



STUDENTS, ASSESSMENT THROUGH OPEN-BOOK CONCEPT FOR FINAL EXAM

Muhammad Fairuz Abdul Jalal[†]

Centre for Advanced Mechatronics and Robotic, Universiti Tenaga Nasional, Selangor

Siti Sarah Ain Fadhil

Centre for Advanced Computational Engineering, Universiti Tenaga Nasional, Selangor

Hasril Hasini

Centre for Advanced Computational Engineering, Universiti Tenaga Nasional, Selangor

ABSTRACT

Starting from Semester 2 2011/2012, open-book final examination has been applied to a third year mechanical engineering subjects; Machine Design (MEMB 333). The student, who are enrolled in this subject, are exposed to critical thinking in designing and evaluating the components. In this paper, the performance of 84 students from 3 sections in answering static and fatigue failure theories by having open-book final and close-book mid semester examination will be presented. The study will focus on the influence of distraction under open-book condition and the evaluation on their overall performance. It is understood that students perform poorly, tended to replicate the solution from textbook.

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1. INTRODUCTION

The Machine Design course (MEMB 333) is enrolled by third year mechanical engineering students in fifth semester at Universiti Tenaga Nasional, Malaysia. This course is focused on the fundamentals of overall machine design, component selection, analysis and evaluation according to predetermined factor of safety. By the end of the course, the students should able to understand static and fatigue failure theory and able to select and evaluate the usage of important machine components for instance gears, shafts, keys, couplings, fasteners, springs, bearings, brakes, clutches etc. Thus, the class tends to be taught in a very content-intensive manner – full of definitions,

[†] Corresponding author

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interrelated relations for calculating component behaviours and component failure in accordance to standards.

The students, who are enrolled in this subject, are often exposed to the uncertainty due to the iterative nature of design, full of assumption and decision, required experience for design conceptualization and need sufficient understanding in the prerequisite subjects; Mechanics of Material (MEMB 243), Manufacturing Processes (MEFB 213) and Theory of Machines (MEMB 263). The students' performance is captured via Quiz/Assignments, Case Study Presentation, Group Project, Midterm test and Final Exam. The open-book concept is applied only to the final examination start from Semester 2 2011/2012 (Abdul Jalal *et al.*, 2012).

The effectiveness of open-book or close-book assessment to measure student performance is open for debate. In general, open-book examination reduces student anxiety (Theophilides and Dionysiou, 1996), push student to read more and focus on understanding concepts and principles. However, Francis (1982), Ioannidou (1997) and Theophilides and Dionysiou (1996) mentioned that the marks attained by students who performed open-book examination were lower than those obtained by traditional manner possibly due to the higher level of difficulty and complexity of the questions, thus required higher order of critical thinking.

In addition, Vanderburgh (2005) indicated that the open-book exam for undergraduate physiology appeared to be beneficial for and received the strong endorsement by students as it promoted a higher level of critical thinking and improved their writing skills albeit exerting extra load and time consuming for preparing the questions and grading the assignment.

According to Theophilides and Koutselini (2000), the students prepared themselves for the open-book examination by referring to various sources and digested the gathered information. Thus, they had better understanding in the subject matter and were able to answer the question creatively. On the contrary, students, who prepared for a closed book examination, tended to do last minute revision and focused only on the given assignment or tutorial question and memorized them.

Open-book examination is not always good as it gives false alarm and hope to the student as they assume all of the questions can be solved by referring to the textbook during the examination period. The survey conducted by Soh-Loi and TEO (1999) at the Nanyang Technological University in Singapore showed that almost two-thirds of the students preferred open-book examinations compared to closed book examinations with intention to have less time for preparation, require less memorization on the subject matter and left more room for logical thinking. Furthermore, research conducted by Therriault *et al.* (2011) showed that students had been distracted by the textbook during the open-book exam. Students with the lowest scores inclined to read the text for information and hoped for the similar examples to guide them for problem solving. On the contrary, students with the highest scores were not textbook reliance and used it to confirm their knowledge. Heijne-Penninga *et al.* (2008) stated that medical students felt more confident and motivated when preparing for closed-book tests compared to open-book exams. The students, who prepared for the open-book exam, had the tendency to memorize and recalled knowledge, thus stimulated a deeper learning approach more than open-book tests.

In this paper, the performance of 84 students from 3 sections in answering static and fatigue failure theory by having open-book final examination and close-book mid semester will be

evaluated. The mid semester and final examinations were conducted in week 7 and 15 accordingly and took place in exam hall environment. The study focused on the influence of distraction under open-book condition by having question similar to the example in textbook and the student achievement in solving questions by having open-book and close-book alternatives.

2. RESULT AND DISCUSSION

The lecture on static and fatigue failure theories was covered in the first 6 weeks. Supposedly, the students had been well prepared to the subject for the mid semester and final examination. The evaluation on open-book assessment concept of 84 students from 3 sections was performed on two questions in the final examination in Semester 2 2012/2013. For evaluation purposes, the marks of 84 students from 3 sections were evaluated using the reference scale as shown in Table 1.

Table-1. The student performance scale

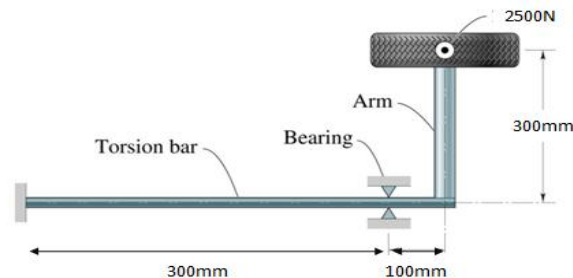
Student marks SM (%)	Student performance
$SM > 75$	Good
$50 \leq SM < 75$	Sufficient
$25 \leq SM < 50$	Poor
$SM < 25$	Very Poor

2.1. Open Book with Distraction

Therriault *et al.* (2011) reported that in open-book assessment concept, the students were exposed to distraction by the textbook during the examination. The students tended to rely on the textbook and had been distracted by the examples in textbook which were similar to the given exam questions. The influence of distraction in open-book alternative was tested via the question below. The question for open-book final examination was formulated in such a way that it was similar to the example in the course textbook by (Norton, 1996).

Figure 1 shows a suspension system of a car. The spring motion is provided by a torsion bar fastened to the arm on which the wheel is mounted. The torsion bar is made of SAE/AISI 1050 quench and temper @ 400°F carbon steel. The torque in the torsion bar is created by the 2500N force acting on the wheel from the ground through a 300mm long lever arm. Due to space limitations, the bearing holding the torsion bar is situated 100mm from the wheel shaft. Given that and the static safety factor in the torsion bar at the bearing is 2.5, find the diameter of the torsion bar according to Distortion Energy Theory (Caceres-Valencia, 2008).

Figure-1. Question 1- open-book final exam (Caceres-Valencia, 2008)



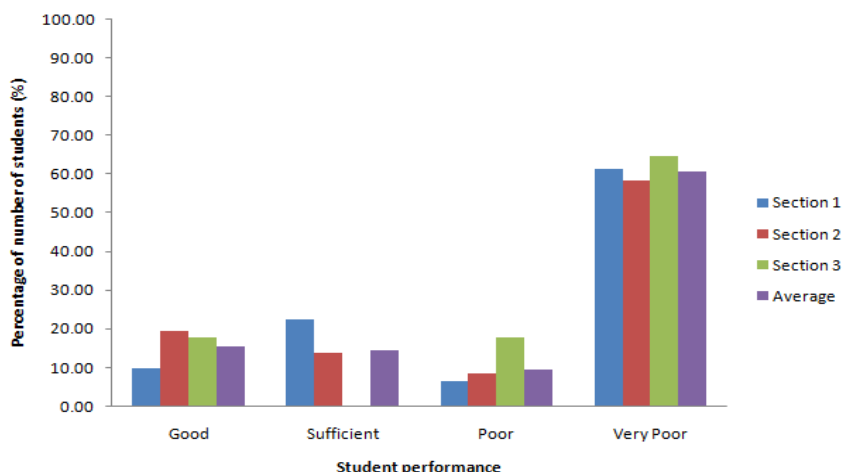
In this question, students were required to determine the diameter of the torsion bar with a given factor of safety. However, the example in the textbook guided the students to find the factor of safety with a given diameter of the torsion bar. The equation for factor of safety (FS) and von-Mises stress (σ_{vm}) is described in equation 1 and 2 accordingly whereas S_y is yield strength of the ductile material. The diameter of the torsion bar parameter is implicitly lies in von-Mises stress (σ_{vm}) equation.

$$FS = \frac{S_y}{\sigma_{vm}} \quad (1)$$

$$\sigma_{vm} = \sqrt{(\sigma_x)^2 + (\sigma_y)^2 - (\sigma_x \sigma_y) + 3(\tau_{xy})^2} \quad (2)$$

The students' performance for 84 students from 3 sections in answering question 1 is shown in Figure 2. On average, only 15.5% and 14.3% of students were able to respond to the question in good and sufficient manner accordingly. The rest inclined to reproduce the exact solution approach as in textbook and 9.5% were able to solve it halfway. The students blindly assumed the diameter of the torsion bar and wrongly solved for factor of safety. The students' behaviour during the examination has also been studied via observation. In general, the students with lower mark were not well prepared in strategizing the answering technique. They were prone to distraction by similar solution in the text, required more time for reading and possibly took the simplest route by replicating the exact solution from the text without any critical interpretation. The same conclusion had been drawn by Carrier (2003) and Gray (1994) and Therriault *et al.* (2011).

Figure-2. Percentage of number of student vs. student performance in answering question 1

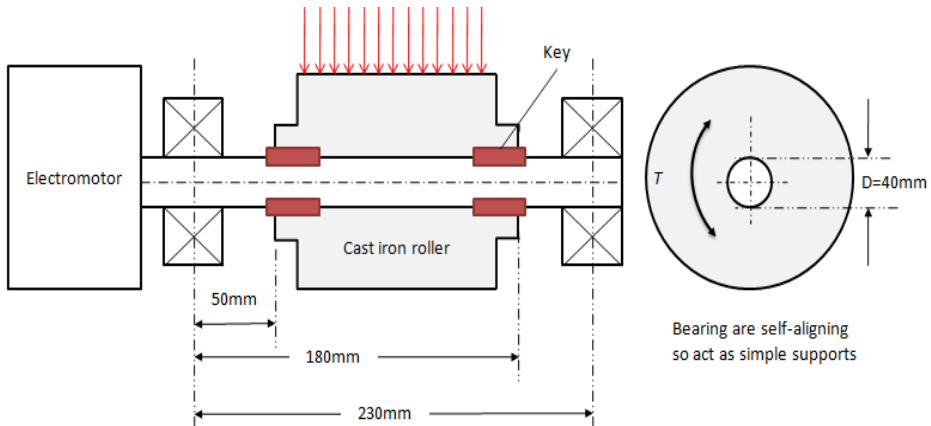


2.2. Open-Book vs. Close-Book Assessment

Question 2 was formulated to address fatigue failure theory in the open-book final examination. The similar question on fatigue failure theory was also tested in the close-book mid semester test as illustrated in question 3. The overall performance in answering open-book and close-book alternatives were evaluated via the questions below:

Figure 2 shows an electromotor connected to a cast iron roller via a shaft. The shaft is subjected to a time-varying torque varies from a maximum torque of 2000 Nm and a minimum torque of 0.0 Nm. Determine the size of key necessary to give factor of safety of at least 2 against shear and bearing failure for infinite life design. Given that the shaft is made of SAE/AISI 1060 hot rolled carbon steel and the key is made of SAE/AISI 1050 cold rolled carbon steel. Assume shaft diameter is 40mm, the finishing of the key is machined, reliability is 99.99% and the key is in 1000 °F working environment (Norton, 1996).

Figure- 3. Question 2 – open-book final exam (Norton, 1996)

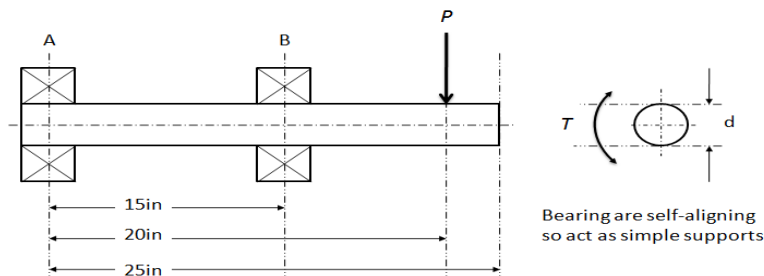


Question 3 in close-book mid semester examination:

Question 2 was Figure 4 show a shaft in an electromotor which is supported by two bearings (at A and B). A constant magnitude transverse load $P=1000$ lbf is applied as the shaft rotates subject to a time varying torque, $T_{min}=100$ lbf.in and $T_{max}=2100$ lbf.in. Knowing that, the shaft made of AISI 1040 quench and tempered at 800 °F carbon steel, find the diameter of shaft required to obtain a safety factor of 2 in fatigue loading condition for infinite life regime. Draw the moment diagram of the shaft. Assume no stress concentration is present, the finishing of the shaft is machined, reliability is 99.99% and the shaft is in 1000 °F working condition. Also assume all stress concentration factors equal to unity.

$$F.S = \frac{SeSut}{\sigma_{vm,a}Sut + \sigma_{vm,m}Se} \tag{3}$$

Figure-4. Question 3 – close-book mid semester exam (Norton, 1996)



The students' performances for 84 students from 3 sections in answering question 2 in open-book final exam and question 3 in close-book mid semester test are shown in Figure 5 and 6 respectively. The results of the open-book assesment (Figure 5) were depressing, as only 6.0% and 28.6% of the students actually attempted and were able to answer the question with good or sufficient level accordingly, while the rest unable to solve the questions. On the contrary, the students' performance in close-book mid semester is illustrated in Figure 6; 26.2% of the students were able to answer the question properly and 20.2% in sufficient manner. The students were more confident and performed better in close-book compared to open-book conditions.

Figure-5. Percentage of number of student vs. student performance in answering question 2

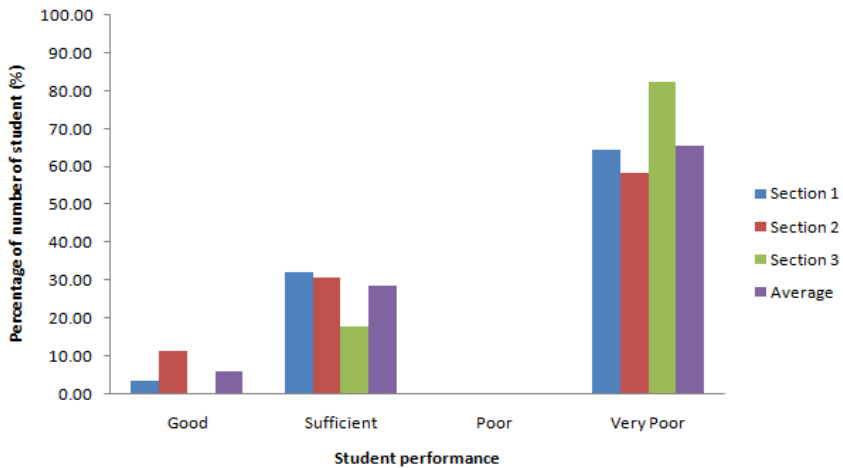
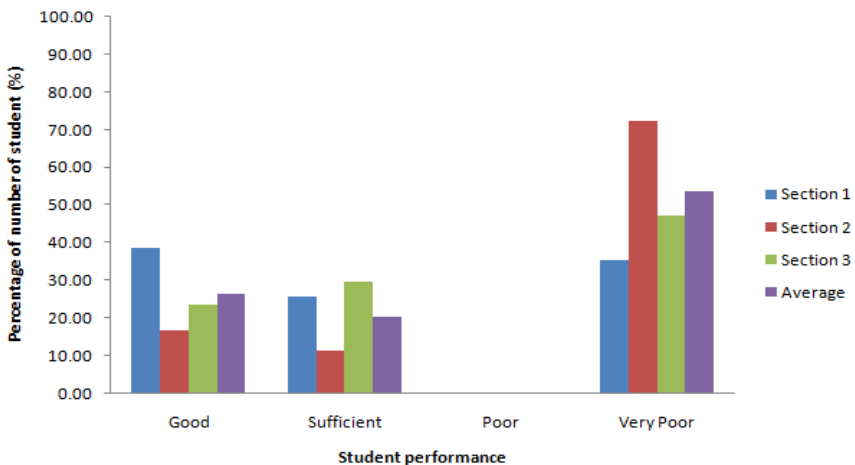


Figure-6. Percentage of number of student vs. student performance in answering question 3



Question 1 and 2 for final examination were formulated to test student understanding in static and fatigue failure theory. In general, the students with lower marks were not able to differentiate the solution approach between both failure theories. This further explained that critical thinking and approach in collecting, analyzing, organizing and critically evaluating the given information into

design question were still deficient among the students. Supposedly, the students were able to answer question 2 as the method is quite similar for question 1 albeit extra working steps are needed to find mean and alternate value of the von-Mises stress as well as strength of the material in infinite life regime. The students with lower marks were unable to systematically answer the question and applied wrong equations or tried to imitate the example in textbook even though not relevant to the question at all.

The research findings obtained from the observations and students' grade showed a cautionary note with the advantages of open-book assessment method listed by [Theophilides and Dionysiou \(1996\)](#). Based on student performance in Figure 5 and 6, it can be concluded that the students behaved differently to the close- and open-book exam. They performed better in traditional assessment compared to open-book alternative. Possibly, the students were not well prepared for open-book concept, did less preparation and had false confidence as they assumed the all answers, techniques and methods are provided in text. The similar students' perception had been recorded via interview by [Eilertsen and Valdermo \(2000\)](#) and survey by [Soh-Loi and TEO \(1999\)](#).

In the reality, the students are lacked of awareness regarding the reality of open-book alternative. In open-book assessment, critical thinking is vital instrument to strategize their solution approach to solve the question in a permitted duration. The questions are not constructed in a straight forward manner. In this matter, students must plan beforehand, think analytically and strategize the working plan thus resulting proper time management. All these must be practiced by the students start from the beginning of the course.

[Therriault et al. \(2011\)](#) stated that there was strong correlation between times spent on hunting through the textbook during open-book examination to the student achievement. It was noticeable that the students with lower marks were stressed-out and seemed to "study during the assessment" instead of answering the questions. Our finding indicated that student performance negatively associated with their reliance upon the textbook.

As mentioned, the main objective of open-book assessment is to culture critical thinking and to educate the students in effective use of resources for professional engineering practice. Therefore, the real engineering problems need to be introduced to the student in "class" and "exam hall" at different difficulty and complexity level in order to align the course for higher level of critical and creative thinking strategy. The student must be able to develop his/her own reasonable assumption and apply the acquired knowledge to the new ill defined problem rather than recalling and memorizing the information or rigidly reproduce the standard solution approach. The lecturers must indeed have deep understanding in subject matter in order to develop comprehensive and compatible open ended assignments and assessments but yet having certain boundary to avoid any trap of unnecessary design iteration.

The conducive environment for teaching and learning activity in the lecture and tutorial session is considered uttermost important to initiate active participation in lecture, encourage independent learning and indirectly culture deep thinking. The students can only do well in the open - book assessment if they are well prepared and have a deep understanding on the current and prerequisite subjects. Therefore, intensive and rigorous assessment, which address higher level of Bloom's Taxonomy in assignments, quizzes and test should be implemented at the beginning of the the course so that the student will restrain themselves from the relax zone due to false confidence of

having “everything” in textbook, be mindful and efficient in using resources with minimal distraction.

3. CONCLUSION

The effectiveness of open-book and close-book examination is open for debate as both alternatives offer various advantages and disadvantages in stimulating deeper understanding in subject matter. Our study showed that the students with lower marks were prone to distraction by similar solution in the text, consumed more time for reading and tried to replicate the exact solution from the text without any critical interpretation. In addition, the overall students' performances were negatively associated with textbook dependency during the open-book examination. The similar findings were also reported by Carrier (2003) and Gray (1994) and Therriault *et al.* (2011). In our case, the students performed better in traditional assessment compared to open-book alternative. Possibly, the students, who were preparing for open-book final examination, had false confidence as they assumed all the required references were accessible during the examination and did less preparation for the examination. The similar students' perception had been recorded by Eilertsen and Valdermo (2000) and Soh-Loi and TEO (1999).

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