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THE INNOVATIVE USE OF SPREAD SHEETS FOR TEACHING AND LEARNING IN AN ODL ENVIRONMENT

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ABSTRACT

The spread sheet is one of the programs that have changed the perception of computers from being a tool for programmers only, and then secretaries to a practically applicable tool useful in one's everyday office experience. Spread sheets have a great potential and are greatly underutilised in educational institutions as a teaching and learning tool. This paper seeks to investigate the innovative use of spread sheets for teaching and learning in higher education, especially in an ODL environment. Focus is on the challenges the author has had when teaching mechanical engineering at higher institutions, including an ODL institution. The engineering field involves rigorous mathematical calculations. Learners go through routine, repetitive and iterative steps that might remove the focus of the learner from the key principles to be mastered. Learners can be introduced to design and other practical processes using spread sheets. Educators can also greatly benefit in designing modules for standard and routing calculations. In ODL institutions this becomes even more helpful as educators can quickly solve problems and give meaningful feedback to learners.

Keywords: Spread sheets, ODL, Teaching, Learning

1. INTRODUCTION

It is difficult to imagine what our normal routine operations would be without the convenience and power of spread sheets. This is because spread sheets have become a vital tool in industry, in the office and in education. A spread sheet consists of rows and columns of numerical data and labels that allow all kinds of calculations and data manipulation.

A substantial amount lot of research has been carried out on the use of spread sheets focusing on different aspects.

The spread sheet is one of the programs that have changed the perception of computers from being a tool for programmers only, and then secretaries to a practically applicable tool useful in one's everyday office experience. Baker and Sugden (2007)) trace the history of spread sheets and their use in education. They note that one of the earliest benefits of spread sheets reported was that learners could benefit from computers without having to learn programming.

Abramovich and Cho (2010) demonstrate how the computational and manipulative features of spread sheets can be used not only for problem solving but also for problem posing in the context of mathematical preparation of elementary teachers. They contend that problem posing is a far more promising area than problem solving, proving that environments for open ended problems encourage learners to be more innovative in finding solutions.

In an article “Why teach with spread sheets” in the Calton College Resource Centre, the authors contend that using spread sheets gets learners involved in data while improving thinking and analysis skills. They also note that it allows greater coverage of topics and analysis of larger models.

Hesse and Scerno (2009) observe that spread sheets allowed them to concentrate on teaching the principle while spread sheets handle the actual calculations.

Healy and Sutherland (5) noted the importance of the teacher in developing the appropriate learning environment. They reiterate that spread sheets are a valuable tool for modelling “real life” situations, removing the learner’s focus from the calculations to using the calculated data as a basis for making appropriate decisions.

Only recently has the author’s interest been awakened to the fact that spread sheets can be used for teaching and learning. For learners it can be a powerful, precise analytical tool for mastering principles. For lecturers, besides being an analysis tool it can also be both a problem solving and an assessment tool.

2. Possible applications of spread sheets

Through his own experiences, the discussion below demonstrates how the author independently developed and used spread sheets in the field of Mechanical Engineering.

2.1. To answer “what if” problems

Spread sheets can easily answer “what if” problems, which is very useful in engineering design. In optimisation for example it is very important to consider alternative options and spread sheets facilitate this by allowing values to be changed to see the impact of the changes on the final result. Spread sheet 1 below clearly demonstrates this.

Spread sheet 1: Answering “what if” questions

m	c	k	ζ	Nature of Damping	dmpd period Tpd	[m] x(0)	[m/s] v(0)	X
0.4	74	1099.53	1.76428	Over	No vibes	0.025	0	0.0278
0.4	21	1099.53	0.50067	Under	0.13844	0.025	0	0.02888
0.4	41.943	1099.53	1	Critical	No vibes	0.025	0	1.31097

In this case a mass of 0.4 kg is supported by a spring of stiffness 1099.53 N/m. This module analyses the effect of changing damping from 63, 21 and 42 Ns/m. It can be seen that the system changes from over-damping to under-damping and critical damping. The effect of this on the period Tpd and amplitude X is then analysed.

2.2. Iteration is done very fast and accurately

Iteration is useful in handling several design considerations which may be conflicting in some cases. An example is in certain gear train designs where it is intended to have a specific overall gear ratio while the size of the gears are as small as possible. In this case calculations need to be repeated a number of times. The calculations involve selecting the number of teeth for the different gears, checking if it gives the required overall gear ratio and checking the size of the gears. The combination that gives the desired gear ratio at the least gear box size will then be selected. This kind of calculation is cumbersome and takes a lot of time. With a spread sheet it becomes much faster and accurate. Time is then spent more on analysis than on performing the same rigorous calculation over and over again. In coaxial trains, as in Spread sheet 2 below, the centre to centre distance must be the same for both stages ie $C_1 = C_2$.

Spread sheet 2: Demonstration of Iteration

					Q. 5				$C_1 = (m_{1/2})(T_A+T_C)$		
			$g_1 * g_2 = G$		$T_A > T_{min}$	$T_C = g_1 T_A$	$T_D > T_{min}$	$T_B = g_2 T_D$	$C_2 = (m_{2/2})(T_D+T_B)$		
					$T_{min} = T$	T=20			$C = C_1$ OR	$C = C_2$	
m_1	m_2	G	g_1	g_2	T_A	T_C	T_D	T_B	$C_1 - C_2$	C_1	C_2
5	8	10	5	2	20	100	20	40	60	300	240
5	8	10	5	2	20	100	21	42	48	300	252
5	8	10	5	2	20	100	25	50	0	300	300
5	8	10	2	5	20	40	20	100	-330	150	480
5	8	10	2	5	64	128	20	100	0	480	480
5	8	10	4	2.5	20	80	20	50	-30	250	280

2.3. Keeping track of work

In spread sheets any option considered remains in its own row whereas any undesirable result is simply discarded when using a calculator. There is then no record that it was considered thus there is a danger of repetition. In the gear spread sheet above only two rows are giving desired results, ie $C_1 - C_2 = 0$, but all the other rows analysed are available. A learner trying to understand the effect of some changes on some quantities will be able to carry out all their comparisons and draw informed conclusions.

2.4. Conducting generic and routine calculations

When a learner is performing some complex analysis they often have to perform some routine calculations like solving quadratic equations (including characterising the roots), finding solutions of polynomial equations, Pythagoras applications, application of sine and cosine rules, integration and differentiation of polynomials and a host of other expressions. The learning point in such instances is not the routine calculation, which will have to be performed, but the problem at hand within which the routine calculation will be imbedded. Unfortunately, it will not be possible to complete the more challenging real problem without doing the routine calculation that the learner already has mastered. This takes quite a long time that can be better utilised by focusing more on the higher level problem, which will be the current learning point and hence is more value adding in terms of the learning experience. One can simply use spread sheet modules so that they may focus on the real analysis at hand.

Spread sheet 3: Routine Pythagoras Calculation

x	y	$z=(x^2+y^2)^{1/2}$
4	3	5
312	116	332.86634
423	228	480.534078
124	57	136.473441

z	y	$x=(z^2-y^2)^{1/2}$
5	3	4
10	6	8
312	116	289.634252

2.5. Easily extensible

Extensibility means modules can be useful over a wide range of problems. The slope and deflection of beams under different loading is important in engineering. First this is important in terms of space considerations, and also in determination of failure of beams. In this sense slopes and deflections are used in finding the maximum stresses and hence failure characteristics of the beam. However slope and deflection can be used to determine vibration characteristics, which is applicable for transverse vibration of beams and whirling characteristics of shafts. For these applications the simple slope and deflection module can be used and extended to perform the further calculations. The extensibility of Excel is demonstrated by using the Pythagoras module in Spread sheet 3 above which is extended in Spread sheet 4 below to measure the angles opposite each given side. It should be noted that the angle opposite the hypotenuse, <Z is always equal to 90^0 for a right angled triangle.

Spread sheet 4: Extending application of a spread sheet

			Sine Rule		
x	y	z	<Z	<X	<Y
4	3	5	90	53.1301	36.8699
312	116	332.8663	90	69.60512	20.39488
423	228	480.5341	90	61.67502	28.32498

2.6. Carrying a design process right through to the final solution.

Design often consists of a number of stages and or modules that have to be designed independently but at the same time with interchange of values between them. In most cases optimising one stage might have adverse effects on another, which requires the need to strike a balance. Typically in design one goes back and forth until a satisfactory result is achieved. Spread sheets allow the whole design to be well laid out in one place and to be carried out right through to the end.

Spread sheet 5: Demonstration of a design process

I	A	k	L	L/k	C	E	Sy	cut off	Pe OR Pj
1.72E-06	0.0036	0	2	91.5	1	2E+11	3E+08	114.715	Johnson

EI	L	Decision	n	Pe	Pe/n	C	Sy	L/k	Pj	Pj/n
344000	2	Johnson	1	0	0	1	3E+08	91.499	736450	736450

In Spread sheet 5 above the first two rows are extracted from the third stage of a strut design calculation, which ends with a decision being made automatically by the calculation on what criteria should be applied for that particular strut. In this particular case the Johnson criteria is selected. The last two rows constitute the fourth and last stage in which the allowable axial force is found to be Pj/n =736 450 N.

2.7. Organising of workflow

A well thought out spread sheet can simplify work flow and lay it out in an easy to follow manner. This is evident in Spread sheet 5 above. Once the module has been developed it then standardises the design process. This is useful to learners as they do their design project at BTECH level.

2.8. Preparation of solution manuals

Preparing solution manuals this way eliminates calculator punching errors, and rounding off errors. Once the spread sheet has been tested the solutions obtained will be very accurate and can have repeated use for similar questions, with different values. For Spread sheet 6 all one has to do is input the new values of a, b and c; and the whole solution manual is recalculated and ready for use.

Spread sheet 6: Preparation of Solution manual

						a	b	c
	$y=ax^2+bx+c$		Given:					
						1	4	4
	b2-4ac =			0				
Nature of roots:			2 equal roots					
$y_{1,2}$ =	$[(-b)\pm\sqrt{}(b^2-4ac)]/(2a)$ =			-2	± 0			
		y_1 =		-2				
		y_2 =		-2				

2.9. Enrichment of the quality of questions for assessment

By being able to change values and getting the result fast, it is possible to analyse the impact of certain range of values in design of questions, which then improves on the quality. Without spread sheets more time is needed to achieve the same thing and some examiners might not have the time to do so and will therefore settle for the first thing that comes to mind.

3. CONCLUSION

Indeed the spread sheet has become an indispensable application in education.
This paper has demonstrated some of the ways spread sheets can be used for teaching and learning. It is the hope of the author that this will inspire the innovative use of this tool in even more ways.

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