Journal of Educational Research and Reviews
Vol. 2(6), pp. 98-107, September 2014
ISSN: 2384-7301
Research Paper

Evaluating math problem solutions with Mathcad software

Navchaa Tserendorj* • Densmaa Maani

Department of Mathematics, School of Arts and Sciences, National University of Mongolia, Mongolia.

*Corresponding author. E-mail: navchaa@smcs.num.edu.mn.

Accepted 14th August, 2014

Abstract. The study aimed to describe links between methods of assessing and teaching mathematics. Specifically, it tried to evaluate the effectiveness of the Mathcad software as a tool in assessing mathematics and its impacts to improved teaching and learning achievements. Teachers often face overburdened tasks to assess and evaluate students learning progresses - attainment of new knowledge and skills – through manuals checks of complicated multi-stage math problem solutions and computations. Thus, it required to prepare worksheets with problem solutions using Mathcad, in order to guide and check students' problem-solving activities. MSW-application (Mathcad-based worksheets with problem-solving computations) was experimented in both traditional teaching environment and Moodle-based learning management system setting. This study assumes the hypothesis that using this software will help both students and teachers to improve learning and teaching activities and efficiency. Under the study, 3-year long experiments were carried out among students, majored in software engineering at National University of Mongolia, during the Linear algebra and Analytical geometry course in 2010 to 2013. The experiments covered 4 experimental groups of 98 students and another 4 control groups of 96 students for three years. Of them, 85% were new students covered throughout the experiments and continued their studies consistently during this period. The study confirmed positive progresses and achievements in regard to teachers' efficiency to evaluate students' tasks by assessing problem solutions and calculations and responding to students on their performance. Moreover, MSW had more positive impacts within Moodle environment than traditional environment.

Keywords: Computer algebra system, Mathcad, worksheet of solutions, learning management system, programmed instruction.

INTRODUCTION

Although there are many factors leading to poorer math skills among university entrants and complicated learning issues, university math teachers should reconsider their existing teaching methodology and practices and focus on adopting technology-supported learning methods (Allen et al., 1999; Cox, 2007; Lavicza, 2008a). Mathematics departments are responsible for the mathematics and didactical preparation of prospective teachers. In addition to these obligations, science and engineering departments increasingly expect students to become proficient in using Information and Communications Technology (ICT) and some particular mathematical software packages. Also, mathematics majors and prospective teachers are expected to use such packages. Moreover, recommend to encourage developing Computer Algebra System (CAS)-related materials, using novel learning materials and taking into account the time spent for applying CAS in teaching activities (Allen et al., 1999; Lavicza, 2008a).

Alsina (2001) outlines myths in the teaching of mathematics at an undergraduate level, and makes suggestions as to changes going forward in teaching, assessment and technology. He distinguished following three levels of innovative teaching, corresponding to tools to be used, new pedagogical strategies and the issue of assessment: Innovative technological tools, Innovative pedagogical strategies, and Innovative modes of assessment.

Integrating a powerful instrument such as CAS into teaching requires changes to many aspects of the classroom, which teachers will make from the base of their prior teaching styles and their beliefs about mathematics and how it should be taught.

Mathematicians highlighted some practices in relation to the purpose of CAS use in their teaching. Mathematicians mentioned that they use CAS to 1) encourage group work in classes; 2) visualize and project images; 3) assist experimentation, exploration, and discovery in classes; 4) offer realistic, complex, or real word problems for students; 5) to enable them to devote more time for conceptual problems; 6) motivate students in classes; 7) prepare and offer homework assignments; and, 8) check solutions of student assignments and worksheets (Lavicza, 2008b).

Stacey (2001) reported the different ways of organising the classroom, variety in approaches toteaching the use of CAS, the increased range of methods for solving problems and for teaching other teacher adopted CAS as an extra technique for solving standard problems, emphasising time-saving routines by hand and with CAS (Stacey, 2001; Wu, 2003).

Allen (1999) lists some possible levels of technology insertion into a standard science or engineering calculus class. Similar levels can be defined for other courses by altering the targeted objectives. As to mention Levels 3 and 4 which are related to our work: *Level Three:* The technology is used to solve complex problems involving only calculus concepts that are ordinarily too complex for hand calculations. Detailed and comprehensive reports are required. *Level Four:* The programming language capabilities of the technology are utilized to allow the solution of even more complex, multistep problems and the creation of general algorithmic procedures.

Cox (2001) suggest basic principles of teaching mathematics in higher education that are evidence-based and can be used as a basis for good teaching practice. The principles have been grouped under the practicalities of setting up the learning environment, how we think students learn and the main teachers' tasks in helping them to do so (Allen et al., 1999).

Background theory

Programmed instruction is the name of the technology invented by the behaviorist B. F. Skinner to improve teaching. It is based on his theory of verbal behavior as a means to accelerate and increase conventional educational learning. (Answers) Programmed instruction is based on Skinner's "operant conditioning", a behaviourist theory stating that learning is change in behavior, i.e. the individual's response to events (stimuli). Behavior can be conditioned by rewarding the right stimulus-response patterns. (EduTech Wiki)

The components of Skinner's programmed Instruction included Behavioral objectives, Small frames of instruction, Self-pacing, Active learner response to inserted question, immediate feedback.

The underlying instructional principles operating Skinner's programmed instruction include:

1. Shaping: refers to "the reinforcement of successive approximations to a goal behavior" (Driscoll, 2000). This process requires the learner to perform successive approximations of the target behavior by changing the criterion behavior for reinforcement to become more and more like the final performance. In sum, learner's behaviors are shaped by the reinforcement of desired learning behaviors
2. Chaining: Skinner proposed that the acquisition of complex behaviors is the result of the process referred to as chaining. Chaining establishes "complex behaviors made up of discrete, simpler behaviors already known to the learner" (Driscoll, 2000). Thus, in the programmed instruction, content is arranged in small steps, which progress from simple to complex and require a response from the learner to go on. (Penn State)

Technology applied

Mathcad is the industry standard software for solving, analyzing, and sharing your most vital engineering calculations. Its live mathematical notation, units intelligence, and powerful calculation capabilities, presented within an easy-to-use interface, allows engineers and design teams to capture and communicate their critical design and engineering knowledge.

Mathcad was selected due to its simple use, similarity with texts written on traditional chalkboards and on paper, and common application practices in Mongolia. Using Mathcad in checking math problems has shown the following advantages:

i) to decide order of doing math problems and didactics solutions based on purposes with help of programming capacity;
ii) to encourage improvements;
iii) to support teachers self-development;
iv) to check faster and save time;
v) to avoid mechanical mistakes of checking exercises;

However, weaknesses include:

i) to require ICT and algorithm programming skills from teachers;
ii) to allow students to "misuse" CAS, if teachers do not organize activities to give, manage and check problems effectively.

An LMS is a high-level, strategic solution for planning,

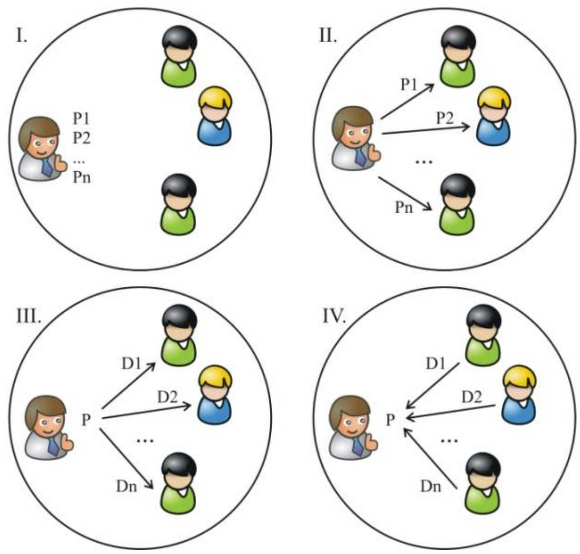

Figure 1. Types to assign students problems.
Here as: P – Problem, D – Data, Pi and Di – i version.

delivering, and managing all learning events within an organization, including online, virtual classroom, and instructor-led courses. The focus of an LMS is to manage learners, keeping track of their progress and performance across all types of training activities. An LMS provides a single point of access to disparate learning sources. It automates learning program administration and offers unprecedented opportunities for human resource development (Greenberg, 2002).

Moodle is a learning platform designed to provide educators, administrators and learners with a single robust, secure and integrated system to create personalized learning environments.

Giving problems, producing solutions and evaluations

Types to give problems and check their solutions:

Type I. All students assigned several problems from the textbook
Type II. Each student assigned to solve different problems from the texbook
Type III. Students assigned the same problem with different variables

a) Many variables (Kuznetsov, 1983; Plis, 2013)
b) Variables depending on parameters (Uvgun, 2007)

Type IV. Students allowed to chooseand create variables in own problems.

Students' creative thinking and teachers' outreach to all students, along with evaluation practices, will improve while moving from Type I to Type IV (Figure 1).

It is in this context that the study was conducted. It examined the teaching–learning process in linear algebra and analytical geometry (LAAG) using the Mathcad software. The study assumed that the use of this software will enhance both students' learning and teachers' performance and help math teachers improve their teaching. Two objectives were set forth in order to confirm the hypothesis of the study:

Objective 1: To determine impacts/changes in teaching and learning processes when using MSW to assess students' math problem-solving exercises.
Objective 2: To identify links between Moodle LMS and MSW application in assessing math problems, when using the Moodle LMS as an additional/complimentary tool.

MATERIALS AND METHODS

Design and participants

The experiments investigated students, majored in software engineering at National University of Mongolia, within the Linear algebra and Analytical geometry course in 2010 to 2013. The experiments covered 4 experimental groups of 98 students and another 4 control groups of 96 students for three years. Of them, 85% were new students covered throughout the experiments and continued their studies consistently during this period. Our experiment can be classified as a quasi-experiment type (Table 1).

The groups observed in the traditional teaching environment with MSW application are considered as the control groups, while other groups observed in Moodle

Table 1. Duration and participating groups of the experiment.

Stage	Academic year	Covered classes[a]	Number of students (sample)	Average achievements (%)	Group
Traditional teaching	before 2010				
Teaching with Mathcad	2010-2011	SE1a	25 (24)	53	Control-2
		SE1b	24 (22)	42	Control-3
		ISE1	30 (26)	41	Control-4
Teaching with Mathcad and with Moodle	2011-2012	SE1b	31 (24)	43	Control-1
		SE1a	31 (24)	44	Experimental-1
		ISE1	32 (24)	30	Experimental-2
Teaching with Moodle	2012-2013	SE1	32 (30)	53	Experimental-3
		ISE1	24 (20)	46	Experimental-4

[a] SE – Software engineer, ISE – Information System engineer.

Table 2. Categories classifying math problems and exercises.

Categories	Types to assign students problems		Level of learner's skill	MSW	
	Number	Figure		Usage	Number
Seminar classes (Sem)	Type I, II	Figure 2	Medium	Occasionally	16
Handouts	Type III	Figure 4a, 4b	Simple	Always	12
Homework assignments (HWA)	Type IV	Figure 3	Complex	Always[a]	4 (from 6)

[a] in case of MSW needed for particular problems.

LMS as the experimental groups.

Context of study

Problems are categorized due to their purposes in the following way (Navchaa and Densmaa, 2008; Navchaa, 2010) (Table 2):

Seminar class (Sem): It aims to strengthen students' new knowledge taught through theoretical lectures and to give them basic problems to be solved. During seminars, students are free to interact with the teacher and other students while solving problems. Teachers will distribute problems, assign students to demonstrate and explain his/her solutions on the chalkboard to others, guide and advise students, and give marks to each students' performance results.

Handouts: They provide problems aimed to strengthen students' basic skills within the given topics so that the teacher should prepare then with many variables. The teacher may distribute handouts to students during the seminar class, check results, guide and advise students during or outside the seminar class, and give marks to each student's performance results.

Homework assignments (HWA): Its homework packages aimed to evaluate and assess students independent work skills to link their theoretical knowledge with practical skills when solving problems independently. Instructions will clearly explain what to do and how to assess them. Independent works shall be scored or marked. The teacher shall check and evaluate them during non-class hours.

When preparing Mathcad worksheets with problem-solving, it is important to consider and reflect each aspect of calculations of all stages to be learned by students, in addition to interim and final results. Mathcad-based worksheets with problem-solving computations can be named as MSW hereafter. Figures 2 and 3 shows the general MSW structure of handouts.

Instruments

Solving problems at linear algebra and analytical geometry requires carrying out lengthy calculations and actions on different matrixes quite often. It is always difficult for teachers to determine students' attainment of new knowledge and skills, when students have made accidental mistakes while doing such arithmetics and computations. Moreover, teachers easily get tired of guiding and checking monotonous calculations while

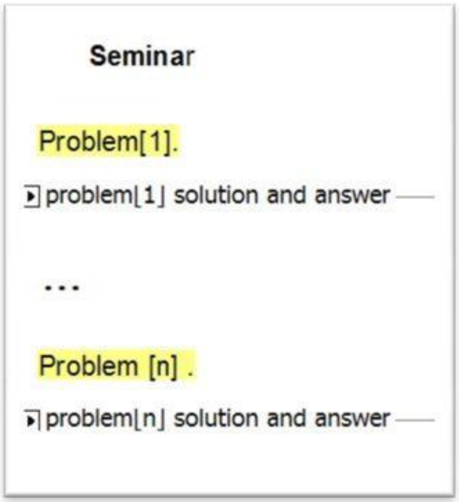

Figure 2. MSW structure of Sem.

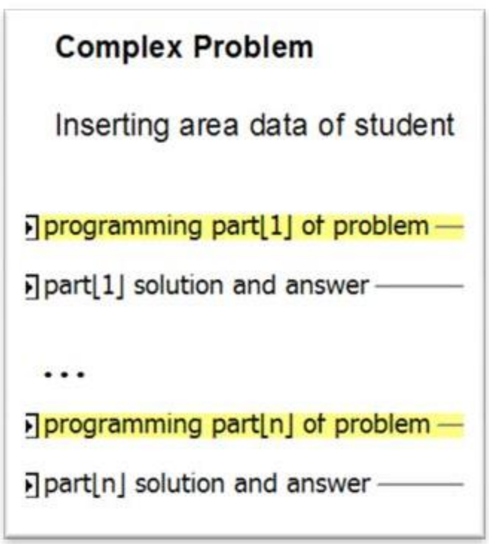

Figure 3. MSW structure of HWA.

evaluating students' results of problem solving. Teachers often face overburdened tasks to assess and evaluate students learning progresses - attainment of new knowledge and skills – through manuals checks of complicated multi-stage math problem solutions and computations. Thus, it required to prepare worksheets with problem solutions using Mathcad, in order to guide and check students' problem-solving activities.

Objective 1: To determine impacts/changes in teaching and learning processes when using MSW to assess students' math problem-solving exercises.

When preparing Mathcad worksheets with problem-solving, it is important to consider and reflect each aspect of calculations of all stages to be learned by students, in addition to interim and final results (Figure 4). Mathcad-based worksheets with problem-solving calculations can be named as MSW hereafter.

Data collection

A multi-method approach to data collection was taken: Both quantitative and qualitative student feedback was collected after each semester. Following variables were collected during the training to realize the first objective of the study. Whereat:

i) In 2010, a questionnaire survey was conducted among 58 math teachers from 4 major universities, including National University of Mongolia (NUM), Mongolian University of Science and Technology (MUST), Mongolian State University of Education (MSUE) and Mongolian State University of Agriculture (MSUA). When lecturers were asked "*How many students can you manage to evaluate during one seminar class in average?*", Teachers from NUM responded that a teacher can evaluate 6.7 students per class in average, while MUST teachers - 15.3, MSUE teachers - 9, MSUA teachers - 11; and the total average –10.8 respectively (Navchaa, 2011).
ii) During the experimental period, teachers keep notes on students' performance in Excel sheets and then process the both quantitative and qualitative data after each semester. (Table 3)
iii) Students' feedbacks on using MSW provided within the questionnaire[1] (Figures 5 and 6, Table 4).
iv) Video recording was used to observe and analyze manual and MSW-based checks to HWA exercises, as a part of data collection (Table 5).

Studies reveal that MSW-based evaluation provides effective activity learning environment through encouraging equal opportunities, effective reachout to all students, and facilitating and automating teachers' monotonous/ repeated activities. This application may help students to self-study and improve their creative skills through seminar classes and homework assignments, and also enhance teacher-student interactive relations.

As teachers use MSW applications, problems and exercises assigned at seminar classes in traditional teaching have been categorized in 2 groups: for seminars and for handouts. Handouts have increased to 12 in 2011-2012 from 2 in 2010-2011 (Table 2). Teachers used to check and evaluate problems, assigned during seminars, only 2 times as midterm examinations which changed into 6 complex assignments and 2 midterm

[1] H_0: no statistically significant difference between the results of the control-1 group and experimental-1 group p = 0.953, H_1: p = 0.047 ($p < 0.05$). Thus, results are incorporated.

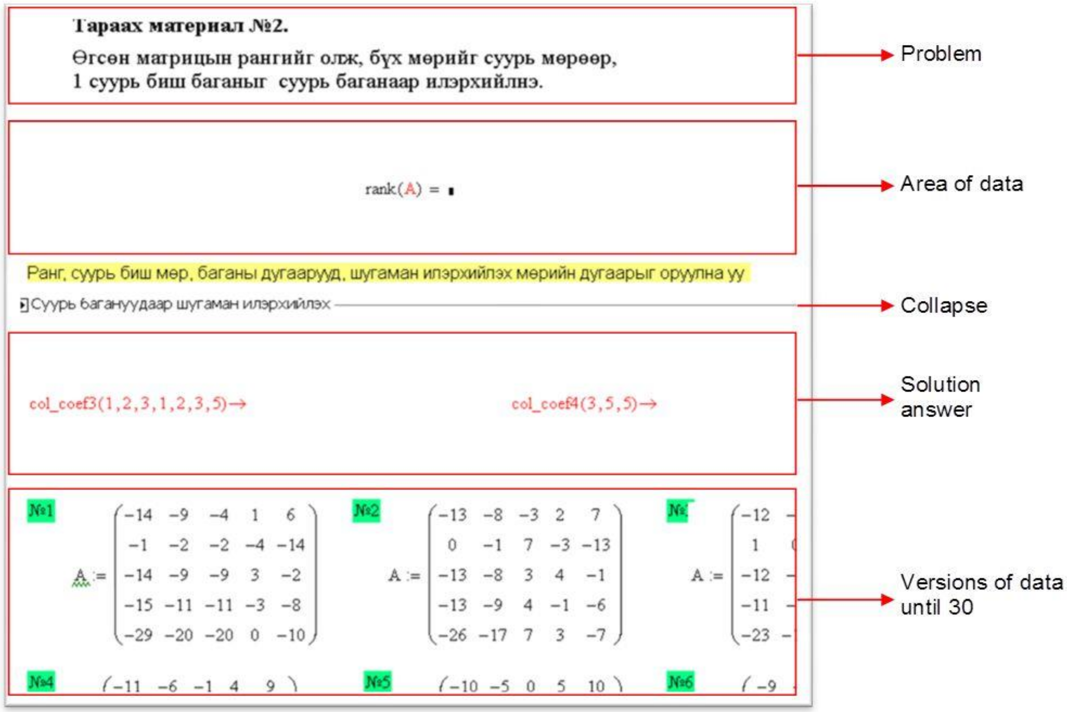

Figure 4a: MSW structure of handouts, before giving variables.

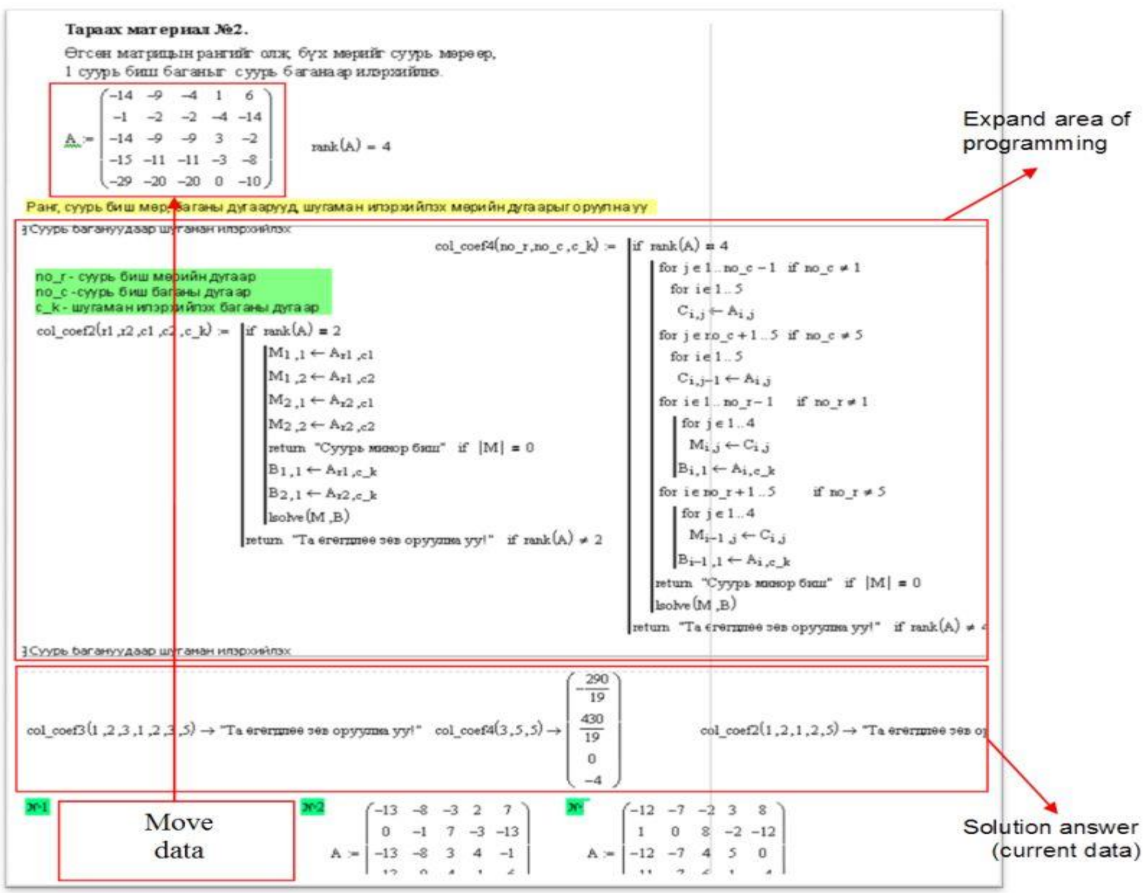

Figure 4b. MSW structure of handouts, after giving variables.

Table 3. Number of math problems and exercises solved by students and evaluated by teachers.

Academic year	Groups	Number of solved problem during semester		Average number of solved prob in sem	Average
		Sem	Handout		
2010-2011	Control-2	205	(2^a) 22	14.2	13.8
	Control-3	222	(2) 19	15.1	
	Control-4	172	(2) 22	12.1	
2011-2012	Control-1	198	(12) 94	15.3	15.9
	Experimental-1	188	(12) 152	16.8	
	Experimental-2	191	(12) 112	15.4	
2012-2013	Experimental-3	239	(12) 172	20.3	17.7
	Experimental-4	184	(12) 113	15.0	

Note: Here some parts of handouts are studied at seminar classes, while all handouts are considered for 2010 and the half – for in the following 2 years. [a] number of handout

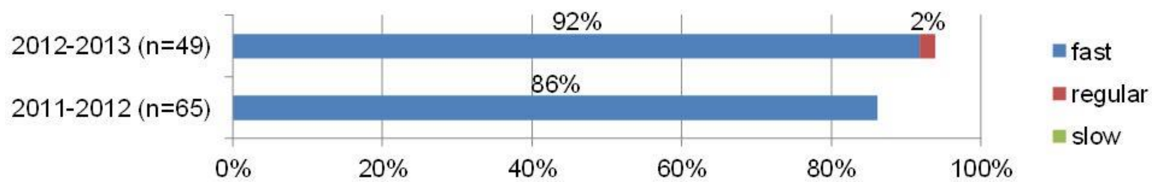

Figure 5. Q: How fast does your teacher check your problem solutions?

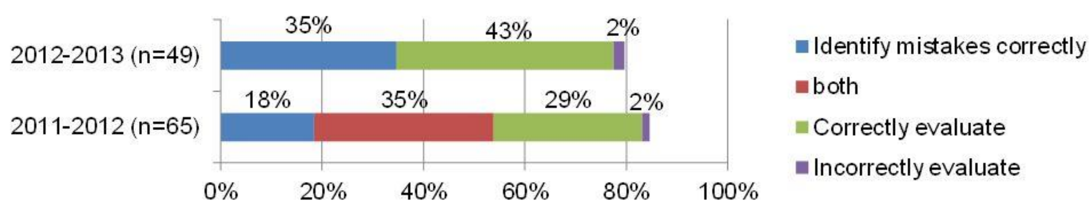

Figure 6. Q: How correctly does your teacher evaluate your problem solutions?

examinations based on tests, and so led to clearer and more detailed evaluation of students' learning achievements. LAAG course often require tasks to carry out complex analysis and calculations. Such practices are included in its curriculum as self-study with MSW-based evaluations.

Broader application of LMS in training activities has become trendier worldwide, so do Mongolian universities develop and employ own platforms for a range of applications. Thus, the study attempted to examine differences between MSW-applications in traditional learning and LMS-based learning environments. In doing so, experiments of blended learning were carried out while selecting Moodle LMS for this subject courses.

Objective 2: To identify links between Moodle LMS and MSW application in assessing math problems, when using the Moodle LMS as an additional/complimentary tool.

In other words, it aims to determine MSW-related factors and impacts, after estimating and comparing learning achievements of the experimental-1 group and of the control-1 group (Table 6).

The course was taught over 16 weeks with compulsory weekly teaching sessions including 3 h of traditional lectures, 2 h seminars.

Moreover, progresses were measured in 2012-2013 after continuing the blended learning method with that of 2011-2012 (Table 7).

Data collection

The following variables were collected during the training to realize the second objective of the study. Whereat:

Table 4. Q: How many questions can you ask your teacher at a seminar class?

Academic year	Groups	3 or more	2	1	0	Average
2012-2013	Experimental-3 (n = 29)	1	11	16	1	1.4
	Experimental-4 (n = 20)	5	8	6	1	1.9

Table 5. Time efficiency between manual and MSW-applied evaluations.

HWA	Point	Number of page	Durability		
			Handing	MSW	Saving (%)
HWA1	5	1.4	3:40		
HWA2	5	2.2	9:00	6:35	27
HWA3	3	0.5	1:02	0:39	37
HWA4	15	3	10:58	5:28	50
HWA5	25	4.5	15:44	9:48	38
HWA6	20	10	2:43		
Average					38

i) Sampling as considered to ensure levels of student achievements from both the control-1 group and experimental-1 group to be of similar levels[2]. Learning achievements of those groups were observed after experiments, as follows: the control-1 group n = 30, M = 38.9, SD = 24 and the experimental-1 group n = 25, M = 51.8, SD = 22.7, the effect size[3] d = 0.55 (p = 0.048) (Navchaa et al., 2013).
ii) Table 7 shows findings of the questionnaire, in regard to suitability of evaluations categories for assessing students' knowledge.
iii) Quantitative of both control and experimental group students' performance within problems categories (Table 8).

RESULTS AND DISCUSSION

This section answers the questions posed in the study. Both quantitative and qualitative data are presented and implications are provided to shed more light on the findings most essential in the study.

Qualitative data collected from teachers' and students' questionnaire were compared and analyzed to generate the following findings. As a result of MSW applications, teachers can provide 39 responds to students' questions (Table 4) in average and evaluate 17.7 students at a time that is higher that both the previous average of 10.8 and the highest of 15.3 respectively. Quantitative data demonstrate that the number of students evaluated per class has increased each year from 13.8 to 15.9 and 17.7 which shows that teachers are also getting experienced in using MSW more efficiently (Table 3).

Looking at students' responds to the questionnaire (Figure 5), 86 to 92% confirmed that teachers' efficiency to check their problem-solving exercises faster, while 78 to 82% of students got their solutions and computations assessed correctly (Figure 6). It shows that software application in assessing math problems help students effectively be provided with easy and clear self and external assessment tools to their learning processes.

Video observations of manual and MSW-applied checks revealed the following findings:

i) Averaged 38% of saved time to evaluate 4 assignments in 10 pages (Table 5)
ii) Possible to avoid mistakes when allowing to check all stages of complex calculations in details by using MSW;
iii) Encouraging students to learn various calculation and problem-solving methods, and improve their independent-learning skills.

Advantages of assessing students' performance and knowledge with Mathcad worksheets were observed, as below:

i) Effective assessment for problem-solving results, by identifying students' mistakes clearly and providing efficient guidance and corrections;
ii) Faster evaluation feedbacks on results of seminar and handouts' problem-solving tasks, and time efficiency to assess homework assignments executed by students;
iii) Helpful to identify students' accidental errors and mistakes.

Impacts of MSW-application as an assessment tool were measured d = 0.55 when comparing learning achievements between experimental-1 group and control-1 group. It also shows that the Moodle environment also accentuates effectiveness of using MSW, despite the fact

[2] H_0: no statistically significant difference p = 0.961, H_1: p = 0.039 ($p < 0.05$)
[3] Cohen (1988) classified anything above *d* = .8 as a large effect, *d* = .5 as a medium effect, and *d* = .2 as a small effect (Cohen et al., 2011)

Table 6. Arrangements of lessons for experimental and control groups.

Component	Experimental group	Control group
Lecture	Used board, chalk, computer and projector	Used only board and chalk
Seminar	Both groups similarly used board and chalk. The lecturer will operate MSW on notebooks and mark students' performance	
Moodle LMS	All students obtained permission to access materials through internet	
Homework assignments	LMS enables students to submit practical works for assessment and view teachers marks online.	Students submit practical works written in papers.

Table 7. Q: What categories better evaluates your knowledge? Score 0–4 points. (best – 4, worst – 0).

Academic year	Classes	Average evaluate		
		Sem	Handout	HWA
2011-2012	Control-1 (n=21)	2.52	3.52	3.29
	Experimental-1 (n=23)	3.39	3.30	2.82
	Experimental-2 (n=21)	3.71	3.48	2.95
	Total (n=65)	3.2	3.4	3.0
2012-2013	Experimental-3 (n=26)	3.58	3.42	3.50
	Experimental-4 (n=18)	3.72	3.67	3.50
	Total (n=44)	3.6	3.5	3.5

Table 8. Effect size of Moodle LMS impacting to MSW application.

Categories	Control-1 group (n = 24)		Experimental-1 group (n = 23)		Effect size	P significant
	Mean	SD	Mean	SD		
Sem	8.3	3.7	8.4	4.4	0.0	0.99
Handout	3.8	3.1	6.6	3.1	0.9	0.00
HWA	0.55	0.13	0.63	0.21	0.5	0.13

that many factors may impact learning achievements in different ways. Now let us try to highlight determinant factors. Considering qualitative data collected from students' questionnaire (Table 7) responds by control-1 group students have reverse relations with other group students moderately and ($r_{1,2}$ = –0.42, $r_{1,3}$ = –0.57, $r_{1,5}$ = –0.51) strongly ($r_{1,4}$ = –0.96). Among students from 4 groups – who learned in LMS environment, their responds differ in the way $r_{2,4}$ = 0.14, $r_{4,5}$= 0.24 (weak), $r_{3,4}$ = 0.31 (moderate), $r_{2,3}$ = 0.99, $r_{2,5}$ = 0.99 (strong), $r_{3,5}$ = 1 (perfect This explains that evaluations through seminars and homework assignments will depend on if LMS exists or not. Organizing homework assignment in LMS environment may have technical issues or preconception about different methods than traditional methods which students get used to.

Variables collected from the questionnaire to identify suitability of classified math problems (Table 8) were 3.2 to 3.6 for Sem, 3.4 to 3.5 for Handout and 3.0 to 3.5 for HWA which are all higher than the average score (2) and more effective to assess students' knowledge and ability. Moreover, it reveals that all methods are effective to evaluate students' knowledge properly. LMS impacts to seminars are seen d = 0.0. It means that seminars, as mentioned in Table 8, have not changed much. However, impacts to Handouts and Independent work got d = 0.9 and d = 0.5 which indicate strong impacts of LMS respectively.

Findings of the comparative research on teaching with Mathcad and Blended learning methods indicate the following results:

i) Students' performance of handouts and homework assignment problem-solving works in handouts and homework assignments was higher in LMS environment than those studying in the traditional learning environment.

ii) Mathcad-based evaluation is more relevant to the Blended learning method, compared to traditional learning ways.

REFERENCES

Allen GD, Herod J, Holmes M, Ervin V, Lopez RJ, Marlin J, Meade D, Sanches D (1999). Strategies and guidelines for using a computer algebra system in the classroom. Int. J. Eng. Educ. 15(6):411-416.

Alsina C (2001). Why the Professor Must be a Stimulating Teacher: Towards a New Paradigm of Teaching Mathematics at University Level. The Teaching and Learning of Mathematics at University Level, Springer pp. 3-12.

Answers (n.d.). Retrieved from http://www.answers.com: http://www.answers.com/topic/programmed-instruction

Cohen L, Manion L, Morrison K (2011). Research methods in education. New York

Cox W (2007). A principled approach to teaching mathematics in higher education, MSOR Connections 7(3):22-25.

EduTech Wiki (n.d.). Retrieved from http://edutechwiki.unige.ch: http://edutechwiki.unige.ch/en/Programmed_
instruction

Greenberg L (2002). LMS and LCMS: What's the Difference? Learning Circuits

Kuznetsov LA (1983). Collection of tasks in higher mathematics. Moscow.

Lavicza Z (2008a). A comparative analysis of academic mathematicians' conceptions and professional use of computer algebra systems in university mathematics. Unpublished Doctoral Dissertation, University of Cambridge, Faculty of Education

Lavicza Z (2008b). The use of Computer Algebra Systems in university-level mathematics teaching. Proceedings of the 11th International Congress on Mathematics *Education.* University of Nuevo Leon, Monterrey, Mexico

Navchaa TS, Uranchimeg T, Ariane HG (2013). Integration of Learning Management System into University-level Teaching and Learning, Germany, Chemnitz

Navchaa TS (2011). Results of the questionnaire about integration of ICT in university-level mathematics teaching (NUM, MUST, MSUE, MSUA - universities). Educ. study 357(11):96-109.

Navchaa TS (2010). Using information technology in training tools preparation (for example seminar classes). Conference proceedings "Innovation's issues of engineering higher education training technology" pp. 60-67.

Navchaa TS, Densmaa M (2008). Using Information Technology in Traning Equipment Preparation (e.g., Linear algebra & Analytical geometry course). Challenges and creation of the promotion of child centered learniing towards the newer society pp. 138-141.

Penn State (n.d.). Retrieved from http://www.personal.psu.edu: http://www.personal.psu.edu/wxh139/Skinner.htm

Plis AI (2003). Mathematical practic for economists and engineers Moscow.

Uvgun L (2007). Home assignment for Plane and Space analytical geometry problems, manuscript

Stacey K (2001). Teaching with Computer Algebra Systems in a Time of Transition. Paper presented at the Computer Algebra in Mathematics Education Symposium. Freudenthal Institute, Utrecht University, The Netherlands.

Wu TD (2003). Teaching Numerical Analysis with Mathcad, Int. J. Comput. Algebra in Math. Educ. 10:1.