TRANSNAV International Journal on Marine Navigation and Safety of Sea Transportation
Volume 2
Number 3
September 2008

Reform of Technical Subject Examination with Multiple Choice – Essay Writing Exam Forms

Ngo Thien Hoa
Vietnam Maritime University, Vietnam

ABSTRACT: For ages, oral and essay writing exams have been used for evaluating the knowledge on technical subjects given to the students at Vietnam Maritime University (VIMARU) and other universities in Vietnam as well. These two examination forms showed a lot of weak points such as limited exam content, no objectiveness and big consumption of time in evaluation. It is the time a reform needed to be done.
Reform of technical subject examination with multiple choice- essay writing exam forms is presented in this research paper. Multiple choice exams have already widely been applied to the subjects in the fields as economics, social sciences and foreign languages, etc, but rather humble to technical ones; because, using only single, multiple choice exam forms for evaluating the students' knowledge on such a subject is not quite reliable or adequate. The situation will be improved with the examination reform. It was proved by carrying out experiments at VIMARU from year 2003 up to now.
In this paper, the methods of preparation of multiple choice-essay writing combined exam questionnaires, especially, multiple choice questionnaires of problems, and the organization of the combined exams are also studied and presented.

1 REQUIREMENTS AND OBJECTIVES OF AN EXAMINATION REFORM AT VIMARU

Usually, oral and essay writing exams are used for evaluating the knowledge on learning subjects, especially, technical ones which given to the students at VIMARU as well as other universities and colleges in Vietnam. With time, these two forms of exams seem to be unsuitable.

Quite precisely, oral exams allow evaluating the level of learning of each examinee about a whole subject; nevertheless, they also have a lot of limitations. First, due to examiners' direct interference, the objectiveness in giving marks is not ensured. Second, it is not suitable to a big number of examinees; because it is time-consuming and tiresome. Therefore, the oral form has hardly been applied to the midterm or final exams of all technical subjects with the number of examinees large and increasing every year like of VIMARU.

And quite reliably, traditional essay writing exam forms can be used for evaluating the examinees' knowledge on a learning subject, and now, are widely applied to almost exams at VIMARU, but, beside some advantages as time spent for an exam is regulated and controlled and it is suitable for a huge number of examinees, they showed rather many disadvantages. One, the testing content in each exam questionnaire set which consists of some essay questions is rather narrow; it cannot cover the whole subject; because of exam time limit. Two, marking exam papers needs much time and work. Three, owing to the evaluating process not free from examiners' subjectivity, exam results are not full objective; (the figure of students' petitions about their exam results certified it). And four, it is

difficult to automate the process of marking exam papers.

At VIMARU and other schools as well, multiple choice exams have just been used for the subjects as foreign languages, but others, especially, technical ones; because, using only single multiple choice exam forms for evaluating the students' knowledge on such a subject is not quite reliable or adequate. Although multiple choice exams have a lot of strong points as it is easy to fully automate the process of marking exam papers; simple to ensure the objectiveness of the exam results and possible to test the whole content of a subject in a quite short exam time, they also have some radical weak points as it is impossible to get a really precise evaluation result; because of probability in choosing right answer options to exam questions and difficult to test the examinees' creativity and ability of self solving posed problems or profundity of understanding and applying the theory which they have learnt. In addition, the preparation of exam questionnaires requires a lot of work and time.

To improve the evaluation of examinees' knowledge on learning technical subjects, the first time, in VIMARU, a reform of examination has been carrying out with a combination of multiple choice and essay writing, of which the highlight is that the multiple choice of problems were applied to final exams. The reform aimed at making use of all advantages of both the two exam forms; namely, to increase the reliability of exam results through intensifying testing contents at unchanged limited exam time and improving the objectiveness in evaluation, reduce learning by rate, and decrease the time and work spent for marking exam papers.

2 EXAMINATION REFORM WITH COMBINATION OF MULTIPLE CHOICE (MC) AND ESSAY WRITING (EW)

The most difficult matters of the reform are how to prepare the exam questionnaires for the multiple choice component, especially, multiple choice questions for the problem parts and to combine the two components: multiple choice and essay writing, so that they will be reliable and meet the requirements of technical subject final exams. These matters were hard studied, tried out, amended, adjusted and finally, well solved through successive exam experiments which are presented hereafter.

2.1 *Exam experiments*

Since year 2003, successive experiments have been done on the final exams of a technical subject named Mechanics of Machines which has learning credits of 4.

The percentage of the MC - EW components of the combination was changed from 30% MC - 70% EW, 40% MC - 60% EW to 50% MC - 50% EW.

Also, the testing contents were different, with the spotlight application of multiple choice of problems of a technical subject to final exams, as below:

- 30% MC theory - 70% EW (30% theory + 40% problem)
- 40% MC problem - 60% EW theory
- 50% MC theory - 50% EW problem
- 50% MC problem - 50% EW theory

And four data were surveyed:

% subject content tested in an exam questionnaire set (%STC)

Exam result (ER): % very good (%VG), % good (%G), % average (%A), and total % pass (% P); (%P = % VG + % + %A)

Time spent for marking an exam paper (T/EP).

Figure of petitions about exam results in percentage (% PR).

2.2 *Experiment results*

The data gained from the experiments in comparison with those from a couple of years before are shown in table 1 below:

Table 1

No	Academic year	% MC - % EW in a combnd exam.	%SCT	Exam. time (min)	Number of examinees	ER *% VG * % G *% A *% P	T/EP (min)	% PR
01	2001-2002	0%MC-100 % EW	35	90	223	5.5 % VG 26.7 % G 40.3 % A 72.5 % P	17- 20	6.17
02	2002-2003	0% MC-100% EW	35	90	328	5.9 % VG 25.4 % G 45.1 % A 76.4 % p	17 - 20	7.0
03	2003-2004	30% MC-70% EW	55	90	434	3.1 % VG 30.3 % G 41.6 % A 75 % P	13 - 15	4.25
04	2004-2005	40% MC-60% EW	70	90	511	2.7 % VG 31.5 % G	9 - 11	3.05

						40.1 % A 74.3 % P		
05	2005-2006	50% MC-50% EW	80	90	507	2.1 % VG 34.1 % G 38.7 % A 74.9 % P	6 - 8	1.68

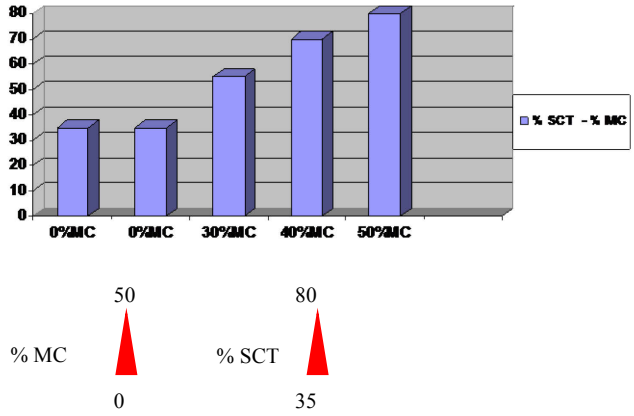


Fig. 1. % SGT - % MC

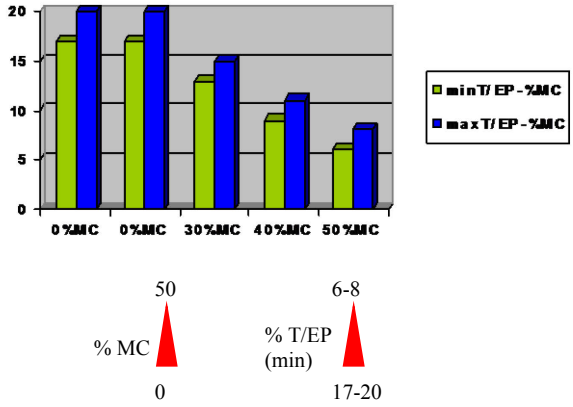


Fig. 2. T/EP - % MC

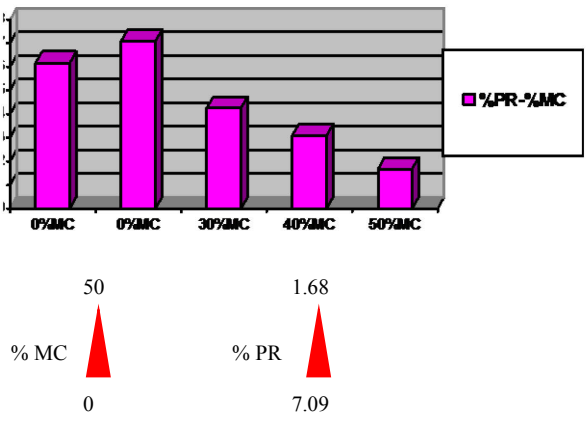


Fig. 3. % PR - % MC

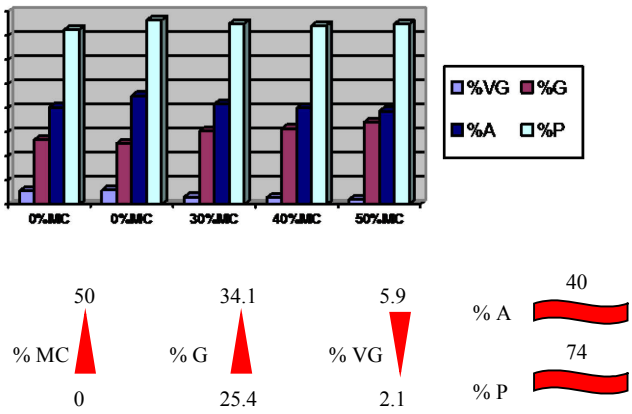


Fig. 4. % ER - %MC

2.3 *Assessment of experimental exams*

The data collected from the successive experiments on the final exams of Mechanics of Machines verify the better of multiple choice-essay writing combined exams. These forms of exams allow making use of all the advantages and by the same time, reducing the disadvantages of the two singles. Combined exams are much less time-consuming and much less tiresome; because of the remarkably shorter time and less work spent for marking exam papers (with the help of answer keys for the MC component, mean time spent formarking an exam paper with 50% MC - 50% EW is about a third of the time spent for that with 0% MC - 100% EW). Also, the exam results are more objective; certified by the figure of examinees' petitions decreased sharply (from 7.09% with 0%MC - 100% EW to 1.68% with 50% MC - 50% EW). Furthermore, the reliability of the reformed exams is visibly improved; shown through the much larger subject content examined in an unchanged limited exam time (from 35% with 0%MC - 100% EW to 80% with 50% MC - 50% EW), and exam results with % P vibrated lightly (about values of 74 %). % G increased continuously (from 26.7% G with 0% MC - 100% EW to 34.1% with 50% MC - 50% EW). % VG decreased noticeably with larger % MC (from 5.9% VG with 0% MC - 100% EW to 2.1% with 50% MC - 50% EW); this can be explained by the difficulty and testing subject content increased significantly with the raise of %MC (therefore only few really outstanding students who well master the whole subject, can do excellently and have the very good marks). Once more, it verifies the better reliability of the combined exam forms and the reduction of learning by rate.

Through the successive experiments, the exams combined 50% MC & 50% EW give the most optimal option. With the data of %SCT, %ER, T/EP and %PR, the combination ensures the optimum for

the examination reform. More than 50% MC in a combined exam is not introduced to the technical subject; because the probability can make the exam results less truthful and other standards and skills as profundity of self - presentation of the knowledge, self - ability and self - creativity in applying the theory to solving the problems, etc, are insufficiently tested.

3 QUESTIONNAIRE PREPARATION FOR MC – EW COMBINED EXAMS

As mentioned before, the MC-EW combined exam questions play a decisive role in assessing the reliability of exam results. Therefore, they ought to be thoroughly prepared.

3.1 *Questionnaire preparation for essay writing component*

The questions for the EW component are essay questions. They are unchanged in comparison with those of the traditional single essay writing exams. For them, the most significant is how to join the MC questions to create well combined exam questionnaire sets which satisfy the requirements of an exam.

3.2 *Questionnaire preparation for MC component*

3.2.1 *Testing content*

3.2.1.1 Theory part

With own specific characteristics, the MC exam questions for the theory part of a technical subject are aimed at testing the examinees' knowledge on the following matters:

Precise understanding and good memory for the concepts, definitions, theorems, principles, classifications, characteristics, uses, applications and so on.

Ability of logical analysis, synthesis and inference for quick selection of the right answer option for a formula, diagram, graph, design approach, and etc.

3.2.1.2 Problem part

Also, with own specific characteristics, the MC exam questions for the problem part of a technical subject are prepared for testing the examinees' skills on the following matters:

Accurate understanding and applying the theory of the subject to solve a technical problem, but not the skill of calculating precise results.

Ability of logical analysis, synthesis and inference for quick selection of the right approach option for solving a type of technical problems.

3.2.2 *Types of MC exam questions*

The types of MC exam questions used for building up the questionnaires of the MC component can be different as Most Accurate, True/False, Extension and Odd One Out, and etc. The larger the number of the answer options in each question is the more reliable the exam results are. Nevertheless, the experiments showed that the suitable number of the options is not less than 3, and not more than 7 for technical subject exams in a rather short limited exam time; e.g., 90 minutes as set for the final exam of Mechanics of Machines. Hereafter, some types of MC exam questions applied to the subject are presented.

3.2.2.1 The MC questions for the theory part

– True/False

Questions require selecting either the True (Correct) or the False (Incorrect); e.g.:

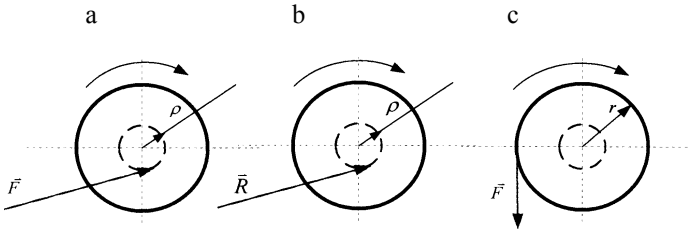


Fig. 5.

1 T/F: At rotating surfaces, the friction ($\vec{F}$) is tangential to a circle of radius ρ termed the friction circle. The point of tangency is such that the moment of the force about the centre opposes the relative rotation, Fig. 5a.
2 T/F: At rotating surfaces, the reaction ($\vec{R}$) is tangential to a circle of radius ρ termed the friction circle. The point of tangency is such that the moment of the force about the centre opposes the relative rotation, Fig. 5b.
3 T/F: At rotating surfaces, the friction ($\vec{F}$) is tangential to the rotating surface circle of radius r. The point of tangency is such that the moment of the force about the centre opposes the relative rotation, Fig. 5c.

– Odd One Out

Odd One Out questions require choosing which answer option is the "odd one out"; e.g.:

Which of the following options is the "odd one out " answer for defining a machine:

1 A machine is a combination of resistant bodies for doing work.
2 A machine is an arrangement of rigid parts for doing work.
3 A machine is a combination of mechanisms for doing work.
4 A machine is a combination of links for doing work.

– Extension

Extension questions require selecting the right option for completing a principle, definition, theorem, formula, approach and etc; e.g.:

A kinematical chain is called a mechanism when:

1 the flame link is specified.
2 there is one fixed or stationary link.
3 there is one driving link.
4 the driven links are specified.
5 its motion is known.
6 its locus is specified.

– Most Accurate

Most accurate questions require choosing which answer option is the best; e. g.:

Which of the following options is the best description of the inertia force ($\vec{P}_I$), on a link AB having mass m and moment of inertia I about G; the centre of gravity, with linear acceleration $\vec{a}_G$, and rotating with an angular acceleration $\vec{\varepsilon}$ as shown in Fig. 6.

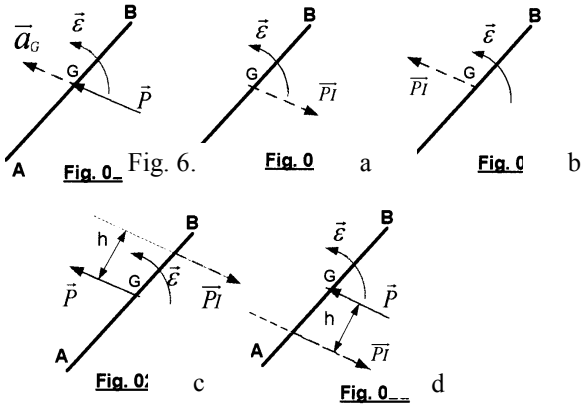


Fig. 6.

a. $\vec{P}_I$ is equal and opposite to $\vec{P}$ ($\vec{P} = m \cdot \vec{a}_G$), as shown dotted in Fig. 6a.
b. $\vec{P}_I$ is equal to $\vec{P}$ ($\vec{P} = m \cdot \vec{a}_G$), as shown dotted in Fig. 6b.
c. $\vec{P}_I$ is equal and opposite to $\vec{P}$ ($\vec{P} = m \cdot \vec{a}_G$), and at distance h (h = I. ε / m $\vec{a}_G$), as shown dotted in Fig. 6c.
d. $\vec{P}_I$ is equal and opposite to $\vec{P}$ ($\vec{P} = m \cdot \vec{a}_G$), and at distance h (h = I. ε / $m \cdot \vec{a}_G$), as shown dotted in Fig. 6d.

3.2.2.2 The MC questionnaire for the problem part

– Most Accurate

Which of the following options is the best approach for finding the velocity of point C in a mechanism with driving link's position; φ_1, constant angular velocity; ω_1, and all necessary dimensions as shown in Fig. 7 ?

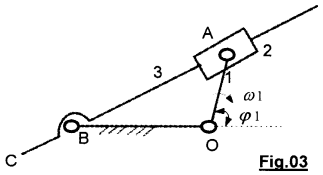
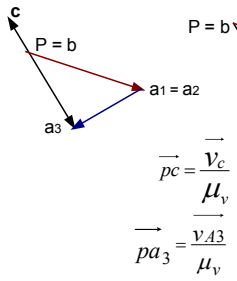


Fig. 7.

Velocity diagram to scale μ_v

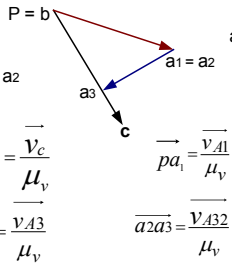
Fig. 7a



$\overrightarrow{pc} = \frac{\vec{v}_C}{\mu_v}$

$\overrightarrow{pa_3} = \frac{\vec{v}_{A3}}{\mu_v}$

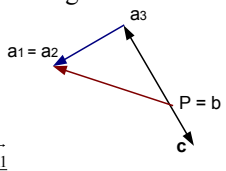
Fig. 7b



$\overrightarrow{pa_1} = \frac{\vec{v}_{A1}}{\mu_v}$

$\overrightarrow{a_2a_3} = \frac{\vec{v}_{A32}}{\mu_v}$

Fig. 7c



	Vector equations of velocities	On velocity diagram to scale μ_v, Fig. 03a,b,c.
(1)	$\vec{v}_{A1} = \vec{v}_{A2} = \vec{\omega}.OA$; $\vec{v}_{A1}$ r OA;	$\overrightarrow{pa_1} = \overrightarrow{pa_2} = \vec{v}_{A1} / \mu_v$
(2)	$\vec{v}_{A3} = \vec{v}_{A2} +$ $\vec{v}_{A32}$; $\vec{v}_{A32}$ // AB;	$\overrightarrow{pa_3} = \overrightarrow{pa_2} + \overrightarrow{a_2a_3}$; $\overrightarrow{pa_3} = \frac{\overrightarrow{v_{A3}}}{\mu_v}$;
(3)	$\vec{v}_{A3} = \vec{v}_{AB}$; $\vec{v}_{AB}$ r AB;	$\overrightarrow{pc} = \vec{v}_C / \mu_v$; $\overrightarrow{pa_3} = \vec{v}_{A3} / \mu_v$;
(4)	$\vec{v}_C = - \vec{v}_{A3} \cdot \frac{CB}{AB}$; $\vec{v}_C$ r AB;	pc = ba3 . $\frac{CB}{AB}$ = pa3 . $\frac{CB}{AB}$

a. Approach 1: $\vec{v}_C = \overrightarrow{pc} \cdot \mu_v$ (shown in Fig. 7a)
b. Approach 2: $\vec{v}_C = \overrightarrow{pc} \cdot \mu_v$ (shown in Fig. 7b)
c. Approach 3: $\vec{v}_C = \overrightarrow{pc} \cdot \mu_v$ (shown in Fig. 7c)
d. None of the approaches a, b,c above is correct.

– Extension

The variation of the driving torque; T_d and resisting torque; T_r of a machine shaft with a mean speed; ω_m is shown in Fig. 8. The moment of inertia of the machine is negligible.

Select the best answer option for completing the solution used for determining the moment of inertia; I_f of a flywheel attached to the machine shaft

to keep the coefficient of speed fluctuation of the machine at the value of δ.

The moment of inertia of the flywheel; I_f, is determined with the following formula:

$$I_f = \frac{U}{\delta \omega_m^2}$$, where U is the excess energy

absorbed by the flywheel and determined as below:

a. $U =$ C area F2 C $= 40 \times \frac{\pi}{2} = 20\pi$ J

b. $U =$ C area F1 C $= 40 \times \frac{\pi}{4} = 10\pi$ J

c. $U =$ C area F3 C $= 40 \times \frac{\pi}{4} = 10\pi$ J

d. $U =$ C area F1 C + C area F2 C+ C area F3 C

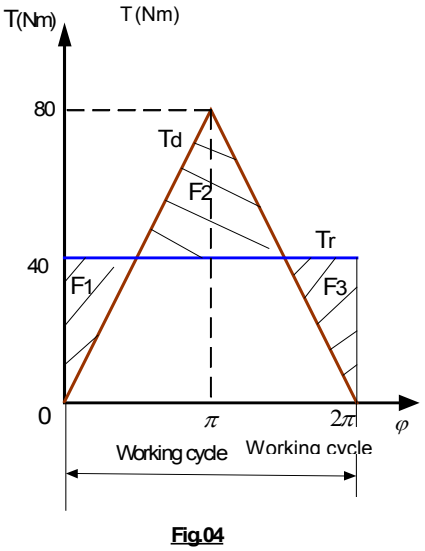


Fig.04

Fig. 8.

4 ORGANIZATION OF MC–EW COMBINED EXAMS

4.1 *Forms of combining the MC component questions with EW component questions in combined exam questionnaires*

4.1.1 *% MC and %EW*

The percentage of combination can be different as 30% MC - 70% EW, 40% MC - 60% EW, and 50% MC - 50% EW.

4.1.2 *Content of combination*

And also, the content of combination can be various as below:

1 30% MC theory - 70% EW (20% theory + 50% problem)
2 50% MC theory - 50% EW problem
3 30% MC problem - 70% EW (50% theory + 20% problem)
4 40% MC problem - 60% EW (50% theory + 10% problem)
5 50% MC problem - 50% EW theory

Notes:
In fact, it depends on the specific requirements of each technical subject, the percentage of the theory and problem can be regulated.

4.2 *Performance of combined exams*

To ensure the reliability of exam results, the MC - EW exam questionnaires, especially, the MC ones must be renewed almost every year. Although the renewal of them on computer is not so hard, but copies of new exam questionnaire sets cost a lot (the financial condition of VIMARU cannot afford it). To avoid doing it too often, the EW and the MC questionnaire sets are made as two separate parts. In this way, the combination of the two parts can be changed variously. Besides, the MC questionnaire sets are so prepared that they can be reused for some more times. At an exam, the chosen answer option to each MC question is written down on the exam paper instead of marking right away on the questionnaire set; e.g., 1-a, 2-d, 3-f, 4-b, etc (1, 2, 3, 4, etc, - the question order numbers and a, d, f, b, etc,- the chosen answer options respective to the questions), and then, the same exam paper is used for EW questions. After each exam, the whole MC - EW exam questionnaire sets together with the exam paper must be handed in.

5 FINAL CONCLUSION

1. After successive experiments on Mechanics of Machines, the examination reform with MC-EW combined exam forms was fruitful. The experience received from the experiments is quite reliable to apply not only to Mechanics of Machines but also all other technical subjects.
2. It depends on the specific requirements of each technical subject; the MC- EW combined exam forms can be applied to midterm and final exams with MC component from 30% up to 50%. The option 0f 50% MC is suggested.
3. To ensure the reliability of the exam results, the MC - EW combined exam questionnaires must be well prepared and renewed quite often, especially, the questionnaires of the MC component.
4. The reformed exam results are more objective and more reliable than those of traditional single oral, essay writing and multiple choice exams.

5. The MC exam questions for the part of subject problems are quite truthful for evaluating the examinees' knowledge on a technical subject.
6. The processes of doing exams and marking exam papers are less tiresome and less time-consuming.
7. The process of marking exam papers of MC component can be partially or fully automated with the help of keys or machines.

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