Context Based Learning in Basic Thermodynamics through Day to Day Events

K V Muralidhar Sharma, **S.G.Gopala Krishna**, **N.Kapilan**,

***Abstract:** Very few students accept that learning basic thermodynamics is really inspirational. Unfortunately the reality is exactly the other way. Even the students after certain years of learning and working experience accept this. Acceptance of the subject's high difficulty level is also a widely acknowledged by the researchers across the globe. Researchers are continuously engaged in finding the root cause of the problem as well possible different solution. This paper is the part of an ongoing research work in designing a Learning system. As part of this work a number of day-to-day events which can be effectively utilized in driving home different thermodynamic concepts are identified. Two scenarios out of these shortlisted is dealt here, namely (1) A traveler scenario with an over pressurized car (2) A hot air blow scenario. These two Contexts have been illustrated to drive home the concepts of basic thermodynamics. A well-established CBL model is used for the experimentation purpose. First year engineering undergraduate students of VTU are selected for the quasi-experimental purpose. The experiment has proved that the context based learning has given an improvement in the learning gain.*

***Keywords:** Thermodynamics, Scenario approach, CBL-Context Based Learning, Learning difficulties*

I. INTRODUCTION

Thermodynamics is a basic science that deals with Heat & Work and those properties of substance that hold a relation to Heat and Work. Almost all the stakeholders namely students, teachers and the Institutional academic administrators think that thermodynamics subject is not only difficult but horrible. Unlike other subjects of engineering one cannot easily demonstrate the applicability of this subject in day to day events.Basic thermodynamics is also an engineering subject. Understanding basic thermodynamics requires the learning of concepts, laws and theories many of them are abstract in nature and indirect or converse in their statement. Concepts like enthalpy, entropy, heat etc. are not only difficult for students to learn but equally challenging for teachers to effectively teach the crowded students with different learning profiles.

Manuscript published on November 30, 2019.
* Correspondence Author
K V Muralidhar Sharma*, Dept. of mechanical Engg., Jyothy Institute of Technology, Bengaluru, Karnataka
Dr.S.G.Gopala Krishna, Professor & Director, Nagarjuna Group of Institutions, Chickballapur
Dr. N.Kapilan, Professor and Head, Dept. of M.E., Nagarjuna College of Engg & Technology, Chickballapur

Without effective learning of these abstract and perceivably difficult and often misconceived concepts, most of the learning objectives and the Improvement in the academic
performance is not achieved .It is often said that a Comprehensive understanding of thermodynamics by graduating engineers is critical for addressing key current and future global issues like energy crisis, pollution and global warming.[1]There are sufficient research evidences [2][3][4] to claim that thermodynamics is one of the difficult subjects across the globe. The case is not different in Indian Universities also[5].Though there are good number of research contributions in analyzing different reasons and different possible solution approaches [6], learning difficulties in thermodynamics is still a concern at large [7]. For example increasing the internal energy of steam in a tank is hardly visible. There is sufficient and enormous scope for each and every student to understand the phenomenon as per his own prebuilt notions. This many times may end up in misconceptions. There is enough research evident to prove that even after "instructions" the built up misconceptions are not eliminated or the worst could be further strengthened.Researchers from the Defense University Centre at Naval Academy and University of Vigo, both of Spain have developed an internet based, inquiry-oriented learning system called WebQuest for Power plants and turbines [8]. This is designed to be used for second year course "Thermodynamics and Heat Transfer". Web Quest takes students to working in a group of not more than 10 through six stages namely Introduction, Task, Sources, Description, evaluation and Conclusion. At the end of the activity, teacher evaluated student's individual as well the group presentations. Researchers reported an improved performance both in an individual and group level. Effectiveness was also measured by comparing the performance with another group "Homework" group and an improvement is reported. Though an improvement in goal achievement at both individual and group level is reported the methodology adopted to evaluate needs some deliberations. Web quest group and "Homework" group normalization process is not evident in the paper.Roman Taraban a Texas Tech University Psychology Professor along with Edwards E.Anderson and others of Mechanical department have experimented on the concept of internet based homework into introductory thermodynamics to undergraduate students of Texas Tech and Wyoming University and found a favorable result [9]. This was a jointly funded project by NSF National Science foundation and Texas Tech University.

Here the Homework was made available to the students online as against the conventional. An exclusively application developed tracked and analyzed individual students learning data under three titles (a) Time spent in Homework (b) Correlation between homework and day to day class room activity and (c) test performance. Researchers have reported a statistically substantiated improvement in the class room performance and Test performance as well. Gains were reported in all the 3 spans namely, Long term gain apart from short term and immediate learning gains. A critical review of this funded work [9] poses certain questions for which the reported work does not seem to give a rationale justification. The consolidated performance of an average student of Wyoming University infers that a 2.73 hrs. of online time spent per semester per student has resulted in a substantial increase of learning gain to an average 86.6 % as reflected by the immediate assessment and an average of 78.48% as reflected by the immediate test performance. This is achieved with a unique hit of 30.58. So also is the performance statistics of Texas Tech University students. 4.33 hrs of online time spent per semester per student has resulted in a substantial increase of learning gain to an average 86.4 % as reflected by the immediate assessment and an average of 85.18% as reflected by the immediate test performance. This is achieved with a unique hit of 21.69. The direct correlation between the effort and outcome looks bit illogical to anyone with a fair understanding of the perceived difficulty level of thermodynamics and the interpretation needs some deliberation. Especially for an inherently difficult subject like thermodynamics, it is difficult to understand how a simple technology enabled assessment strategy alone can improve the learning gain. There could be other interventions about which this paper is silent. To make the experimental design more meaningful in this scenario, both the control and treatment group must have assessed initially through the same pretest, treatment group alone processed through the online homework and then control group must have given the conventional home work. In that scenario the test performance of both the groups and its statistical inference shall represent the effect of online home work. In the absence of such an experimental design certainly the gain cannot be attributed to the online homework strategy alone. Other interventions like teacher's intervention, strategically designed contents / instructional designs etc., could be the contributory factor in the result improvement.

II. CBL – LITERATURE REVIEW

Context based Learning is one of the non-conventional learning pedagogy and is based on the hypothecation that social context of the learning environment is the key factor to the acquisition and processing of knowledge. CBL assumes that learning is a social activity. Any class room practice that does not structure the learning activity to the learner's social structure may well inhibit the process of learning. Learning can be more meaningful to the students when it connects them to the real world. It focuses upon students' diverse skills, interests, experiences, and cultures and integrates these into what and how students learn. Thus, contextual teaching situates learning and learning activities in real-life and vocational contexts to which students can relate, incorporating not only content, the "what," of learning but the reasons why that learning is important. Simply quoting or citing a context with an objective of explorative learning is not sufficient. The contexts are to be designed and developed to ensure students engagement, meaningful interactions and collaborative activities. CBL context based learning which is sometimes referred as STS Science-Technology-Society strategies is a simple pedagogical strategy to induce an element of active learning. Here the students are given some well-designed social scenario he/she has encountered in her day to day life. Scenario must have an implicit/explicit element of science or technology related concepts and students led discussion process duly monitored by a trained teacher will help in exploring the learning needs of students and further aims towards a solution focus. CBL in its earlier avtaar was known as PBL problem based learning. Researchers & educators were not comfortable with the negative connotation associated with the term "Problem" and hence the terminology "Context" replaced it. In 1960s at McMasters University of Canada while teaching health care concepts the utility of Contexts was first explored. University has used this strategy in preparing medical graduates for practicing.[10] This is the first reported use of CBL as a pedagogical strategy in literature.There is sufficient research evidence to prove the existence of learning problem in teaching and also in specific to the course thermodynamics. Researchers have also deliberated on the root cause of these problems and some suggested way put. States sponsored and heavily funded project by the Department of "Educational theory and Practice" spanning over five years (1998-2003) by the University of Gorgia on contextual teaching and learning (CTL), has not only demonstrated the usefulness of CTL but also developed useful tools and repositories [11]To sum up, the various research findings across the globe in different faculty of study indicate encouraging results. But there is a need to conduct a systematic study, especially for engineering courses.Hence through this paper an attempt is made to investigate on "How best the given two contexts can solve the conceptual learning problem in Basic thermodynamics".

III. METHODOLOGY

The researcher has selected two most common scenarios that are reflected in our day to day social Context namely (1) A traveler with an over pressurized car tires and (2) Hot air blow scenario of a domestic refrigerator. These three Contexts have been illustrated to drive home the concepts of basic thermodynamics. The broad framework of CBL model is followed for the experimentation purpose.Situation in need of improvement: It is a very common scenario in most of the VTU affiliated engineering colleges that both the student community and the teaching fraternity find the difficulty in understanding several concepts of thermodynamics due to its abstract nature. Unlike the other courses students cannot relate what they are learning to the real time context. Conceptual understanding of second law of thermodynamics is one such course content that needs an educational researcher's attention.

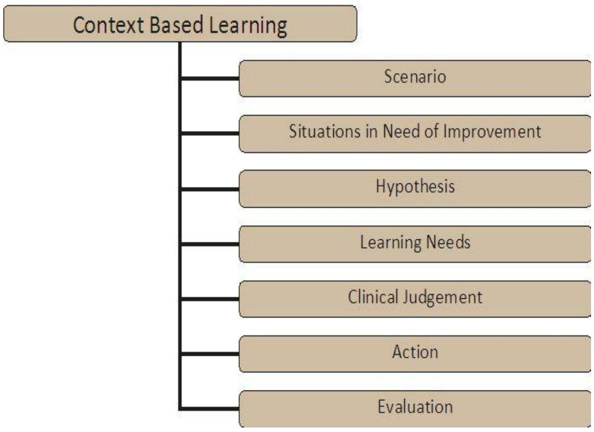

Fig.1 : Context Based Learning Framework followed.

There are some solution approaches adopted by different colleges like "remedial classes", Repetition classes etc. Especially for a subject like "basic thermodynamics" most of these existing approaches don't work. Teachers many a time attribute the reason for these difficulties to the quantum of syllabus and heavy dependency on fundamental concepts. This scenario is almost the same even in other universities as well. The best administrative efforts and proctoring /counseling at the most have marginally reduced the problem but certainly could not eliminate.

Scenario: The working of VCR – Vapor Compression Refrigeration is one of the broad areas selected for the purpose. Why a Compressor is required in VCR? is one of the specific learning outcome identified under this. All the three identified scenario/contexts have been experimented.

Selected 3 contexts are related the concept of primitive properties and their inter relation, Concept of latent heat , Latent heat Vs Energy transfer by virtue of Heat etc. The contexts are so selected that the conceptual understanding of the three contextual narrations has the bearing in understanding the Working of VCR Vapour Compression Refrigerator.

Hypothesis: The selected two contexts namely (1) A traveler scenario with an over pressurized car tires and (2) A hot air blow scenario will improve the conceptual understanding of I semester mechanical engineering undergraduates of VTU.

Learning Needs: After going through the learning process student should be able to (a) demonstrate the working of domestic refrigeration (b) Explain the significance of each of the major components in a domestic refrigeration.

Experimental plan: In the first phase, students were given each of the selected day to day events and their response elicited through interaction and group discussion. In the second phase the teacher has explained how the course content is related to the discussed scenario. In the third phase teacher explained the thermodynamics concepts with the help of the scenario.

IV. RESULT AND DISCUSSIONS

The learning outcome under investigation is one the concepts not understood by students and the reason was explored from CBL perspective.

To explain the relevance of compressor the researcher has been asking a simple question semester after semester - What is the boiling point of Water?. Irrespective of the branch, Student's intellectual level, background the most vocal and the majority answer is "Water boils at 100 degree". Actually this may not be a totally wrong statement but certainly an incomplete/incorrect statement from the perspective of "Defined learning need/outcome".

If the pressure of a container with water is increased above 1 atm. the boiling temperature also increases. Look so simple. But ask any teacher engaged in teaching this concept in classroom. The sad story is very much evident.

As it is very evident in some of the research the reason for wrong understanding is the built in mis-concepts. Even the conventional teaching or remedial classes cannot rectify the mis-concepts. The only solution is to elicit the misconception from each individual, to discuss and to eliminate through any workable strategy.

In terms of teachers observation the first phase of experimentation students are very enthusiastic and most of the students engaged in to the discussion actively. The real challenge was in the execution of the second and the third phase where the teacher explained the relevance of the phase 1 contexts to the learning needs and explaining the thermodynamic concepts with the help of contexts.

At the end of the context drive students were tested the conceptual understanding of VCR through simple quiz and the results of the assessment clearly proved a satisfactory level of performance. This improved level of performance is attributed to the contextual learning strategy adopted.

V. CONCLUSION

The Context based Teaching and learning adopted under the general CBL model framework has resulted in the overall marginal improvement of understanding of the selected concepts of basic thermodynamics. Learning gains are also evident in the Application level which was evident through the improvement in the evaluation quiz.

VI. SCOPE FOR FUTURE WORK

There is sufficient scope for recording the initial and final conceptual understanding through improvised method of data recording. Data are further to be evaluated and validated using appropriate statistical techniques. This is the part of a comprehensive analysis of the shortlisted day-to-day contexts to evaluate the effect of context based Learning in basic thermodynamics. This part of the work is under progress. The Author is also working on integrating the Learning strategy of Flipped class room and TPS Think-Pair-Share in driving the concepts of CBL

REFERENCES

1. Dukhan N. On the worldwide engineering students' meager performance in thermodynamics, QScience Proceedings (Engineering Leaders Conference 2014) 2015:17, http://dx.doi.org/10.5339/qproc.2015.elc2014.17
2. Mettes CT, Pilot A, Kramers-Pals H. Teaching and learning problem solving in science, part II: learning problem solving in a thermodynamic course. J. Chem. Ed. ;58:51–55.
3. De Berg KC. Student understanding of the volume, mass, and pressure of air within a sealed syringe in different states. Journal of Research in Science Teaching. ;32(8):871 –884.
4. Kavanagh L, O'Moore L, Samuelowicz K. Characterizing the First Year Cohort Knowledge. 2009, Proceedings of the ASEE Annual Conference and Exposition, Austin, TX, USA.
5. Banerjee C. Teaching chemical equilibrium and thermodynamics to undergraduate general chemistry classes. J. Chem.Educ. 1995;72:879–887.

6. Cobourn, W. G., & Lindauer, G. C.,A flexible multimedia instructional module for introductory thermodynamics, Journal of Engineering Education, 83(3), 271-277. 1994
7. Melaku Masresha Woldamanuel, Harrison Atagana & Dire, Students' conceptual Difficulties in Thermodynamics, Dawa University, Ethiopia and Temechegn Engida University of South Africa (UNISA), Institute of Mathematics, Science and Technology Education UNESCO-International institute for capacity building in Africa, ISSN 2278-6783, *Chem Sci Rev Lett* 2015, 4(13), 299-309
8. Carlos Ullos. Guillermo D. Rey, "Power plants, steam and Gas turbines WebQuest" Education Sciences, Oct 2012, 2, 180-189
9. Roman Taraban, Edward E Anderson & Matthew Warma, Developing on-line homework for Introductory Thermodynamics, Journal of Engineering Education, July 2005
10. Alexander, J., McDaniel, G., & Baldwin, M. (2005). If we teach them to fish: Solving real nursing problems through problem-based learning. *Annual Review of Nursing Education*, *3*, 109–123.
11. . http://www.coe.uga.edu/ctl/