students learn about laws of reflection at a plane surface that (i) incident ray, reflected ray and normal to the surface all lie in the same plane, and (ii) angle of incidence is equal to angle of reflection. Teacher can teach this experimentally using pin and mirror and constructing ray diagram. These days, it is easy to demonstrate using simple LASER torch. Having established this, students can be asked or shown construction of position of image due to point object using laws of reflection and two or more rays.

Having done this, following is what can be done for dynamic assessment: Students can be asked to construct (i) image of an extended object, and (ii) image/s of a point object in case of two mirrors inclined at an angle *è* (say 90^0). These are meaningful activities that can be part of activity or problem-based learning.

Typically, students who know laws of reflection otherwise would have confusion even in constructing image of a point object. They do not know how to start as which should be the incident ray? How does reflected rays lead to position of image? They may not be able to decide that they can construct image for each point on the extended object, etc...

Teacher can help students to construct their knowledge by giving them support in terms of guided intervention, by challenging them through cognitive conflict if they are off the track or auxiliary activities/problems. Students learn by building upon knowledge they already possessed themselves and guided interventions are used to correct errors, which crept in their understanding. Most importantly, there will be effective scaffolding, i.e., students are not given answers to any questions, but are guided (using interventions like auxiliary problems, counter questions, cognitive conflicts) to converge to the right answer themselves.

Our experience and experiment has shown that students not only succeed in solving problem but improve in their cognitive ability. Thus, we can say that they advance in their zone of proximal development and in ability to use their multiple intelligences.

It can be seen that solving problems involve use of multiple intelligence which Gardner has described as capacities. When students try problems obviously as they have to read and understand the information given and challenge posed, which needs linguistic intelligence. When they try employing their resources and techniques to solve, they need math-logical intelligence. If problem involves diagram or some visualisation, they need to use spatio-visual intelligence. If they are dealing with movements that they have to incorporate into equation or convert into diagram they need bodily kinesthetic intelligence. As the course makes them struggle through, they introspect about their own thinking processes, which help develop their intrapersonal intelligence. They also get opportunity to discuss with their peers developing their interpersonal intelligence, which in traditional system would not develop, as all they do is memorising the study material. Since, science deals with nature, it involves naturalist intelligence. When students make progress through problem-solving, obviously many of their intelligences develop. It is not right to talk how these intelligences work individually. In fact a bit of thinking makes it clear that most of them play their role simultaneously during the process of problem solving. Thus though initially students may not display these abilities, their success in solving problem (even with scaffolding provided by instructor) indicate development of multiple intelligence/capabilities.

Such problem-solving activities in class can also be used to integrate teaching-learning and assessment. This is known as *Dynamic Assessment.*

Holt emphasise the concept of dynamic assessment, which is a way of assessing true potential of learners that differ significantly from conventional tests... assessment is a two-way process involving continuous interaction between both instructor and learner... that measures the achievement of the learner, the quality of the learning experience and courseware.

According to Poehner, "Dynamic Assessment (DA) is an approach that takes into account the result of an intervention." In this intervention, the examiner teaches examinee how to perform better on an individual item or on the test as a whole. The final score may be a learning score representing the difference between pre-test (before learning) and post-test (after learning) scores, or it may be the scores on the post-test considered alone....The *interactionist* DA focusses on the development of an individual learner or even a group of learners, regardless of the effort required and without concern for pre-determined endpoint... The result of DA procedures must report the mediating moves as well as the reciprocating behaviours that contribute to the overall performance. Importantly, this information can highlight aspects of development that would likely remain hidden in non-DA, as learners who are not yet ready to perform independently may exhibit changes in the form of mediation they require or in how they respond to mediation.

As Mayer puts it, "If the goal of problem-solving instruction is to improve the cognitive processing of students when they are confronted with a novel problem, then the goal of problem-solving assessment is to describe the cognitive processes they use in their problem-solving."

Students can be assessed while they perform these activities depending upon how well they employ their resources (previous knowledge about laws and geometry). Suppose these activities are to be evaluated on a scale from 0 – 5, then they can be given 5 to start with and can be given – 0.5 (negative marks) each time they need teacher's intervention. Since, they will complete this activity any way and can be made to reflect upon their construct or solution, each would score at least 2 (40%).

A student who succeeds herself/himself without any assistance would have achieved all the educational objectives of Bloom. Others would still be achieving it partially with instructor facilitating their construction of knowledge.

If we allot 50 per cent weightage to such (dynamic) assessment, students definitely become active learner and eventually this helps them to enhance their cognitive capabilities and reduces importance of rote memorisation. We can certainly keep periodic tests (25% weightage) of traditional type but without too much importance to memorisation, i.e., MCQ or small problem type, and final examination (25% weightage) carrying similar activities/problems will generate meaningful grades.

Instead of translating marks to grades as it is done by CBSE (which reduces importance of marks by bunching to some extent but meaningless otherwise), we can assign grades A: B, C, D with following reflection:

A : Have successfully completed and mastered the course.

B : Have satisfactorily completed the course but need to put more efforts.

C : Have completed the course but need to be given remedial coaching before next level of learning.

D : Need to repeat the course before student can be allowed for the next level of learning.

With these strategy (dynamic assessment as discussed) most students would succeed with A and B grades. It may be exceptional case who scores C and extremely rare to score D.

One may justify the grading by statistically grouping students rather than merely translating marks from 0-100 into grades. It is this grading that would not only do justice to students' true potential but also reduce stress level significantly. A lot of work needs to be done to develop this type of grading system. This also demands training teachers to achieve higher objectives.

Conclusion

We have discussed how meaningful problem-solving can be part of teaching-learning process and is useful in helping students to construct their own knowledge of the subject. Such a process involves use and enhancement of students' multiple intelligence. It is possible to integrate assessment with learning with such a methodology that would do justice to students' true potential and learning. However, we recommend traditional testing should also be the part of this assessment, as we do not want to downplay first objective of Bloom's taxonomy.

Grading scheme proposed here truly reduces undue weightage to marking scheme and makes it stress free. Such a grading avoids unnecessary distinction on the marks and reflects genuine learning and not only rote memorisation.

The only hurdle here is, student to teacher ratio. However, if we need to make education stress free and do justice to students' true potential, this ratio have to be brought down to right number. This is the major challenge. Merely stuffing 100 students in a classroom would not achieve 'education for all' and yet keep it 'stress free for all'.

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