LOGISTICS AND TIME EFFICIENCY OF MICRO EXAMS

Samuel Kosolapov and Nissim Sabag
ORT Braude Academic College of Engineering
Israel

Abstract

Micro Exams (*ME*) are short exams composed of a few multiple choice questions, provided during lectures, exercises, and laboratories in order to actively involve the students, collect feedback from students, and to monitor how they follow the educator, as suggested by the Active Learning concept. Students can answer *ME* questions by writing on plain paper, selecting the answer on a multiple choice form, using clickers, or other techniques. Proper *ME* logistics must have minimal non-educational time overhead both for the educator and for the students. The time efficiency of a number of *ME* techniques was evaluated in several courses.

Introduction

Micro Exams (*ME*) are short exams (tests) provided during lectures, exercises, and laboratories to actively involve the students in the learning process. Another purpose of using *ME* is to obtain immediate feedback from the students during the lesson, thereby giving the educator a real-time picture of how they are following the studied material. In a modern class *ME* questions are best presented to the students using a projector during the lesson, at any point the educator decides appropriate. There are different methods for the students to answer such *ME* questions: writing on plain paper, selecting the answer on a specially prepared Multiple Choice Form (*MCF*), using clickers, or other Instant Feedback Techniques (*IFT*).

Many educators (Haynie, 1994; Funk & Dickson, 2011; Kosolapov & Sabag, 2012) studied the pedagogical efficiency of short exams (referred to as *ME* in this contribution). According to the authors' opinion, providing *ME* during the lessons is a useful pedagogical technique, providing real-time feedback to the students about their proficiency in the studied material. Additionally, the educator can evaluate the clarity of the lectures, the teaching methods, and other learning materials; and, if the *ME* results are poor, the educator can provide relevant clarifications to the materials presented to the students.

In recent years a number of combinations of *ME* techniques and grading techniques were tested in the Electronics Department of the ORT Braude Academic College of Engineering.

The goal of the current contribution is to compare the time efficiency of the different *ME* techniques from the educator's point of view, as well as from the students' point of view. It is reasonable that good *ME* logistics would have minimal non-pedagogical time overhead for both educator and students. While the time spent by the educator to prepare questions for *ME* and analyze their results can be considered an important and valuable educational task, the preparation time for the *ME* (e.g., time required to distribute and collect the *ME* forms and pre-process results of the *ME*) can be considered as burden, and must be minimized. From the students' point of view, the time required to answer *ME* questions and time spent to understand errors in *ME* can be

considered as valuable learning time, whereas the time required to provide the answers within the framework of selected *ME* techniques and transfer those answers to the educator must be considered as logistic overhead. The technical aspects of some *ME* techniques and systems used in this contribution were described earlier (Kosolapov, Sabag, & Gershikov, 2014; Gershikov & Kosolapov, 2015).

The terms and symbols are defined in Table 1. A number of combinations {*ME* Technique – Grading Technique} used in real classes are specified in Table 2. Table 3 contains a list of courses used in the current research.

In this paper, logistics aspects of some *ME* techniques used by the authors in the recent years are described. More specifically, parameters and time efficiency of a number of *ME* techniques were evaluated in a number of courses.

The results are summarized in the following tables and exemplary formulae. Using those tables and formulae the educator can evaluate the time efficiency of the specific *ME* technique in specific cases. Notation T[x] specifies the time needed to execute a step having index X as specified in Table 4.

ME Techniques and Logistic Steps

Practical execution of *ME* consists of a number of steps. Some steps can be considered as having educational value for the educator and/or for the students (marked as *EV*), whereas other steps must be considered as logistic overhead (marked as *LO*) to be minimized.

In this contribution we consider the case where the educator provides all logistic steps without assistance from administrative staff (for example, the educator manually prints *MCF* using a PC and a printer). The result times are calculated as the time required for one semester.

Preparation of Micro Exam Questions and Answers

For all techniques used, the educator prepares *ME* questions and answers and presents the questions to the students during the lesson using a computer projector. In most cases, one slide contains one *MEQ*. For the educator, the time required to prepare *MEQ* (T[1] in Table 4) and the time required to generate the answer to MEQ T[2] must be considered as *EV*. However, the time required to prepare question slides T[3] and the time required to prepare answer slides T[4] must be considered as *LO* for the educator.

Table 1

Definitions, Parameters, and Values Range (When Applicable)

Symbol	Meaning	Values Range
ME	Micro Exam: short exam containing a small number of questions	-
MEQ	Micro Exam Question	-
MEQs	Micro Exam Questions	-
MEA	Answer to Micro Exam Question	-
MEAs	Answers to Micro Exam Questions	-

Table 1. *Definitions, Parameters, and Values Range (Cont.)*

Symbol	Meaning	Values Range
MCF	Multiple Choice Form	-
MCL	Multiple Choice Label	-
*Nm*e	Number of Micro Exams during the semester	5-10
Nq	Number of questions in the typical Micro Exams	3-5
*N*s	Number of students in the class/laboratory	10-60
EV	Logistic step with Educational Value	Yes-No
LO	Logistics step considered as Logistic Overhead	Yes-No
App	Students answer *ME* questions by manually writing pairs {number of question – selected answer} on plain paper	-
Amcf	Students answer *ME* questions by blackening relevant rectangles on specially prepared multiple choice forms (*MCF*) printed on a plain paper	-
Amcl	Students answer *ME* questions by raising properly oriented specially prepared labels (*MCL*) printed on thick paper and folded in a particular way	-
MAN	Manual procedure	-
HAS	Human Assisted Software	-
AS	Automated Software	-
SID	Short student ID. May be student' number in the class list or any other number unique in the class	0-100
T[X]	Time in minutes required for the execution of a specific step. X: index in the Table 4. This time is multiplied by the relevant factor specified in the Table 4	0-60

ME Techniques – Short Description

In our research a number of *ME* techniques were used.

App. Students answer *ME* questions by manually writing pairs {*number of question – selected answer*} on plain paper, and at the end of the lesson they put their papers on the lecturer's table. This option, obviously, requires no equipment: considering the diversity of the students' handwriting styles, the educator is forced to validate the answers and calculate the grades manually. However, a simple software utility can be instrumental in speeding up the entry of answers into a PC, tablet, or smartphone; still, the time required to enter the answers is, obviously, *LO*. If the software utility can create an Excel file, automatic calculation of grades and generation of a report is trivial and requires nearly zero time.

Amcf. Traditionally, MCQs are answered using specially designed forms, which are later scanned. While scanning by using high resolution opto-mechanical scanners is extremely reliable, it is not suited for the *ME* concept: opto-mechanical scanners are slow, and, additionally, opto-mechanical scanners are not available in class. Camera-based acquisition of *MCF* and algorithms of reliable processing used in this research were described earlier (Kosolapov, 2015). In the simplest logistics, the required amount of MCFs can be printed using an ordinary PC printer. Using a stand (see Figure 1) can significantly speed up *MCF* collection and acquisition.

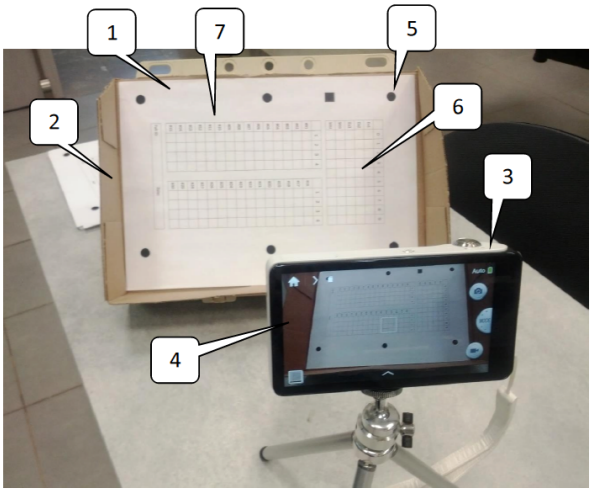

Figure 1. Camera-based FFS. (Kosolapov et al., 2014).

1 – *MCF* printed on plain paper positioned on the simple stand (2).
3 – Smartphone high-resolution camera ready to grab the image of the *MCF*.
4 – Image of the *MCF* on the screen of the smartphone is geometrically distorted.
To compensate for geometrical distortions, a plurality of markers (5) is added to the *MCF*. *MCF* has a region (6) dedicated to specifying the last five digits of the students' *SID*. 7 – Region dedicated to entering up to 30 *MEAs*.

Amcl. Students answer *MEQ* by raising in a proper orientation specially prepared labels (printed on a thick paper and folded in a special way) (see Figure 2). The logistic advantage of this approach is that all the answers are grabbed practically in zero time -- in the time required to take a photo of the class. If automatic grading software is sufficiently reliable, the time efficiency of this approach is very high for students and for the educator.

Unfortunately, this approach becomes problematic in bigger classes because nearer students hide the labels of the students in the back rows. Practically speaking, this approach is better suited for small classes up to 20 students.

Figure 2. Camera-based IFS (Kosolapov et al., 2014).

Table 2

Combinations of ME Technique – Grading Technique Used in Real Classes

ME Technique	**Grading Technique**		
	Manual	**Human Assisted Software**	**Automatic Software**
App	App/MAN	App/HAS	-
Amcf	-	Amcf /HAS	Amcf /AS
Amcl	-	Amcl /HAS	Amcl /AS

ME were part of the syllabus for the following courses: Introduction to Analog Electronics, Analog Electronics, Theory of Analog Electronics, and Image Processing (see Table 3).

Results

Table 4 summarizes the data required to evaluate the total time required to provide selected numbers of *ME* during semester. Additionally, the data in this table can be used to evaluate the time efficiency of the selected *ME* technique by comparing the time required for *educational tasks* with *logistic overhead*.

ET stands for the educator time (in minutes) required to execute a specific step.
EF stands for the factor to be used to calculate the educator time required to execute the selected task during one semester. For example: T[1] is the time required to generate one *ME* question. This time is estimated as 15 minutes, taking into account that the questions are modified to some extent every semester. To calculate the time needed to prepare all ME questions and answers for one semester (*Taq*), one can use this obvious formula:

$$Taq = (T[1]+T[2] + T[3] + T[4]) * (Nm*Nq)$$

Table 3

In-Class Use of the Different ME Techniques in the Electronics Department of ORT Braude Academic College of Engineering

Name of the Course	**Year/Semester**	**ME Techniques**
Introduction to Electronics (lectures)	2011/spr	App/MAN, App/HAS, Amcf /HAS, Amcl /AS
Analog Electronics (lectures)	2011/spr 2011/au	App/MAN, App/HAS, Amcf /HAS, Amcl /AS
Theory of Analog Electronics	2011/au … 2015/au	App/MAN, App/HAS, Amcf /HAS, Amcl /HAS Amcf /AS, Amcl /AS
Image Processing (lectures & exercises)	2012/au … 2015/au	App/MAN, App/HAS, Amcf /HAS, Amcl /AS Amcf /AS, Amcl /AS
Image Processing (laboratories)	2012/au … 2015/au	App/MAN, App/HAS, Amcf /HAS, Amcl /AS Amcf /AS, Amcl /AS

For example, if the number of Micro Exams in one semester (Nme) is ten, and number of questions in one *ME* (*Nq*) is five, one can evaluate *Taq* as 2000 minutes (about 33 hours of work per semester).

EM defines the educator mode as educational value (*EV*) or logistic overhead (*LO*). One can evaluate the time required to execute all the tasks relevant to the preparation of the questions and answers during one semester and having *EV* as:

*Taq_ev = (T[1]+T[2]) * (Nm*Nq)* ~ 1500 minutes ~ 25 hours

Hence, the time efficiency of the preparation of ME questions and answers as a percentage is:

100* (Taq_ev / Tac) ~ 75%.

ST, SF, and SM are acronyms for student time (required to execute a specific ME step), student factor, and student mode correspondently.

In a typical case students are not expected to prepare questions and answers for their exams; hence the student items 1-4 in Table 4 are marked as 0 or as "-" (not relevant). However, answering *MEQ* is *EV* for the student and *LO* for the educator.

Figure 3 presents the total educator time required to implement a specific *ME* technique as a function of an Ns. All the technologies have significant "preparation" overhead, so that if the educator can use questions and answers prepared by a third party, the total educator time required to provide *ME* drops significantly.

Data presented in Figure 3 clearly shows some *ME* techniques better suited for a small class with fewer students (Ns), whereas other *ME* techniques are better suited for a big class (having larger number of students *Ns*). For example, the case when students answer *MEQ* by manually writing pairs {*number of question – selected answer*} on a plain paper and when the educator manually keys in those pairs using a mouse (or touch screen) controlled software utility (simple and even primitive *App/HAS* technique – see line 4 on Figure 3) can be considered as the most time-effective techniques for small classes of roughly ten students. It is clear, however, that reliability of manual numbers' input is reasonable only for a really small number of students in the class, so that using properly implemented *AS* would be preferable in the real class even if time-efficiency of *HAS* is slightly better than time-efficiency of *AS*.

As for bigger classes (more than 15 students), techniques that use *AS* have better time-efficiency than those using *HAS* (compare lines 3 and 4 to lines 4, 5 and 6 in Figure 3).

One can see that time-efficiency of the *Amcl/As* (line 3 on the Figure 3) is less dependent on *Ns* and, thus, is the most time-effective technique of the techniques tested in this contribution. Unfortunately, as it was mentioned before, *Amcl/As* in the current implementation is limited to small classes of 20 students.

Table 5 summarizes times and time efficiency for a number of cases. Time efficiency is calculated as a ratio of the sum of the time for the steps having *EV,* divided by the total time required to execute all the steps for the selected *ME* technique.

Discussion

While we consider using Micro Exams as an important pedagogical tool, the total time required for *ME* arrangements and time efficiency of the Micro Exams logistics must be taken into account when selecting the number of exams, the number of questions in

each exam, and the time allocated to answer those questions. A low number of exams and questions might not provide reliable feedback. A high number of exams and questions may require too much time. Our selection of between five and ten Micro Exams, each having about five questions, seems reasonable for our students and our courses; however, other educators may select other parameters.

Conclusions

The data in Table 4 enables estimating the time required to prepare and provide a series of *ME*. Our conclusion is that even in the current implementation, *Amcf* is mature enough and time-efficient enough to be used with *HAS* in a small class. *Amcl* with a mechanical stand is close to be considered as mature enough and time effective enough for big classes up to 60 students. Surprisingly, the "primitive *App/HAS* technique" when students answer *MEQ* by manually writing pairs {*number of question – selected answer*} on a plain paper and when the educator manually keys in those pairs using a mouse (or touch) controlled software utility, is reliable enough and time effective enough to be recommended for small classes of roughly ten students.

Table 4

Parameters of Logistic Steps

#	Logistic step	ET	EF	EM	ST	SF	SM
1	Generate *MEQ*	15	*Nme*Nq*	*EV*	0	0	-
2	Generate *MEA*	15	*Nme*Nq*	*EV*	0	0	-
3	Prepare slide with *MEQ*	5	*Nme*Nq*	*LO*	0	0	-
4	Prepare slide with *MEA*	5	*Nme*Nq*	*LO*	0	0	-
5	Install, register, and test software utilities	60	1	*LO*	0	0	-
6	Print *MCF*	0.3	*Nme*Ns*	*LO*	0	0	-
7	Prepare *MCL*	1	*Ns*	*LO*	0	0	-
8	Deploy *MSF* stand	2	*Nme*	*LO*	0	0	-
9	Distribute plain paper or *MCF* to student	0.15	*Nme*Ns*	*LO*	0.15	*Nme*Ns*	*LO*
10	Distribute numbered *MCL* to student by *SID*	0.5	*Ns*	*LO*	0.5	*Ns*	*LO*
11	Time allocated for students to read and answer *MEQ*	3	*Nme*Nq*	*LO*	3	*Nme*Nq*	*EV*
12	Educator grabs image of the raised *MCL*	0.5	*Nme*Nq*	*LO*	0.5	*Nme*Nq*	*LO*
13	Student put his/her paper or *MCF* on the educator's table	0.1	*Nme*Ns*	*LO*	0.1	*Nme*Ns*	*LO*
14	Educator validates student answer manually	0.15	*Nme*Nq*Ns*	*LO*	0	0	-
15	Educator calculates student grade manually	0.15	*Nme*Nq*Ns*	*LO*	0	0	-
16	Educator enters student answer manually in the software grading utility	0.15	*Nme*Nq*Ns*	*LO*	0	0	-
17	Student puts *MCF* on the stand for acquisition	0.1	*Nme*Ns*	*LO*	0.06	Nme*Ns	LO
18	MCF grading by *HAS*	0.01	*Nme*Nq*Ns*	*LO*	0	0	-

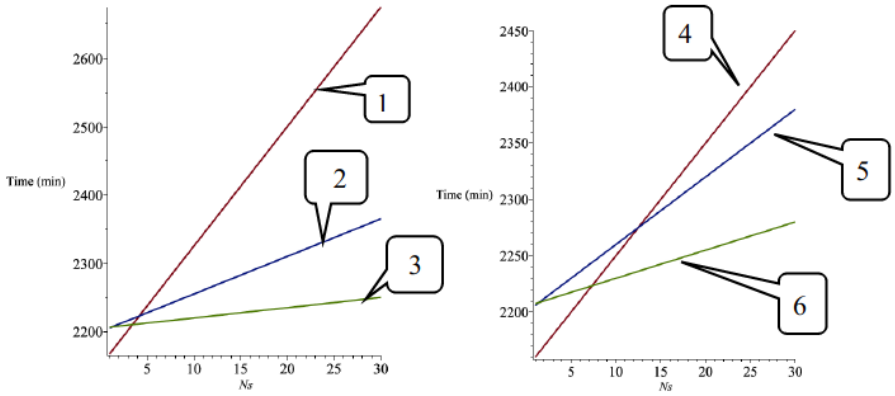

Figure 3. Total time (in minutes) required for the educator to implement all the steps as a function of the number of students in the class Ns for: 1 – App/MAN; 2 – Amcf/AS; 3 – Amcl / AS; 4 – App/HAS; 5 – Amcf/HAS; 6 – Amcl/HAS.

Table 5

Total Time of Steps having "Education Value" (EV Time), Total Time Required to Execute All the Steps, Time Efficiency in %. Nme=10; Nq=5; Ns = 25

***ME* Technique**	***EV* Time (hours)**	**Total Time (hours)**	**Time Efficiency**
App/MAN	25	50	50 %
Amcf/AS	25	41	60 %
Amcl/AS	25	38	62 %
Amcf/AS for students	2.5	3.12	80 %

Future Improvements

More research is required to improve the automatic software reliability and time required to process a large number of MCF and MCL.

References

Funk, S., & Dickson, K. (2011). Multiple-choice and short-answer exam performance in a college classroom. *Teaching of Psychology*, *38*(4), 273-277.

Gershikov, E., & Kosolapov, S. (2015). Camera-based instant feedback systems. *International Journal of Advanced Computing*, *47*(1), 1463-1473.

Haynie, W. (1994). Effect of multiple-choice and short answer tests on delayed retention learning. *Journal of Technology Education*, 6(1), 32-44.

Kosolapov, S., & Sabag, N. (2012). Using instant feedback system and micro exams to enhance active learning. *American Journal of Engineering Education*, *3*(2), 115-121.

Kosolapov, S. (2015, July). Monte-Carlo reliability evaluation of multiple choice forms recognition algorithms. *16th ASMDA Conference Proceedings* (pp. 485-497). Piraeus, Greece.

Kosolapov S., Sabag, N., & Gershikov, E. (2014). Evaluation of two camera-based approaches for collecting student feedback. *Educational Alternatives*, *12*, 1173-1182.

Author Details : Samuel Kosolapov ksamuel@braude.ac.il Nissim Sabag nsabag@braude.ac.il