Review-A Study of Thermodynamics Learning

Dr..R.N.Patil, PCET;s Pimpri Chinchwad College of Engineering & Research, Ravet, Pune

---

***ABSTRACT*:** The present study is an attempt to understand different dimensions of difficulties and their nature, a quick preview of Student learning difficulties in Thermodynamics course across the globe. Engineering in general and thermodynamics in particular, isprone to difficulties. The course is reviewed for the available research findings on different basic pre-concepts like process, temperature, work, heat and energy. Apart from these pre-concepts there are other parameter ranging from socio-cultural difficulties to the difficulty associated with the very subject itself.

KEY WORDS: TLP, LEARNING DIFFICULTIES, MISCONCEPTIONS, THERMODYNAMICS, PRE-CONCEPTS

I. INTRODUCTION

There is no dearth of evidence [1] to prove the difficulties associated with the teaching – learning processes TLPfor many engineering courses. Basic thermodynamics is prone to elicit a negative impression from students who perceive the subject as dry and abstract.

Academicians and researchers across the Globe have tried new methods and written about the results. However, the validity of a method remains suspect if the only evidence on its behalf is one person's testimony that "I tried this and liked it and so did the students." Many of the online packages, E-learning materials, Interactive learning systems are yet to make a head way due to probably their lack of systematic approachin solving the identified problems. Even amongst those solution approaches that claim success a "comprehensive understanding of the problem before rushing in to a solution" seems missing.

II. RESEARCH REPORT ON LEARNING DIFFICULTIES

II B : STUDENT'S LEARNING DIFFICULTIES ABOUT HEAT,WORK,TEMPERATURE & PROCESS

The students frequently failed to differentiate the concepts of heat, temperature, work and internal energy. Yeo &Zandik,[2] showed that students have difficulties to understand the basic concept of heat and work, and thermodynamic processes. The students also have difficulties how to apply P-V diagram for problem solving. Researcher found that students have misinterpretation of understanding of ideal gas laws [3].

To probe student understanding of the path dependence of work, Popatet al[4] have designed several problems in which two different paths between an initial state and a final state are shown on a PV diagram. Only 30% student's responded correctly.About 42% students believe that there is change in internal energy in both isothermal and adiabatic processes.The student believes that no work is done in an isothermal process because the temperature does not change, no heat is transferred, and if no heat is transferred, then no work is done.In a recent study conducted by Kulkarni and others only 14 % students were able to apply the ideal gas law in an adiabatic expansion. About 52% students responded that the internal energy changes in an isothermal process [5]

II B : STUDENT'S LEARNING DIFFICULTIES ABOUT ENERGY

There is a general agreement among science teachers on the importance of choosing the teaching of energy as a focus of interest in the science curriculum, since this is a central idea which provides an important key to our understanding of the way things happen in the physical, biological and technological world [6].The conception of energy 'as capacity for doing work', whose origin goes back to the 17th century (Trumper 1990), was still used by many 19th century scientists such as Maxwell (1877). However, when the Second Law of Thermodynamics was established, it became clear that not all energy is able to perform work.Energy issues have personal, social and environmental implications that may help to enhance students' interest in learning. Understanding these implications is necessary in order to make informed decisions

Trumper&Gorsky [7] state that some studies investigated student's alternative conceptions and others focused on how to remedy them. However, the researchers state that few studies explored cognitive and personal factors in the perception of a new concept and their effects on the development of alternative concepts should be investigated. Energy is not a kind of fuel needed to produce transformations, as students often conceive it (Ogborn 1986; McClelland 1989; Trumper 1993), Watts (1983)[8] suggests that energy is related to many subjects in curricula and adds that students are introduced with energy concept long before formal education. In this study, the researcher calls the gains of the students prior to formal education as alternative conceptions and indicates to the need for investigating what these gains are.

II C: SOCIOCULTURAL FACTORS

In the Taiwan national project on Assessing Students' Conceptual Understanding in Science, with the involvement of about 30 senior researchers and 80 research assistants and the findings from the national data some aspects of the students' learning difficulties that is unique to Taiwanese culture and language. This article concludes with some educational implications from the research findings. Küçük*et al*. (2005) investigated how the Turkish students perceived energy and related concepts[9]. Yuenyong*et al*. (2008) state that learning is not only constructing knowledgebut also expressing a standpoint with this knowledge embedded in one's own culture.[10]

In other words, learning has a socio-cultural nature and contextual bases should be taken into account. In this sense, the comparison of the perceptions of students from different countries and cultures (e.g. Thailand and New Zealand) is suggested to contribute to science teaching and learning Environmental conditions, cultural beliefs and social values have an impact on students' construction of their knowledge about energy[10].

TussatrinKruatong et al [11] in their research focused on Thai students' conception involving heat and thermodynamics. Twelve Thai students were interviewed to determine the way they thought about heat energy, temperature, heat transfer, thermal properties, insulators, conductors and thermal equilibrium through everyday thermal situations. The compiled data from the interviews were used for developing a Heat and Thermodynamics Concept Questionnaire (HTCQ) which administered to 214 students from three high schools in Bangkok. The HTCQ findings revealed that most of the students lacked the understanding of heat and thermodynamics concepts. For example, at least 84% of the students lacked the understanding of absolute temperature. Most of the students defined temperature as a variable that can be measured, and heat was a sensation. Only 10% of the students understood that heat is extensive quantities. Researchers [10] found that students considered the environmental conditions, cultural beliefs and social values in constructing their knowledge about energy and had difficulty in understanding the relationship between political views and studies on energy.

However, researchers addressed some specific questions based on countries because the sample included students from New Zealand and Thailand.

II D: INFLUENCE OF CHILDHOOD EDUCATION

A questionnaire administered by H Goldring and J Osborneto [12] 75 pupils in the beginning of the lower sixth form showed that a high percentage do not understand some of the key concepts of energy. Little or no correlation was found between answers to questions involving the application of qualitative knowledge and understanding and those involving quantitative reasoning. Suggestions are made on how the situation might be improved.For meaningful learning new knowledge should correspond to existing knowledge (Çalık, 2006; Özsevgeç, 2007) because students construct their new knowledge based upon their existing experiences, abilities and beliefs Trumper (1993) cited in his study that, many studies determined that students developed scientifically incorrect perceptions regarding physics concepts before formal education. Trumper states that the most usually encountered concept among these is energy and in order to prevent scientifically incorrect perceptions regarding energy, it should be questioned at the very age.

II E : TEACHERS DIFFICULTIES AND INSTRUCTIONS METHODOLOGY

Learning difficulties associated with Energy gave rise, in the1980s, to a wide debate about how to introduce energy into the curriculum [13]

Knowledge should not be directly presented in its final form as something to be accepted. On the contrary, we should guide the students to follow, to a certain extent, the process of construction of knowledge, enhancing the open and tentative nature of this process. But at large sans some adaptations there is not much rational change in the classroom teaching at majority of the Institutions.[14]

Planck predicted at the beginning of the 20th century that the traditional way of introducing energy in association with the concept of work would disappear in about twenty years (Duit 1986). Now we know that he was wrong: successive analyses of physics textbooks have shown that most of them still introduce the concept of energy as the capacity to do work (Lehrman 1973; Hicks 1983; Duit 1986; Dome´nech et al. 2001), in spite of the many disadvantages of this definition (Sexl 1981; Hicks 1983; Trumper 1990). For instance, Sexl [15] states that this definition is not useful in thermodynamics, because 'the internal energy of a system cannot be transformed completely into work.Odell (1997) concluded in his/her study on students from different programs that there are differences among the perceptions of students about energy before and after attending basic courses

II F : STUDENTS BACKGROUND

The perceptions of biology and chemistry students are reported to be more realistic than those of physics and science students. Odell, in 1997 reported thatstudents ideas of plants and animals obtaining their energy from water, air or soil.Students mostly concentrate on the energy concept from physics' point of view, as reported by Köse*et al*[16]. David E. Meltzer did a comparative study of the learning difficulties encountered by physics, chemistry, and engineering students enrolled in different Universities selecting common topics of "THERMAL" related subjects namely Introductory physics , Physical chemistry and thermal physics respectively. Majority of engineering students in comparison to others were unfamiliar and uncomfortable in reasoning associated with problem solving.

II G : MATHEMATICAL INFLUENCE

Although students can use complex formulas for the solution of problems, they cannot justify their solutions. Kurnaz, 2007; Kurnaz&Sağlam Arslan, 2009 students had low proficiency in handling problems which require explanation and interpretation; and students became automated in using formulas in solving problems. Researchers

Students couldn't justify the formulas they've used in solving problems and this showed that they automatically use formulas. Kurnaz, 2007; Kurnaz&Sağlam Arslan, 2009

II F :AGE FACTOR

Students from different age levels pervasively define energy as the capability to do work. Sağlam Arslan

The TCE, which was administered to 515 Korean students from years 10–12, was developed in Australia, using students' alternative conceptions derived from the research literature. The conceptual structure comprised four groups—heat transfer and temperature changes, boiling, heat conductivity and equilibrium, and freezing and melting—using 19 of the 26 items in the original questionnaire. Depending on the year group, 25–55% of students experienced difficulties in applying scientific concepts in everyday contexts. Years of schooling, science subjects currently studied and physics topics previously studied correlated with development of students' conceptual understanding, especially in topics relating to heat transfer, temperature scales, specific heat capacity, homeostasis, and thermodynamics. Although students did improve their conceptual understandings in later years of schooling, they still had difficulties in relating the scientific concepts to their experiences in everyday contexts.

III. DISCUSSIONS AND INFERENCES

Is it possible to source these wide-ranging difficulties to any common reason? What are the reasons behind the difficulties?Though there are ample research reports about the difficulties most of the research works just stop at that point.

Work by Reiner et al. (2000) explored reasons why four basic conceptual quantities important in thermal studies like heat and temperature have been found to be the source of "robust misconceptions" among students. For all of these concepts, Reiner et al. noted that students tend to have a "substance-based" model, e.g., they view heat transfer as a fluid that flows through as if they were pipes. They also postulate that as students try to make sense of these concepts that they do so by forming analogies to their experiences with physical substances for which they are already familiar.

III A – DIRECT AND EMERGENT PHENOMENON

More recent work by Chi (2005) has developed an alternative argument for why some misconceptions are more robust than others. She points that there are two classes of phenomena: "direct" and "emergent". Direct phenomena are those in which causal connections are readily observable and in which the components involved have clear functions, e.g., the pumping of blood through the cardiovascular system. In emergent Processes the observed phenomena are not directly caused by the underlying physical processes, but rather “emerge” indirectly from them.

III B - INTERCONNECTIVITY

A simple analysis infers the inter connectivity between some of the difficulties. Childhood education has contributed considerably to the learning difficulties in almost all the topics except ENTROPY. The simple reason for this is that most of these topics like primitive properties, concept of energy, Heat and work all are re-encountered by undergraduate students after their initial introduction at school education at different levels. What is learnt at school level weather right or wrong is well reinforced in to the student’s belief system.

III C – MISCONCEPTIONS AND ALTERNATE CONCEPTIONS

Many researchers have proved that BELIEF plays a major role in learning process than the REASONING. This brings in the MISCONCEPTION factor in to picture which seems to have a strong shadow effect in almost all PRELEARNT concept. Misconceptions are the wrong understandings of the concepts mostly during their earlier education process. Even misunderstandings have multiple attributes. Socio-cultural factors are one of the crucial aspects that drive the Misconceptions. Students especially during their early education process tend to understand the explanations of basic physics by correlating their day-to-day usage in their existing social and cultural context.

The very nature of the subject or the concept themselves are the potential sources of difficulties. For example the definition of energy as the “CAPACITY TO DO WORK” is certainly unacceptable from thermodynamics perspective. Despite no coherence amongst the researchers, majority of the school text books continue with the same definition even today. Thus it is evident that even the text books themselves are one of the sources of difficulty. Alternate conceptions differ from Misconceptions in the sense that they need not contribute to the wrong understanding of the concepts at that stage. What a student understands may not be wrong but could be INCOMPLETE.

Thus alternate conceptions are not Misconceptions and at the same time they also may lead to misconceptions in future learning process. This could be due to lack of total understanding of the concepts. Their BELIEF faculty of psychology may overshadow his unlearnt part of the same concept resulting in a potential danger of misconception.

III D – INSTRUCTORS

Despite number of research contributions to the field of teaching learning process, not much seems to have changed in teaching learning process in Indian Engineering colleges. Baring few exceptions TLP in India is still an Instructor driven, teacher cantered class room phenomenon. Thus it is obvious that teacher’ s ability like his knowledge, skill, delivery style, motivation and such factors are still a pivotal point in deciding the outcomes of TLP and hence the difficulties. There are sufficient research evidence to prove that a student’s perceived subject difficulty is the indication of degree of difficulty he has with the respective teacher rather than the subject itself. This is especially true in school education. This fact may well drive a greater danger in terms of students learning difficulties because any misconceptions of the teacher is prone to adversely effectstudents difficulties and not only that that is going to stay there for a long.Most classes in engineering are auditory, deductive and intuitive. However many engineering students are visual, inductive and sequential learners which renders an immediate mismatch between teaching and learning styles. (Kapadia, 2008, p. 2)

It is broadly agreed that the traditional instructions does not take in to account of the existing beliefs and alternate conceptions of students and hence the reason for the wide ranging difficulties. Reported reviews support these facts. The difficulties raised from the misconceptions are reported to be so strong that even after successful instructions at undergraduate level students have been reported to have carried the misconceptions.

IV. CONCLUSION

Literature review infers that the difficulties in teaching learning process are sourced from wide ranging aspects. Difficulties are almost omnipresent across all the topics though the degree and nature could be different. Also difficulties in "thermodynamics" are attributed to different aspects ranging from socio-cultural environment to the very nature of the subject itself.Misconceptions and alternate conceptions seem to have a bigger say in student difficulties especially because of the very abstract nature of thermodynamics, most of the learning being CONCEPTUAL and many of these concepts are re-encountered.

Students bring misconceptions to university education and these misconceptions persist after traditional teaching process. Students' prior knowledge should be valued and can be restructured. Therefore, conceptual change approach should be emphasized. Education not being structured by considering students' alternative conceptions and misconceptions are one of the major reasons for learning difficulties.Structuring instructional design upon prior knowledge of students facilitates learning. Constructivist approach which considers students' existing knowledge is recommended Many of the available e-learning packages, Interactive packages fail to deliver for this difficulty.

Age is not a significant contributory factor.

Though there are enough research reports available about the learning difficulties on energy, temperature, heat, work, entropy etc very few Indian works reported and almost none from Indian engineering student's perspectives. As it is quite evident that the difficulties are also socio – cultural driven there is enough scope.

It's recommended to conduct different studies on student learning difficulties with a well validated testing Instruments and with significant explicit sampling criteria with a more intensive literature review.

REFERENCES

[1] Dukhan N., “The worldwide engineering students’ meager performance in thermodynamics”, QScience Proceedings (Engineering Leaders Conference
2014) 2015:17

[2] Yeo, S., &Zadnik, M., “Introductory thermal concept evaluation: Assessing students' understanding”. The Physics Teacher, 39(8), 2001, 496-504. V37.

[5] David E. Meltzer., “The Questions We Ask and Why: Methodological Orientation in Physics Education”, Research Department of Physics & Astronomy, Iowa State University, Ames, IA 50011. 2004, pp.11-14.

[4] Vasudeo Digambar Kulkarni, PopatSavaleramTambade, “Assessing the conceptual Understanding about Heat and Thermodynamics at Undergraduate Level”, EJPE, Vol 4 Issue 2, 2013, pp., 9-16.

[5] David E Meltzer, “Investigation of Student Learning in Thermodynamics and Implications for Instruction in Chemistry and Engineering”., 2006.

[6] In R. Driver, E. Guesne, &E.Tiberghien, Erickson, G., “An overview of pupils’ ideas”. (Eds), “Children’s ideas in science”, 1985, (pp.55-66). Milton Keynes: Open University Press.

[7] Trumper, R., &Gorsky, P. “Learning about energy: The influence of alternative frameworks, cognitive levels, and closed-mindedness”. Journal of Research in Science Teaching, 30(7), 637–648. (1993).

[8] Roberts I F, Watts D S., “The teaching of thermodynamics at preuniversity level”. Phys. Educ.;11:277–284.

[9] Küçük*et al*. investigated how the Turkish students perceived energy and related concepts. (2005)

[10] Yuengyong, C.& Jones, A. N. “A comparison of Thailand and New Zealand students’ ideas about energy related to technological and societal issues”. International Journal of Science and Mathematics Education, 6, 293-311. (2008).

[11] TussatrinKruatong ,Sunan Sung-ong , Penchantr Singh and Alister Jones, “Thai High School Students’ Understanding of Heat and Thermodynamics”, Kasetsart University, (Soc. Sci) 27 : 321 - 330 (2006).

[12] Goldring, H., & Osborne, J. (1994). “Students’ difficulties with energy and related concepts”. Physics Education, 29(1), 26–32

[13] Kesidou S, Duit R., “Students’ conceptions of the second law of thermodynamics – an interpretive study”. J. Res. Sci.Teach. 1993; 30(1):85–106. [14] Gil-pe’rez, D., Vilches, A., Fernana’ndez, I.& Salinas, J. Technology as “‘applied science’: A serious misconception that reinforces distorted and impoverished views of science”. Science and Education 14:309– 3202005

[15]RU Sexl**,**ReindersDuit, “Understanding Energy as a conserved quantity”, Remarks on the European journal of Science education, Vol 3, Issue 3,