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Can Engineering Learners Attain Bloom's Learning Level and Course Outcome in a Real Sense without Logical Approach?: Demonstration Through a Structural Analysis Concept in Civil Engineering

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Abstract - *As per Bloom's revised taxonomy, six levels of learning in ascending order are depicted by the verbs: Remembering, Understanding, Applying, Analyzing, Evaluating and Creating. Outcome Based Education (OBE) focuses on design of curriculum and effective teaching, with reference to the outcome that learners would exhibit after being taught. OBE's instruction planning mechanism is a reverse of that associated with the Traditional Education Planning (TEP). As a requirement of OBE framework, engineering teachers generally adopt five to six course outcomes (COs) for a particular course; usually a CO belongs to a module. The combination of module-level COs leads to a Course Outcome of a particular course. Learning level is decided based on a verb or combination of verbs used in the CO statement. However, the attainments of desired learning level and CO in a true sense depends upon various factors such as depth of teacher's knowledge, his/her reference materials, his/her ability to teach conceptually rather than mechanically, learners' grasping capacity, their logical skills, etc. The CO and learning level are shown to be attained as a part of documentation; however, their practical realization remains an ambiguous issue. In this paper, learning level 4 problem, analysis of a statically determinate, perfect, stable pin-jointed plane truss by method of joints has been attempted; once by mechanical approach and once by logical and conceptual approach in order to demonstrate the advantage of later over the former for attaining the CO and learning level in their true essence and not as a mere formality.*

***Key Words*: Bloom's learning levels, teaching-learning, course outcome, structural analysis, OBE, etc.**

1. INTRODUCTION

Engineering institutes are striving hard to equip the current generation learners with the skills required to face the real world challenges. This is because of traditional curricula being taught to the engineering graduates. Such curricula focus on teacher-centric learning method [1]. A large gap gets created between the skills imparted to the engineering graduates and the skills needed to succeed in their career. However, OBE philosophy can reduce this gap to a large extent [2]. OBE stresses upon learner-centric teaching-learning mechanism. It defines clear-cut outcomes which learners shall attain after undergoing a particular course and program of study. OBE gives more impetus on the competencies, skill-sets, knowledge and desired outcomes that learners should gain. For more organized and transparent educational mechanism, teaching strategies, question paper setting and assessment should be perfectly aligned with the desired outcomes.

It is usually presumed that the engineering learners are self-motivated; they can use their well-developed cognitive skills to grasp the concepts. However, engineering teacher plays a vital role in inculcating them in such a way that they can grasp the concepts most efficiently [3]. The instructional strategies of a teacher greatly influence the effective learning and academic excellence of the learners [4]. Good teaching is a combination of various parameters such as in-depth knowledge, pedagogical skills, ability to teach the same concept in a number of ways, motivating the learners and strong commitment towards the learners [3].

A systematic strategy for adopting a streamlined curriculum for engineering programs in line with OBE is demonstrated [5] to enhance the quality of graduating students. Views of teachers and learners on the engineering curriculum and industry requirements are discussed [6] in order to decide upon the actions to be taken to improve graduating students' skills. A model was presented [7] to enhance curriculum compliance in connection with the graduating attributes' attainments.

In this article, intentionally, a very simple and basic problem of truss analysis has been chosen for the demonstration purpose so that the author's views and opinions can reach to the wide spectrum of readers in a lucid way.

2. COGNITIVE LEARNING AND REVISED BLOOM'S TAXONOMY

Cognitive learning consists of learning skills in conformity with the thinking mechanism. Bloom's taxonomy stresses upon the attainments of different learning levels. It does not consider a need of process skills. It does not cater to address the way in which a learner excels from the lower level to the higher levels.

This domain encompasses the skill-sets which facilitate in organizing a complete, accurate and complementary listing of learning attributes that are much-needed for each process.

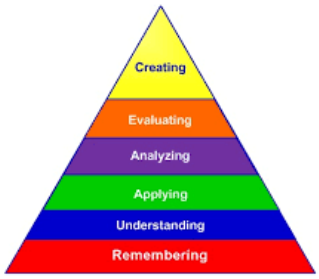

Fig. – 1: Revised Bloom's Taxonomy [8]

There are different enhanced features in the revised approach of Bloom's taxonomy [8]. Many times, it's not possible to draw a rigid line between the various learning levels attained by the learners for a particular CO.

3. REFERENCES AND STUDY MATERIALS

Many authors write the engineering books containing numerous solved problems. However, the concepts are not explained at a real depth. Such books resemble ready-made notes. They lack in imparting the desired level of knowledge component to the readers. To add to this, the current generation the so called smart learners adopt "short- cut" way of learning a course by referring sub-standard study material.

Though not all; but, some of the engineering teachers have a tendency to refer such books and solve the problems in a highly mechanical way. Perhaps, a herculean task of covering the voluminous content in shorter semester duration compels them to adopt a quick and examination-oriented teaching style. Many teachers and learners make use of modern tools and methods. However, these don't necessarily ensure that the concepts are taught and learnt at the required depth.

4. COURSE OUTCOME ATTAINMENT AND BLOOM'S LEARNING LEVEL ATTAINMENT THROUGH THE TERM TEST AND END SEMESTER EXAMINATION

As a matter of fact, the nature of questions usually asked in term tests and end semester examinations requires straight forward approach, without posing much challenge to the lateral and fundamental thinking capacity of the learners. Hence, Bloom's learning levels and corresponding course outcome are attained for the documentation purpose. On the contrary, when the questions pertaining to the same Bloom's learning levels, with a little logical twist are posed, how many learners will even try to attempt those is a million-dollar question. More importantly, what about the attainment of Bloom's learning level, which is decided only based on the "verb" used in the CO statement? The elite engineering learners, generally from the premier engineering institutes, may be able to answer the questions which demand logical thinking, owing to their quick grasping ability, combined with their self-study capability. However, those are very few in a large pool of engineering learners.

5. DEMONSTRATION OF ANALYSIS OF STATICALLY DETERMINATE, PERFECT, STABLE PIN-JOINTED PLANE TRUSS: BLOOM'S LEARNING LEVEL 4

Mechanical Approach: Analyse the truss shown in figure 2 and determine axial forces in the members, using method of joints.

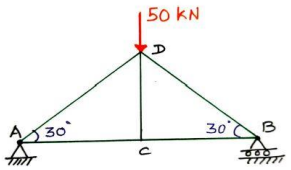

Fig. - 2: Pin-Jointed Plane Truss

Solution: At B, roller cannot develop any reaction parallel to its base; so horizontal reaction $H_B = 0$. As no load acts in horizontal direction on the truss, $H_A = 0$.

Due to the symmetry of loading and truss geometry, vertical reactions at A and B are 25 kN each, in the upward direction, to resist the downward load of 50 kN.

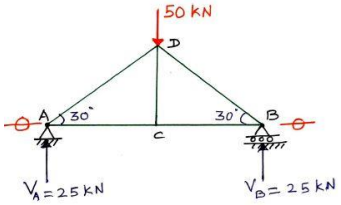

Fig. - 3: Reactions of the Truss

There are 4 joints, A, B, C and D, each forming a concurrent force system. Hence, only two equilibrium equations, $\Sigma f_x = 0$ and $\Sigma f_y = 0$ can be applied at each joint. Obviously, a joint with unknown forces not more than 2 has to be selected to begin with. There are 2 such joints, i.e. A and B.

Joint A with 2 unknown member forces, F_{AD} and F_{AC}, has been selected.

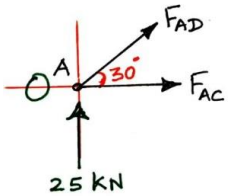

Fig. - 4: FBD of Joint A

Both the member forces have been assumed as tensile forces. Tensile forces are considered positive and compressive forces are considered negative in the calculations.

$\Sigma f_y = 0$ (upward +ve) gives, $25 + F_{AD} \text{ Sin } 30^0 = 0$

So, $F_{AD} = -50$ kN

-ve sign indicates that the force is compressive.

$\Sigma f_x = 0$ (rightward +ve) gives, $F_{AC} + (-50 \text{ Cos } 30^0) = 0$

So, $F_{AC} = 43.30$ kN (Tensile)

Due to symmetry of loading as well as geometry, $F_{AD} = F_{BD}$ and $F_{AC} = F_{BC}$

Now, joint C can be selected.

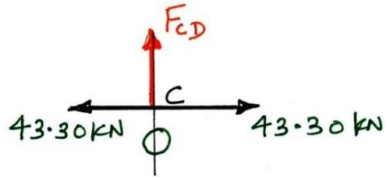

Fig. - 5: FBD of Joint C

$\Sigma f_y = 0$ (upward +ve) gives, $F_{CD} = 0$

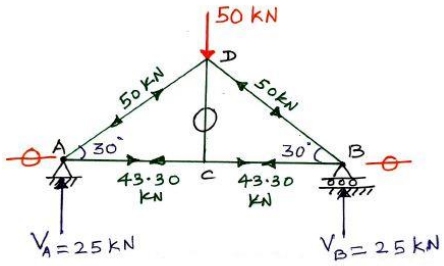

Fig.- 6: Forces in All the Members

Logical Approach: Analyse the truss shown in figure 2 without making use of support reaction values and determine axial forces in the members. Use method of joints.

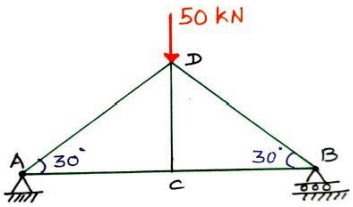

Fig. - 2 (Repeated): Pin-Jointed Plane Truss

Solution: As support reactions are not to be used in the calculations, joints A and B cannot be selected. Though there are 3 unknowns at joint C, there are no inclined members at this joint. Moreover, no load is acting at C.

So, $F_{CD} = 0$ for vertical equilibrium of joint C. This shows that DC is a dummy member, carrying no force. However, its removal would make the truss deficient and unstable.

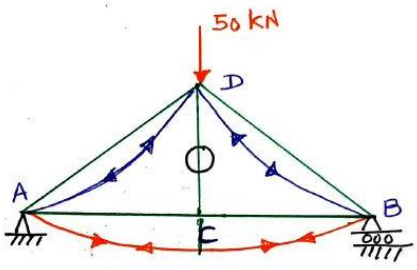

Fig. - 7: Deformed Shape of the Truss

Referring fig. 7, truss deforms due to 50 kN load in such a way that the members AD and BD are subjected to axial shortening; so F_{AD} and F_{BD} are compressive forces. Members AC and BC are subjected to axial elongation; so F_{AC} and F_{BC} are tensile forces. Using this fundamental structural engineering "common sense and logic", the nature of axial forces have been already decided before calculating their magnitudes. This logic obviously applies to trusses with greater number of members and loadings as well. More importantly, it facilitates in cross-checking the correctness of the nature of axial forces obtained through the calculations.

Considering joint D, member DC carries no force; members AD and BD each carry half the effect of load 50 kN, owing to the symmetry.

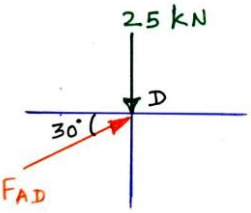

Fig. - 8: Partial FBD of Joint D

It's already known from the deformed shape that F_{AD} will be compressive; so, there is no need to assume it as a tensile force initially.

AD will carry half the effect of 50 kN; therefore, 25 kN is shown at D.

$\Sigma f_y = 0$ (upward +ve) gives, $F_{AD} \text{ Sin } 30^0 - 25 = 0$

So, $F_{AD} = 50$ kN (Compressive) $= F_{BD}$

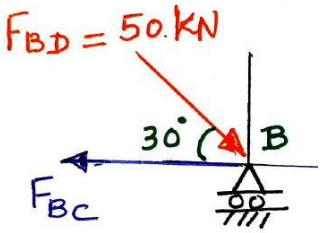

Fig. - 9: Joint B Details

Referring fig. 9, it is obvious that F_{BC} must be (50 Cos 30^0) = 43.30 kN (Tensile) for the horizontal equilibrium of joint B. At joint C, F_{AC} = 43.30 kN (Tensile) for horizontal equilibrium of the joint.

Detailed steps have been explained just for the purpose of demonstration. However, in logical approach, one can obtain the answers quickly without writing too many formal mathematical steps and without drawing too many diagrams.

6. RESULTS AND DISCUSSION

The mechanical approach followed the usual set rules of method of joints and it was more of stereotype way of solving a problem, without requiring a critical thinking approach. However, when the same problem was solved complying with the constraint of not using support reactions, it necessitated fundamental knowledge of structural engineering and logical thinking. This may not be the cup-of-tea of majority of the students. Many students would struggle to obtain the solution with the imposed constraint.

Enormous study material is available in the print form and digital form like YouTube videos; MOOCS notes and videos, Google search engine content, etc. Though not all; but most of this material reflects highly mechanical way of solving a problem through following steps in a chronological order. Sticking to the mechanically set rules, every time, is in sharp contrast to the very purpose of engineering philosophy itself!!!. Here comes the role of an intellectual creature i. e. "human being". Hence, it becomes imperative for an engineering teacher to impart critical thinking to the learners by exercising an extra effort in order to make their fundamentals strong and sound. This may not be possible in every case by adopting "Artificial Intelligence (Actually Non-Human Intelligence)". An engineering teacher shall adopt a teaching style, wherein an optimal combination of mechanical and logical approach can be practiced for the OBE philosophy to be realized in a pragmatic sense.

7. SUMMARY AND CONCLUSIONS

Apple started falling not because Newton invented gravity law!!!. It was falling since time immemorial; Newton could give reasoning to it with his logical explanation. On the similar line, engineering principles do not follow mathematics; rather mathematical approach has to be used to express the engineering concept. If learners get accustomed simply to use mathematical equations and formulae to solve an engineering problem, without really understanding the underlying engineering principles, will they be able to acquire the required practical knowledge? If an engineering concept, pertaining to a certain CO and learning level, is taught to the learners as a part of covering regular course syllabus and if questions based on it appear in relatively tough competitive examinations or unexpectedly difficult university examination paper, requiring logical thinking and sound engineering fundamentals, the learners should be able to solve it completely or at least develop a logic to partially tackle the problem. This would truly reflect the CO and learning level attainments.

Though attainment is vital and essential in OBE framework, the success of engineering education cannot be only confined to and measured by the attainments of CO and learning levels in the formal documents having more of a quantitative approach; it has also to be assessed qualitatively in terms of graduates acquiring the strong engineering concepts which is an essential factor in obtaining an engineering degree.

Deciding the attainments of Bloom's learning level and CO based only on the usage of an appropriate "verb" symbolically in a CO statement is too shallow, immature and superficial way of dealing with a particular course. On a Professional note, it shows a lack of real seriousness expected in engineering teaching-learning process. The engineering learners must be taught "what" to do, "how" to do and very importantly "why" to do. If the last component is missing, then it is simply "Output Based Education", smartly projected as "Outcome Based Education". In such a case, the CO statement has to be changed to: "The students will be able to analyze the truss only with reference to the questions pertaining to what to do and how to do way of thinking". This statement may seem to be funny to some of the readers, but a little consideration would underline a serious message it carries.

The teachers and learners must do Strength, Weakness, Opportunity and Challenge (SWOC) analysis for self-introspection and work honestly towards overcoming Weakness and Challenge, with the help of Strength and Opportunity. Considering the "2-minute noodles" attitude of the current generation learners, the onus is on the engineering teachers to convince them the importance of in-depth study through imparting the knowledge conceptually and logically so that, at least some of the learners can attain the expected learning level and the course outcome in a real sense!!!.....Till then, across many institutes in India, the same old story continues and so does the colossal documentation (by cutting thousands of trees so that one of the vital Sustainable Development Goals is not attained in a real sense!!!!!)……..??????.....

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