The Importance Of The Choice Of Text book In Studying And Teaching Thermodynamics

M.B. Awang , R.B. Mat
Faculty of Chemical and Natural Resources Engineering
Universiti Teknologi Malaysia
81310 Skudai, Malaysia

Abstract
While it is generally true for most science and engineering subjects that an appropriate textbook can immensely aid a student in achieving the objectives of the subject, the study of thermodynamics at our faculty is even more dependent on it. Our students often have little knowledge of the hardware given in the subject, English is now the language of instruction and there is little repetition of the subject matter in other subjects. Ideally, many books ought to be considered before choosing a text, but given the large amount of literature available, we had considered two books in our study that aimed to find a suitable text. While the authors preferred one book, more than 63 % of the students preferred the other book based on its simple English, sufficient description of the systems and clear explanations. About 15 % of the students preferred a book in Malaysian.

1. Introduction

In a typical engineering thermodynamics curriculum, the systems analysed are cycles consisting of several units. For example, refrigeration cycles have at least four units such as condenser, expander, pump and valve. Students do not necessarily have the knowledge of these units, other then the information given in their textbook. At the Faculty of Chemical and Natural Resources Engineering, University of Technology Malaysia, three problems related to the teaching of thermodynamics have been identified. Firstly, it is taught as one of the basic engineering subjects, which means that almost all of the subjects taken before thermodynamics were on science and mathematics. Therefore, knowledge of the hardware aspects of the systems depends on the individual student. Secondly, thermodynamics is now taught in English, which is the second language for most of the students. Words with implied meanings often need to be elaborated. Finally, students in the Faculty major in petroleum, chemical, gas, polymer and bioprocess engineering. Except for heat exchangers, there are no other subjects for the students to be exposed to power plants, heat pumps or power cycles.

Tools such as multimedia [1] and computer programmes [2] have been reported to greatly enhance the study and teaching of thermodynamics. However, working within our constraints, books and classroom instructions are the main methods of teaching.

There is no lack of literature on thermodynamics. Nevertheless, in our experience, the textbook is usually the same as was used by the lecturers in their schooldays. Several books have been used as text in the Faculty over the last twenty years. Lecturers have always been the party that made the choice. Currently several lecturers use one book and the other group uses another. In our research, we aimed to find out which of the two books was suitable for our students. Although ideally, many books should be considered, the large number of available thermodynamics' books gave us another problem of deciding how many and which ones. Our criteria for the suitability of a book were a) it must cover the syllabus b) the complexity or simplicity of problems given in the book must be on par with thermodynamics' books used by other universities [3], [4], [5], [6]. The two books satisfied the criteria.

1.1 Teaching Practices

Both authors depend extensively on the textbook for reading assignments, order of topics covered and problem solving. In addition, the style of questions used in tests and quizzes are similar to those in the book and therefore it can be construed that the standard of assessment is based on the book.

2. Design of the Questionnaires

The following factors were taken into account when the survey questions were formulated: The questions

1. either length or complexity, should not tax the students.
2. should cover comprehension, simple applications and simple deductive thinking.
3. should cover language aspects, technical knowledge and preparedness of the students before taking the subject

3. Methodology

Three set of questionnaire were given to the students as attached in the Appendix.

i) Questionnaire 1 was given to the student together with a photocopy of chapter from both textbooks (i.e. Properties of a Pure Substances). Students were asked to read and answer the multiple-choice questions within 50 minutes. No prior lecture was given on this topic. Students answered purely based on their reading.

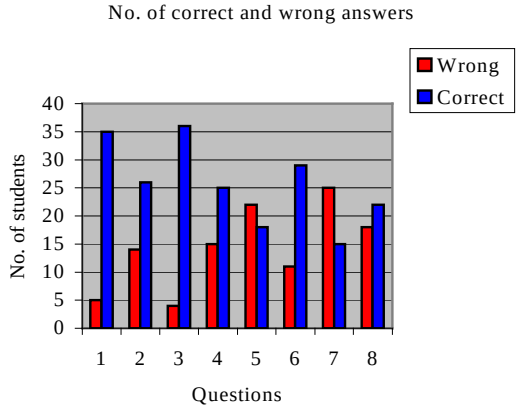
ii) Questionnaire 2 was given after three of 1-hour lecture in the same topic as in questionnaire 1. Students were given 15 minutes to answer the question.

iii) Questionnaire 3 was carried to find out about students opinion on textbook it self. Question related to the textbook English, illustration and content were asked.

4. Results and discussion

Forty students answered the first questionnaire. In that questionnaire, answers to problems one and two were expressedly written in the two books (S and C) and all were expected to get the correct answers. Yet five students were wrong for problem one and 14 were wrong for number two (Fig. 1). This is probably due to the 'background' factor. Most students who took science subjects would know that a pure substance has one component. But in problem two, the treatment of air as a pure component was new and peculiar to thermodynamics. Another possibility is that the students did not comprehend the explanation for treating air as a pure substance and therefore, the information was not applied.

Fig 1. Results of Questionnaire One



For problems three and four, a similar conclusion to the first part was made. Most people knew how to find the multiples of a unit quantity, in this case the volume of five kilograms. However, in question four, one needs to recognise the units of specific volume are just the reciprocal of density or knows the relationship. Again 15 of the students gave the wrong answer. Problems five to eight are deductive in nature and require some analysis. More than half of the students did not seem to know what saturation meant, even though book C had a section on it. In both books, the behaviour of water and steam were well described and it seemed to help the students in answering problem six. The critical point was not extensively covered in the books and it was not surprising that many could not answer the question. The responds to question eight was similar to those of two and four. While the answer was in the book, the concept was new to the students. From this questionnaire, the extensive treatment of the two-phase behaviour of water and steam allowed the majority of the students to answer problem six, indicating that for new concepts, a detailed description was needed. In the case of 'saturation', the application of an old concept to a new system i.e. blue liquid, could be confusing to the students. Both books had a chapter on unit conversions but were not given out in this exercise. The advantage of either book could not be determined at that stage. It would seem that lectures were still very necessary at that juncture.

The result of the second questionnaire is shown in Figure 2. Most of the students can answer the questions one to three and six, which are related to the phase diagram. Both textbooks and lecture were clearly explained on the phase diagram. Question three is again related to the pure substance. It is stated in the textbook that, air can be considered as a pure substance since it has same composition throughout, but in this question three, mixture of air and liquid air is not a pure substance. About 75% of the students answer it correctly.

To answer problems five and seven, students need to understand the concept of saturation. From the result of the second questionnaire, about 75 % of the students can answer it, which has improved compare to first questionnaire. This showed that lecture helped students understanding. Problem eight and nine were related the application of the concept learned. About 70% students can applied the concept that they have learned. Although considerable emphasis is placed on this topic, the importance of general concept is lost in many students. It has shown that many students (about 30%) had not developed an understanding of the

relative importance of the concepts and principles they had learned.

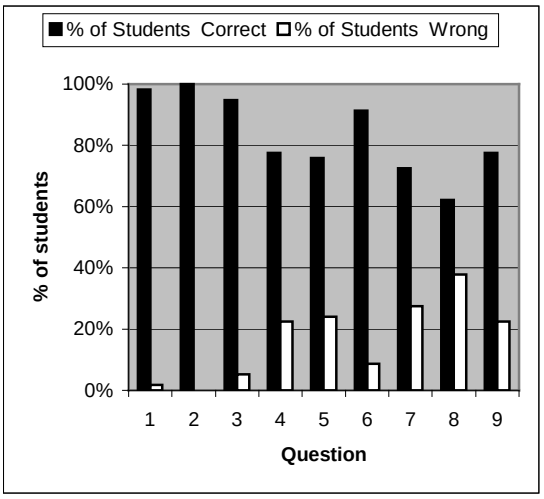


Fig 2. Results of Questionnaire Two

In term of textbook choice, a survey was carried out to compare those two textbooks, which are widely used in teaching thermodynamics [3], [4], [5], [6]. Figure 3, 4 and 5 illustrate the results of the survey. On the English language used, most students agree that textbook C used simple English and description as depicted in Figure 3.

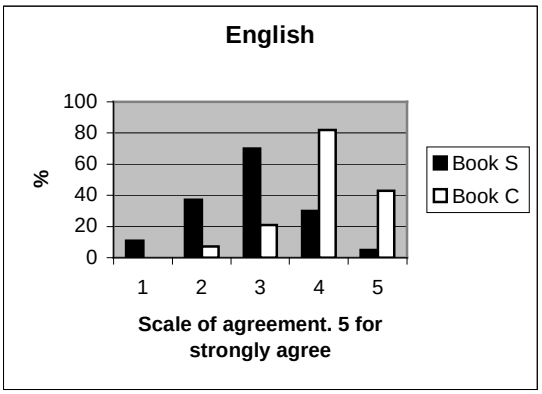


Figure 3: Students Response on the English Used in the Textbook.

Students also agree that textbook C gives sufficient description and illustration which help student reading as shown in Figure 4. The content of the book helps student in understanding the subject. Figure 5 shows that the content of textbooks are about the same, though text book C shows a little higher scale of agreement. The content refer to the topic covered, example given and problem.

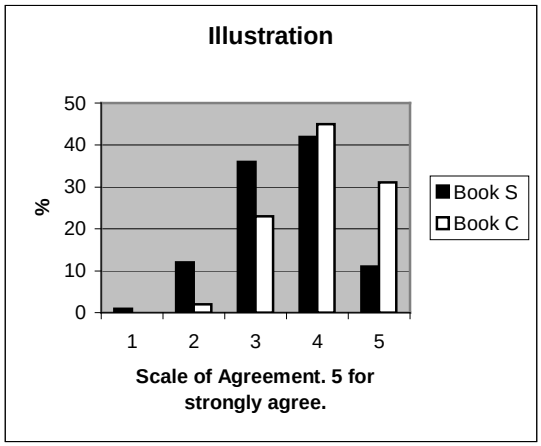


Figure 4: Student Response on the Illustration Depicted in the Textbook.

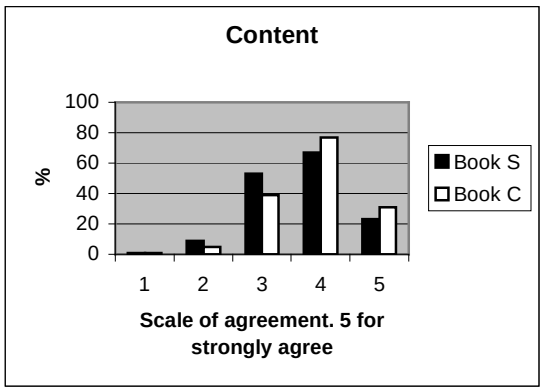


Figure 5: Students Response on the Content of Textbook.

Based on this survey, most students (63%) prefer textbook C, 22% prefer textbook which currently being used while 15% of them prefer textbook in Malay.

5. Conclusion

From the survey carried out, it can be concluded that

1. Reading textbook alone will not help student to solve applied problems. Although it help in solving basic or simple problem.
2. Explanation of the term or definition help student understanding.

3. Most students prefer a textbook which used simple English and good illustration even though the content is about the same.

References

1. G.M Reistad, R.A.Gaggioli, A.Bejan and G.Tsatsaronis, 'Thermodynamics and Energy Systems - Fundamentals, Education and Computer Aided Analysis', Proceedings of Winter Annual Meeting of the American Society of Mechanical Engineers, Dec 1-6 1991, Atlanta, GA, USA
2. G.W Lopez, 'Cutting computation time and mastering the underlying science of introductory thermodynamics', Proceedings of 2002 ASME International Mechanical Engineering Congress and Exposition, Nov 17-22 2002, New Orleans, LO, USA
3. www.berkeley.edu
4. www.stanford.edu
5. www.psu.edu
6. http://baklava.caltech.edu/me18/

Appendix

Questionnaire 1

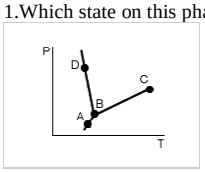
'The aim of this questionnaire is to help lecturers in estimating the students needs. You are to read both textbook to help you answer the questionnaire.

Pick one correct answer for each of the question:

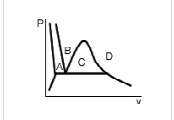
1) Substance A is made up of 100% methane gas and substance B is made up of 100% methane liquid.
   a. A is a pure substance and B is not a pure substance
   b. A is not a pure substance and B is a pure substance
   c. A is a pure substance and B is a pure substance
   d. A is not a pure substance and B is not a pure substance
2) Air is considered a pure substance in this book because
   a. It has only one component
   b. There is no phase change for the calculations using air
   c. There is phase change for the calculations using air
   d. It is in liquid phase and gas phase
3) The specific volume of air measured in the morning is 1.15 m^3/kg. What is the weight of 5 m^3 of air at that time?
   a. 4.348
   b. 0.4348
   c. 5.75
   d. 0.575
4) The specific volume of a substance X is 0.55 m3/kg. What is its density?
   a. 0.55
   b. 0.11
   c. 1.818
   d. 0.909
5) A few closed containers are described below. Which one is <u>not</u> in a saturated state?
   a. Contains a blue liquid
   b. Contains water with salt crystals at the bottom
   c. Contains liquid methane with bubbles on the walls
   d. Contains steam with droplets at the bottom
6) H_2O in a closed container at 100 ^oC and 101 kPa initially was all liquid with a few bubbles present. It was heated until all water vapourises except for a few droplets. The final temperature is 100^oC and the final pressure is 101.3 kPa. Which is true?
   a. The container was leaky and steam had escaped.
   b. The container was initially saturated water and finally saturated steam.
   c. The container was initially unsaturated water and finally superheated steam
   d. The container was initially supersaturated water and finally saturated steam
7) A substance is at its critical state when the liquid and gas phase have the same properties, therefore all of the following are true except for
   a. The specific volumes of the gas and liquid phases are equal
   b. There is one phase only
   c. There are two phases
   d. The gas phase is as dense as the liquid phase
8) Pick the correct answer for a triple point
   a. The triple point of water is higher than its critical point
   b. The triple point of some substances may have only two phases
   c. The word triple refers to the presence of 3 components
   d. The triple point of water consists of water, steam and ice.

Questionnaire 2.

1.Which state on this phase diagram is the critical state?



2. In which region of the property diagram below are liquid-vapor mixture states located?



3. The temperature of saturated liquid and saturated vapor are _____ at the same pressure.

a) equal b) not equal c) Can't tell

4. Which of the following is not a pure substance

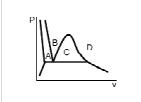
a) **Water vapor** / **Liquid water**

b) **Air** / **Liquid air**

c) **Iced water**

5. Water boils at its saturation temperature.
a) True b) False

6. At atmospheric pressure, water boil at 100°C. If you increase the temperature of water to 130°C while maintaining at constant pressure, in which region of this final state is located?



7. At 1 atm, water boil at 100°C, If the pressure of the water is at 0.8 atm while the temperature is still 100°C, The state of the water is
a) Saturated liquid b) Saturated vapor c) Compressed liquid
d) Superheated vapor

8. We wish to compare the heights that the piston rises to when the valve is opened and 1)1 mole of oxygen or 2) 1 mole of helium was in tank A. Assume that the tank initial condition is: temperature is 25°C, pressure is 2 atm, the tank volume is V_a and the area of cylinder B is A_b. Pick one answer

a) the height for oxygen is higher because its molecular weight is lower than helium
b) the height for oxygen is higher because it is pure substance
c) the heights are the same because the gases are ideal
d) the heights are the same because the gases have different reactivities

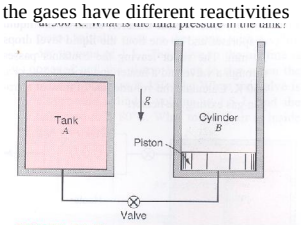


FIGURE P3.99

9. You have a tank 1 m^3 and you have to fill it with R12. If the temperature must remain at 30°C and the pressure cannot exceed 300kPa. How much R12 can you put in?
a)13.5 kg
b) 10 kg
c) .100023 kg
d) 0.078 kg

Questionnaire 3

Make you comment using scale 1 to 5. 1 is for strongly disagree while 5 is for strongly agree

	Book S	Book C
The text book uses simple English	~~1 2 3 4 5~~	~~1 2 3 4 5~~
The sentences are short and clear	~~1 2 3 4 5~~	~~1 2 3 4 5~~
Description of the devices are sufficient (ex: Pump, compressor, turbine etc)	~~1 2 3 4 5~~	~~1 2 3 4 5~~
The style of writing is not boring nor dull	~~1 2 3 4 5~~	~~1 2 3 4 5~~
The topic are arranged in sequence that help my understanding	~~1 2 3 4 5~~	~~1 2 3 4 5~~
Diagram and illustration is sufficient for clarity	~~1 2 3 4 5~~	~~1 2 3 4 5~~
Problems are acceptable standard- not too easy or not too difficult	~~1 2 3 4 5~~	~~1 2 3 4 5~~
Example given helped in understanding the subject matter	~~1 2 3 4 5~~	~~1 2 3 4 5~~
With this text book, less time is needed for understanding the lecture	~~1 2 3 4 5~~	~~1 2 3 4 5~~
Does class lecture make text book reading easy to understand	~~1 2 3 4 5~~	~~1 2 3 4 5~~
As a student, which book do you prefer (choose one)		
a) Book S	~~1 2 3 4 5~~	~~1 2 3 4 5~~
b) Book C	~~1 2 3 4 5~~	~~1 2 3 4 5~~
c) Other book in English	~~1 2 3 4 5~~	~~1 2 3 4 5~~
d) Other book in Malay	~~1 2 3 4 5~~	~~1 2 3 4 5~~

The Importance of Reading Books. Reading is important, and its value canâ€™t be overestimated when it comes to both adults and children. It might easily help you develop your own way of thinking and point of view; it gives you endless knowledge on various topics (depending on what you like and choose) and broadens your horizons â€“ all while keeping your mind active and you entertained.Â Not to mention that many books and other texts can truly lift your spirit, improve your mood, or even make you laugh.Â Books offer a moment of peace in an otherwise busy world. Among all the other activities you fill your day with, reading can certainly make a difference and help you feel a little better. Thermodynamics is one of the few engineering courses that I would say are more conceptual than computaional. I can not emphasise how important it is to fully understand thermodynamic terminology and process. Once you understand those any problems ...Â Then get a good book on thermodynamics and study. You will need to do or view basic thermodynamic experiments to get a good feel for what is going on. There are also some very good virtual experiments (thermodynamic simulations) available on the web.Â My first experience teaching it to undergraduates was a disaster. None of them really got it, although they sort of slipped through. It made me think very hard about how to teach it better and I think I made some progress in my later classes. PDF | Abstract This study aims to investigate the applicability of context- and problembased learning (C-PBL) into teaching thermodynamics and to | Find, read and cite all the research you need on ResearchGate.Â based learning (C-PBL) into teaching thermodynamics and to examine its influence on. the studentsâ€™achievements in chemistry, retention of knowledge, studentsâ€™attitudes, motivation and interest towards chemistry. The embedded mixed method design was.Â which the studentsâ€™understanding of the subject may be applied as well as the importance of. problem solving skills to professional^(Williams and McKenzie 2013). Therefore, as argued by.