Using games in mathematics teaching

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Abstract

The author experimented with the use of some games in mathematics lectures during 2006-07 and found that the games were both well received by the students and effective in the intended learning goals. However, the first games (Rossiter (2007)) had some weaknesses so improved versions were trialled in semester 1 of 2007-08. This paper explains the rationale behind using games, describes the games and provides some evaluation.

Introduction, motivation and background

Several aspects help student learning (Race, P. (2005)) but primarily students need to be actively engaged (Gallop, Bell & Barnes (2005), Guzman et al. (2006), Huxham (2005), Khan & Vlacic (2006)) and this is facilitated by positive experiences, enjoyment, encouragement, a need to learn, practise, feedback and several other factors. Critically, students must be active rather than passive and this may not happen with a didactic teaching model. Good teaching practise encourages lecturers to find mechanisms for increasing student alertness and participation and to find means of engaging more senses (touch, vision, emotion etc.) (Challis (2006), Pickford & Clothier (2006)) to improve learning (Foss et al. (2006), McKay (2006), Middleton, Mather & Diamond (2006), Thomas (2006)); examples include group debate, peer learning, risk taking, competition and games. A sense of fun helps with recall and games can also give immediate feedback on current understanding.

In the second section this paper presents an idea adapted from a management game (Hill et al. (2006)) that is easy for lecturers to adapt to their own topics. The 'model', has been used in two different modules for two years: (i) year 1 engineering mathematics and (ii) frequency response methods (FRM) (complex number algebra) and thus the third section reports on the student feedback and staff perception of the exercise and how reflections were used to modify the initial games. Some conclusions on efficacy are given in the fourth section.

The game – context, origins and modifications

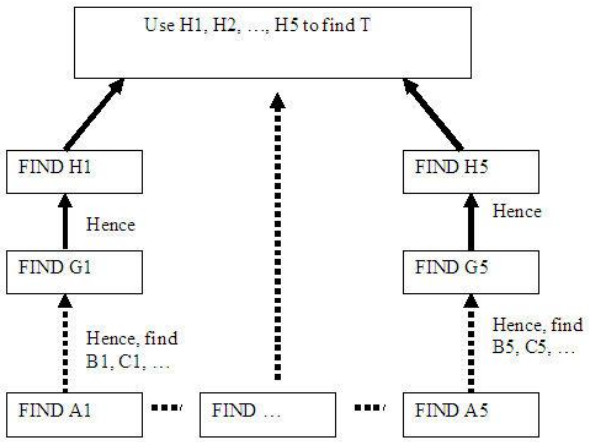
Typical student problems are associated: weakness with core mathematical skills, disengagement, not fully convinced of the importance, not fully aware of their own weaknesses. So, as part of wider departmental strategy, group based competitive games were introduced to: increase student awareness of their understanding; encourage peer assisted learning and making lectures more fun and thus improving the potential for deep learning (engaging emotion and attention). So far the games have been used in semester 1 for systems engineering mathematics (year 1) and FRM (year 2).

- FRM requires fluency with complex number algebra and the game used fun to expose the importance of a year 1 topic many had not learnt.

- Mathematics is core for new students and has to deal with transition issues such as the variability in the mathematical competence and aptitude of the intake. The 1st semester covers a quick review of basic algebra and functions before introducing trigonometry, calculus, solution of ODEs, curve sketching and optimisation.

Find-T game

The basic game concept used (Hill et al. (2006)) was developed for management and is intended to help develop team working skills; being a race the most effective team wins. The game itself requires teams to find the value of **T** by answering, in sequence, the questions on a number of cards; teams need to discern what this sequence is. Thus a team must first sort out the correct sequence and then distribute cards between team members to ensure effective use of everyone's time. A typical scheme is outlined in the figure: (i) solve A1, use to solve B1, use to solve C1, …., use to solve H1; (ii) solve A2, use to solve B2, use to solve C2, …., use to solve H2; (iii) etc and finally H1, H2, … to solve for T.



Modifications of find-T for engineering teaching

The basic concept requires 30-40 numeric/algebraic questions which build one upon another and are based on key learning from the module. The questions should have simple numbers to allow consistent computation and are printed onto small colour cards.

Use in teaching and evaluation

The game was used very early in semester with mathematics and FRM and late in semester with maths; an alternative game format was used late in semester for FRM. The intent was to engage students immediately in appraising their own preparedness for the modules and hopefully to encourage them to work hard to catch up if necessary.

Evaluation by students

Students were asked to select keywords, as many or as few as they liked, to comment on their perception of the games. Some comments and quantitative data are given next.

'*Showed me how much I forgot after the summer', `Out of practice from the summer', `Probably a bit much to begin with', `A good mix of topics', `Not just about maths but getting people to work in groups and get to know one another', `Made me realise how little I know', `Must study harder', `It showed me how much I had learnt in the semester and which parts I need to focus on for the exam', 'A good revision* '.

Time in semester	Fun	Good idea	Refreshing change	helpful	GBU	Difficulty about right
Week 11	50 and 46	85 and 57	65 and 54	90 and 63	85 and 44	90 and 33
Week 1	35 and 50	76 and 63	65 and 46	68 and 54	46 and 29	54 and 33
	Frustrating	Boring	OK	unhelpful	Too difficult	Better later
Week 11	25 and 33	0 and 13	55 and 71	0 and 8	5 and 13	10 and 30
Week 1	35 and 12	3 and 21	49 and	5 and 13	41 and 29	57 and 38

GBU (Good benchmark of understanding)

Week in semester	Fun	Good idea	Refreshing change	helpful	GBU	Difficulty about right
Week 11	50 and 48	59 and 79	46 and 52	65 and 75	54 and 73	39 and 38
Week 6	35 and 40	50 and 67	35 and 42	41 and 40	20 and 40	20 and 21
	Frustrating	boring	Ok	unhelpful	Too difficult	Better later
Week 11	8 and 10	2 and 4	35 and 40	0 and 4	0 and 6	2 and 8
Week 6	2 and 21	2 and 6	28 and 48	8 and 8	8 and 21	8 and 21

Table I,II: Student feedback on games within mathematics and FRM module. Numbers are percentage of returns marking selected keyword (2007-08 first and then 2006-07)

The majority of students were very positive marking either good idea or helpful or fun (or all three). A small minority found the quizzes difficult or frustrating although many of these still thought it was a good idea and helpful. Thus, there is certainly ample evidence that this type of exercise is worth repeating with future students.

Evaluation by staff and further modifications

The lecturer observed that in all sessions: (i) students seem to be highly engaged and animated; (ii) there was clear evidence of team working and group discussion; (iii) most students made a very obvious effort to complete the game and concentrated well and (iv) a small minority disengaged from the activity. However, in 2006-07 he felt that many groups struggled to progress due to lack of key knowledge and thus could not continue up the ladder of questions. No groups managed to complete the game and thus there was no winner! In the second year, he introduced a mechanism to release blockages and to ensure a winning team (enhance competitive aspect). In essence:

- added a scoring system with increasing points for each completed answer.
- added the option to purchase (with negative points) hints or answers.
- gave bonuses for the first team to compute a few pre-specified variables.

Although hard to unpick the effect from the data sample, the lecturer's view is that the games did run better overall with these changes. In fact, there does seem to be marginally better feedback with the second FRM quiz; in this case there was no sequencing of questions so it was easier for students to divide and conquer. The find-T format does require the team to work sequentially and many ran out of time (we allowed 45min) or were blocked by some topics. Finally, the quizzes late in semester seemed to be viewed slightly more positively, perhaps because these had the advantage of reflecting the upcoming exam as opposed to exposing lack of assumed prior knowledge.

Conclusions

The games have been successful in that the students both enjoyed the exercise and recognised their value in encouraging reflection on their abilities and needs. The format seems to be working reasonably well, although the reliance on sequencing seems to be an obstacle to effective progress for many and so this will be considered. The author's view is that the format is perhaps secondary; the novelty of the activity within lecture time and the group competition, based on key learning, is probably most important. However, he is planning further modifications for 2008-09 to facilitate better progress for groups where certain topics are a big barrier.

References

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Appendix A: Typical questions (Will happily email soft copy on request)

CARD	QUESTION	ANSWER
SYSTEMS ENGINEERING METHODS		
B5	(7/5)A5x-C5	21x
A5	Hypotenuse with sides 9 and 12	sqrt(225)=15
C5	Min root of $(2x^3+6x^2+4x)$	0
F5	$\log[\sin(D5\pi/4)]+3[E5^6/E5^4]/4$	12
D5	Max. root of $(2x^2-6x+4)$	2
E5	$[3^4 2^6 4^2 9^{-1} 4^{-4}]/9$	4
	cos(B5)-F5/2	cos(21x) -6
FREQUENCY RESPONSE METHODS		
P5 = $[B5/7]^3/(F5+4i)^2$	$[4\arg(60)]^3/[1-5i+4i]^2$	32arg(270)
R = $P1^2P2P3P4/P5$	(16.16.3.2)/(32sqrt(2))arg (30+120+180-150-270)	24sqrt(2) arg(-90)