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Estimation in Classroom Setting

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Abstract

Each country has its particular aims and objectives of education. Those objectives are contextual as per the country. But one common objective of most of the countries is to relate the knowledge acquired in classroom to combat the real-life issues and concerns. One important topic which comes to the scene is estimation. It involves clear understanding and application of knowledge for problem solving. This paper is an attempt to implement the conceptual understanding of classroom knowledge to different circumstances, scope of Estimation in the curriculum and teachers' role in enhancing the estimation ability of students are the points highlighted in this paper. Estimation focuses on the process rather than product. It assumes that if process can be given a right direction, product itself will shift toward perfection.

Introduction

Since time immemorial India has focused on education. In earlier times, this was provided in the setting of *Gurukul*. This setting has no boundry walls, it is all to be learnt in ground facing the real-life situations. Moreover, the Vedic period writing materials were rarely used. All was done in head and then verified through discussion among the peers and with the teachers. The modern education system follows a completely different approach. In the theoretical knowledge delivered in the classroom, the topic of estimation is an attempt to view knowledge as converted to understanding, which then goes a step further in implementation for solving a problem.

Ability to estimate an attribute of physical quantity may have its link with other aspects like knowledge, understanding, application of

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different concepts and attitudes, etc. Study of these aspects, from different perspectives, requires due attention for detailed investigation (Ramacharya, 2006). Estimation requires that several ideas be firmly in mind:

- the unit of measure;
- the size of that unit relative to familiar objects or to other units of measure for the same attribute;
- other measurements in that unit; and
- a commitment to perform the estimating so that the product is as close to the actual measurement as possible.

Thus, although estimating is guessing, it is educated guessing. Bright (1976) is of view that among the advantages to giving children experience with estimation is a growth in their ability to understand and use of concepts. Hence, estimation is divergent in nature with various components in its process to deal a problem effectively.

Conceptualisation of Estimation

Estimation is an educated guess, where estimator tries to get as near as possible to the actual answer. To be a good estimator, prior experience proves to be a major contributing factor. "The skill of making an educated guess as to the value of a distance, cost, size, etc., or arithmetic calculation" (Clayton, 1996).

The output or product in estimation comes with a value and unit. It is of immense significance, as both value and unit should be adequate in approximation. It involves no tool, as estimators' senses, perception and processing of the stimulus complete the picture for output. "A process to reach a measurement or measure without the help of measuring tools. It corresponds to a mental process that includes visual or manipulative aspects" (Bright, 1976). This definition gives clarity of the concept of estimation. It is a skill which involves a stimulus as perceived by the estimator, processed in the brain and product comes as an estimate value along with the unit. This stimulus is perceived by different sense organs as visual (eye-sight), audio (ear-hearing), olfactory (nose-smell), tactile (skin-touch) and gustatory (tongue-taste).

The first requirement of the act of perception, in fact, is the experience of stimuli which may be environmental conditions, guidance or instruction offered by some external agent, or any phenomena such as size, weight, shape, colour, texture and smell which the individual experiences. The experiencing of these stimuli "direct and immediate contact" (Piaget, 1950). These stimuli are organised, interpreted, related to one another, compared with previously experienced sensations and given meaning. When a sensory experience occurs, all past sensory experiences are called into play to resolve the present experience.

What result is an organised, unified whole, some-times called a percept, which is stored to be used in the interpretation of later stimuli. Perception operates simultaneously with sensation and is the source of all concepts and mental activity.

Problem Solving through Estimation

Estimation is an essential thinking skill which enables observer towards problem solving. There is a significant correlation between estimation competency and problem-solving ability. To confront a problem, the ability to estimate the feasibility is greatly helpful in the process of finding a practical solution. The NCTM (2000) state "the essence of problem-solving is knowing what to do when confronted with unfamiliar problems."

Gagne (1980) emphasises the criticality of problem-solving to scientists and practitioners in many disciplines, while stating that problem-solving is a primary factor in and consequence of learning. An individual gains new knowledge through the articulation of and expansion of their cognitive structure. This enhanced cognitive structure, then serves as the foundation for information search and processing as well as in problem-solving (Gagne, 1977); Gagne and White, 1978). Polya (1973) created the four-step approach to problem-solving in order for students to be able to learn 'how to think,' not 'what to think' or be told 'what to do'. Polya (1981) described the scientific method as "Guess and Test" and suggested that teachers should encourage pupils to guess with the exhortation.

Estimation too is an educated guess with instructions as imperative in estimation. Estimation starts with a perception of what is to be estimated. What is the dimension of the problem which is to be estimated? Processing of the stimuli takes place in the mind where they eventually begin to internalise that some attributes of objects are measurable, while others are not. What are the known features of the problem based on prior knowledge? Is the existing problem exactly the same as that of confronted in the past? Students try to find a suitable referent benchmark depending on the prior experiences. If the student can find some benchmark exactly same, then it can be applied readily. How was the previous problem solved? Once the student is able to recall the approach, a progress can be made. Or, what if it is slightly different? Then the benchmarks that would suit the problem through some modifications. Other strategies can be worked upon, such as re-composition or decomposition of the problem, where atleast a part of the problem should be tried to solve by regularising a problem by assuming regularity and then averaging.

The result of estimation must seem to fit and be reasonable to serve the purpose. Unless and until one finds a reasonable estimate, one should work

with some better modifications to be more accurate in their estimation (Siegel, Goldsmith & Madson,1982). Students with good estimation skill have multiple strategies available to them. Thus, they are not only more likely to have a repertoire of strategies available to them, but they are also more likely to choose the strategy most appropriate to the situation. Selection of best strategy assures estimation towards perfection. The problem itself should help the estimator in forming mental image and hence in processing of best suited strategies in the mind. Simple previous problem is used as a base to solve complex ones. An individual widens the horizon of their existing cognitive structure through accommodation and assimilation of new ideas to the existing ones. This enhanced cognitive structure then serves as the foundation for problem-solving. A complex cognitive structure provides the opportunity to apply previous learning to existent problems and to integrate new learning that are relevant to future problems.

Estimation as a Skill

Calculators can give you every possible answer to the question at hand, yet it is up to the user to distinguish a correct answer from an erroneous. However, many engineers and experts from spatial field have hardly learned the skill of estimation. Too often, inexperienced problem solvers will take an answer or group of answers as correct, without checking to see if the answer even makes sense.

Another significant use of estimation lies in the area of answer cross checking. Then the problem solver recognises how absurdly low the answer is or degree of accuracy of the estimated value. A third application of estimation lies in the area of making modifications in the approach towards a problem, further arm oneself with improvised strategies. For example, if one happens to have only a single value for a particular problem, and if one puts it in parallel with another similar problem, what effect would be expected? How large the effect is expected to be? The answers to these questions are speedily found by estimation, which is much quicker than exact calculation.

A final, but very important advantage to learning the skill of estimating is that, to estimate well, one must truly understand the entire system. An exact calculation only requires that one choose the correct equation and provide the correct values for all variables: the source of the values does not need to be understood, nor does their relation to the system as a whole. Even the equation does not need to be understood for an exact answer to be found; one need merely “plug and chug” (Lunt & Helps, 2001). A rough estimate often carries more credibility than an answer with many digits of resolution, simply because there is

clarity on the steps of reaching the estimate; there may not be clarity of understanding an equation or complicated calculations.

Inculcation of Estimation Skill through Science Subject

Estimation is the process of making an approximate calculation or judgment of a value, quantity, or result. It is a valuable skill to have in many areas of life, from everyday tasks to complex tasks related to science. The Standards (1989) views that estimation should not be added as a topic but should instead be integrated across many areas of the curriculum. The Third International Mathematics and Science Survey (TIMSS) (Schmidt et al., 1997) criticised curricula that were "a mile wide and an inch deep." It highlights that a superficial coverage of many topics in the domain may be a poor way to help students develop the competencies that will prepare them for future learning and work. Estimation measurement is a concept that has not been investigated in depth, and in which difficulties have been detected in the learning of the students (Jones, Forrester, Gardner, Grant, Taylor and Andre, 2012). Estimation will further develop perceptive ability (Hogan and Brezinski, 2003).

Vernon, 1971 gives in-depth detail of estimation in different aspects of life. Often, we find situation where use of any specific tool is not possible. Some of Vernon's points are highlighted in below the following description. These have extensive pedagogical relevance for the initial years of schooling.

Role of Estimation in the Concept of Movement and Speed of an Object

Piaget found that children perceive movement at an early age, and in a practical age, and also learn to estimate speed of movement in a practical way so that they anticipate and avoid moving objects. But below the age of 8 or 9, the children were apt to be influenced by in their judgements of the extent of movement by the total situation in which the movement occurred and were unable to analyse out its essential features.

For example, when two objects which started at the same point were moved, one along a straight path and the other along a very crooked path, a child asked to make the first one go as far as the second usually stopped the former opposite to the latter, regardless of the different lengths of two paths. Here, he was unable to single out features essential to making the judgement correctly. Relative speed was also little understood. Two objects arriving at the same place at the same moment were judged to move equally fast, no matter when or where they started. If two objects were made to rotate in concentric circles, starting and finishing at points opposite to one another, the children either thought that they moved at the same speed;

or that the object on the inner circle moved faster because it had less to do. These observations show that practical estimates of movement are not necessarily the same as abstract concepts and verbal formulations are related to it (Vernon, 1971).

Role of Estimation in the Development of the Concept of Shape

Vygotsky analysed that children of 5–6 years did not scan figures systematically. Their gaze was often directed irregularly over the field and even wandered outside it; or it was 'centrated' upon a particular part of the field. This might result in overestimation of the magnitude of the part 'centrated'. But at 6 or 7 years, the children explored the figure systematically, comparing one part with another and perceiving more accurately the inter-relationships of the parts of the figure. Hence, it appears that below a certain age children are not able to analyse shapes correctly, giving due weight to the general structure and relating detail to it. The tendency to ignore spatial orientation may indicate the child's inability to analyse what he/she perceives, to separate out certain aspects and to give them due weight.

Role of Estimation in the Concept of Velocity and Distance

If two objects at different distances move to and fro with equal velocities across the field of view in a direction at right angles to the line of sight, the angular velocity of the nearer object will be greater than that of the farther because the distance moved by the nearer subtends a greater angle at the eye than does the distance move by the farther. An observer usually perceive that such objects are at different distances, by virtue of these different velocities and after some consideration observer may be able to estimate which is the nearer and even estimate their distances apart. The same effect may be obtained if the objects are stationary and the observer moves his head from side to side (Vernon, 1971).

Role of Estimation in the Concept of Movement in Relation to the Surrounding and the Body

If a person is sitting in a stationary train and another train to one side is moving past, the person would tent to perceive the latter train as stationary and the train in which he is seated as moving. This is particularly likely to happen if the moving train cuts out most of our view of the surrounding; it then forms the background which we assume to be stationary. This is a complex instance of the process of estimating the relative distances of objects by perceiving their relative speeds of movements across the field (Vernon, 1971). Superficial coverage of all topics in a subject area must be replaced with in-depth coverage of fewer topics that allows key concepts in that discipline to be understood.

Teacher's Role in the Development of Estimation Skill Among Students

Estimation was treated as a predictive hypothesis, in a vague and superfluous way, as a process failing to produce satisfactory answers to solve situations that only a measuring tool would be able to answer. Forrester and Piké (1998) observed that in the teachers' speech in the classroom there was a significant separation between measurement and estimation. Teachers confused estimation of measurement with measurement itself, using non-standard units of measurement. Teachers consider that the estimate of measurement is a superfluous task, like a guess. At the same time, there are studies that claim that teachers' work in estimating measurement is superficial and that they do not feel confident about working with students (Lang, 2001).

Their exist shortcomings as identified by international mathematics studies regarding the teaching skills of teachers on the estimation of measurement (Chamorro 1996, 1998; Joram, et al., 2005; Forrester & Pike, 1998). Providing opportunity to students in classroom is a prior responsibility of teachers. It can not be denied that the curriculum has scope to certain degree for estimation, then it is of immense importance to nurture the skill of estimation among students and widen its scope. Certain duration of time must be assigned for activities on estimation in classroom, with aim of development of various approaches to solve a problem and refine those approaches through different and relevant strategies. McAleer (2017)proposes eight steps to implement an effective estimation plan, as mentioned below:

(i) Establish a Routine— It is important to establish a routine, so that students can rely on regularity and learn to expect this type of practice everyday. Pick a time daily or weekly to devote to estimation.

(ii) Provide Students with a Way to Show Their Thinking and Keep Track of Their Estimations Over Time— If students finish quickly, "How did you get that answer? Is there a different way you could think about it? How did you know to do that?" Students should be given a chance to make high and low estimates. These estimates can be discussed in a class. After discussion, the students should be given chance to settle on their choice to see where their numbers fall between the high and low estimates. It is important to ask students to justify their choice. This is not a quick process. Some students will take more time than others. On first-hand, time duration taken for estimation should be considered secondary while priority should be to see students' thinking.

(iii) Give Students Ample Time to Reason on Their Own—Never rush the process. Depending on the richness of the task, the students should be given time to think on their own

for at least five minutes. This time gives them the opportunity to—(i) make sense of the information they have, (ii) develop an approach or strategy to find a solution, and (iii) develop a justification for their estimation.

(iv) *Display the Estimations in a Meaningful Manner, So That All Students can See all Estimates*—Provide an area in the classroom for students to display their estimated value. Students write their estimates anonymously on a sticky note and place it on a number line, which can either contain or not contain a scale. Hence to reason, students should be made to place their estimates relative to those already on the wall, thus offering a chance to develop their estimate sense.

(v) *Throw Out or Disregard any Estimate that is Unreasonable and Explain Why*—Whenever a student proposes an estimate that is believed to be unreasonable, they must also state why: "I think _____ is unreasonable because _____." Then it should be debated and discussed.

(vi) *Discuss Students' Strategies and how they Evolved*— Students should be made to share their estimation strategies, and also the class should be allowed to ask clarifying questions and agree or disagree with any of the reasoning.

(vii) *Allow Time for Students to Adjust their Estimations as the Discussion Progresses*—After the class discussion, the students should be allowed and encouraged to update their choices. It is important to encourage students to rethink their process along the way.

(viii) *Reveal Answers, Discuss Why the Answer was or was not Surprising, and How Students Could Adjust or be more Effective with their Estimations*—The answer is not as important as the process. Where did our process lead us? What did we learn from our approach? What could we change in the future to be more accurate?

Use of proper instructions is effective in estimation. In a study by Ibe (1973), estimation before measuring serve to be one of the instructional treatments for one group, while the other treatment involved measuring without estimation first. The estimation treatment proved to be superior to the measurement only treatment on transfer, estimation and achievement. As estimation involves use of strategy, teaching of estimation strategies reinforces and elaborates the fundamental structural concepts of measurement (Osborne, 1980). The strategies applied in estimation help to clarify concepts of different subjects such as mathematics and science. This strategy can be a result of prior experiences.

Language plays an important role in the articulation of estimation. Usually, a good estimator applies numerous strategies to come to a

conclusion. They also frequently and easily switch from one to other type of strategy in-order to come with best answer. While in case of poor estimator, it is usually found that they limit themselves in the use of strategies. In both the cases sometimes it is difficult for the estimator to explain their used strategy. So, it becomes the teachers' responsibility to encourage students to use language in every step of their inquiries. Their perception and thought process must be articulated together. The exploration of their strategies towards estimation motivates the students and enhances their confidence in their own ideas. Teacher should take care to go for activities dividing some for each student, some for small group of four or five students and some for the whole class. Indeed, teacher should provide opportunity to each student to express their strategy towards a problem. Everyone for sure would come up with their unique approach, and hence it can stimulate someone else's strategy.

Further, estimation is a reflexive methodology through which teachers themselves might wish to examine the processes and procedures that might constrain or facilitate learning in conversational contexts (Forrester, 1991). Each student should discuss their strategy towards a problem, they must also pay attention to the discussion by other students. during the discussion some questions to focus are how did they reach to the response? Why did they use the particular strategy: how do they know about such referents? Teacher can also manipulate the problem and ask the student to respond using the same strategy. These will further help students to deal with divergent situations in real life. They must learn to generate a process for estimation. They can enrich their process by altering or switching to other better forms by incorporation of the best parts. They can learn from trial and error, and hence march towards perfection. So, these practices help teachers to gain insights into the processes of learning by the students, the understanding level as well as the maturation level of the students. It also reveals the manner in which teaching procedures might facilitate or constrain learning.

Mode of Assessment in Estimation

Assessment related issues are in some sense unique. It is different from other assessment issues. Estimation is considered to be best on the basis of its nearness to the perfection. It is quite a difficult approach. In estimation, no answer is considered to be incorrect as each involves estimation. Undoubtedly, the degree of correctness varies in each response from Good Estimator to Poor Estimator.

The question format is significant. Assessment tools are usually either multiple choices which have options with varied degree of proximity to the actual answer, i.e., from far to near to

nearest. For example, a rectangle with a length of 15 cm and a breadth of 10 cm has an area of 150 cm^2. Hence the options can be (a) 145 cm^2 (b) 180 cm^2 (c) 100 cm^2 (d) 120 cm^2. The best answer would be option (a) while others are correct to varying degree. Next assessment format involves the questions with multiple based options which are to be compared with the original object mentioned in the question. For example, one-inch object in a pencil box: (a) blade of a sharpener (b) ruler (c) pen (d) un-sharpened pencil. In such case, it becomes quite convenient for the estimator to estimate as materials mentioned in the options are of day-to-day use. One more question format is the open ended type. For example, what is the mass of a tennis ball? Write the value along with its unit. In this format, estimator is free to respond as per their understanding, but they get no idea or some sort of limiting boundaries to confine their response as no options are provided. It sometimes results in vague answers, that indicates poor level of implication of the conceptual knowledge.

Further, at the initial level students can be provided with easiest form of assessment format where the nature is known to them beforehand. The format of open-ended type might prove to be quite abstract in nature with no hint towards answer. It is also possible that an open-ended format might be a better choice in terms of allowing maximum freedom for responses (Reys & Bestgen, 1981). This is not always the case as open ended test might fail to measure students' ability with respect to any strategy but rounding (Schoen, et al., 1986). Thus, it shows that assessment tool specifically with its format is major contributor in classifying estimator to be good or poor.

Conclusion

Classroom environment must be enriched with opportunities of application of knowledge. Estimation should be inculcated to an extent where one tries to approach to a problem first without use of any tool or later assure their answer through estimation. The more estimation is valued, in our daily life, the more development one feels for it and hence better try to make strategy involved in estimation.

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