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Refined 'Chalk-and-Talk' of Lecture Content: Teaching Signals and Systems at the Griffith School of Engineering

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BACKGROUND
As a core fundamental subject in all Electrical and Electronic Engineering courses, Signals and Systems has traditionally been a difficult subject, not only for engineering students to learn, but also for lecturers to teach effectively. The inherent mathematical nature of the subject, coupled with highly abstract concepts, such as Dirac delta functions, convolution, orthogonal signals and frequency-domain analysis, causes students to find the subject matter too challenging and difficult to understand. This is an unfortunate outcome, given that Signals and Systems provides the essential foundations for further subjects, such as communication systems, digital signal processing, and control systems. When coupled with the trend in Universities toward PowerPoint™-based teaching, important derivations, process, and understanding are often not communicated effectively, with students either becoming dazzled by fancy slideshows rather than achieving a deeper understanding; or skipping lectures because they feel they do not gain any more than what they would by simply reading the slides themselves in their own time. This study reports on the changes made since 2008, in "Signals and Systems", which is a second-year subject in the Bachelor of Engineering in Electrical and Electronic Engineering degree at Griffith University, Gold Coast campus.

PURPOSE
The question that this study hopes to address is: *what is the best way to teach Signals and Systems, which is a core and mathematically-intense discipline of electrical engineering, in a way that promotes student learning, retention and understanding?*

DESIGN/METHOD
Written feedback from students and quantitative data from student evaluations and grade distributions have been collected to support the findings of this study. An additional questionnaire utilising the Likert-scale opinions along with open-ended feedback was undertaken to further gauge the opinion of students, in relation to the effectiveness of 'chalk-and-talk' delivery compared with PowerPoint.

RESULTS
Feedback from students suggested that 'chalk-and-talk' lectures improved their motivation to attend lectures, moderated the pace of lectures, and facilitated their learning in a course where seeing the step-by-step process was important. The student performance was noted to have improved since the changes were made.

CONCLUSIONS
For engineering subjects that are by nature abstract and highly mathematical, the desired objective is for students to gain a solid and deep understanding of the content. This paper aims to show that presenting to students in a way that highlights the step-by-step process in deriving equations or solving problems is central to achieving this. The changes made in Signals and Systems to a refined and balanced 'chalk-and-talk' lecturing style, which inherits the advantages of traditional 'chalk-and-talk' teaching, while being complemented with an appropriate use modern lecture theatre technology, has demonstrated that not all Engineering subjects benefit in terms of effective student learning, by using PowerPoint in their lectures.

KEYWORDS
Chalk-and-talk, Signals and Systems, PowerPoint

Introduction

Signals and Systems is a second year core course taught in the four-year Bachelor of Engineering in Electrical and Electronic Engineering at the Griffith University on the Gold Coast campus. Signals and Systems is the first course that electrical engineering students encounter in their degree, where there is a heavy use of engineering mathematics, such as differential equations, integral calculus and complex numbers. The course largely deals with the mathematical description of continuous-time signals and the analysis of linear time-invariant (LTI) systems. Specifically, the concepts that are covered include singularity functions, convolution integral, Fourier series, Fourier transform and Laplace transforms. Therefore, this course exposes students to important fundamental concepts, such as impulse response, orthogonal signals, frequency response and system transfer functions, which are used in other engineering fields and are taught later in the degree, such as control systems, digital signal processing, communications, circuit design, etc.

It is well-known that Signals and Systems is a challenging course, both for students to learn and for lecturers to teach. As pointed out in previous studies (Vaz and Arcolano, 2001, Ayazifar, 2009), the course is heavily dependent on high-level mathematics (calculus and differential equations) and deals with many abstract concepts that are "in large part detached from daily experience" (Nasr et al., 2003). The question that arises from this is *what is the best way to teach this core and mathematically-intense discipline of electrical engineering in a way that promotes student learning, retention and understanding?* This paper endeavours to address this question by reporting on changes made to the teaching style in the Signals and Systems course. Prior to 2008, the course was delivered using static PowerPoint™ slides, which were also made available online to students (an example is shown in Figure 1 below). The course was modified in 2008, where the teaching delivery style was changed to a refined form of the traditional 'chalk-and-talk'. Appropriate forms of PC-based demonstrations were used to complement the lectures. However, students were expected to take notes from every lecture since they were not provided online.

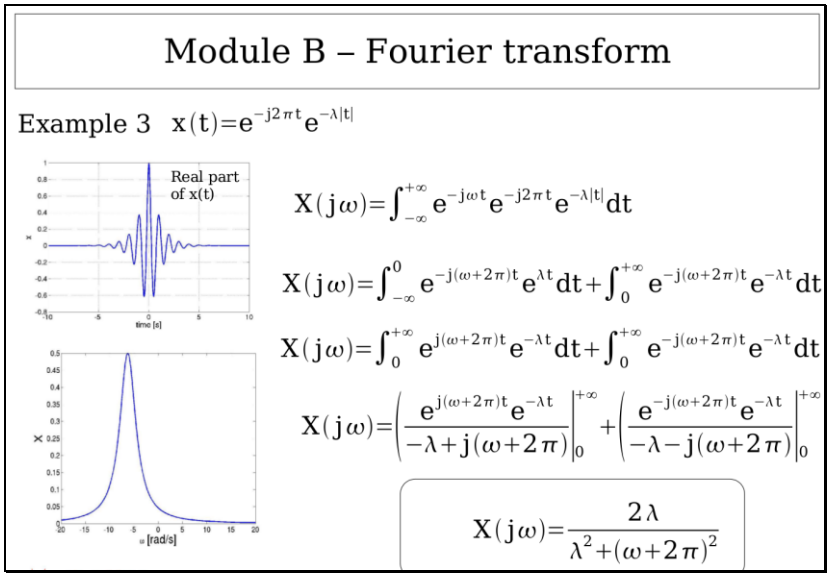

Figure 1: Example of a PowerPoint slide from Signals and Systems (prior to 2008)

The structure of the paper is as follows. The first section will review the relevant literature on lecture delivery styles, specifically on the merits and effectiveness of traditional 'chalk-and-talk' versus PowerPoint. Following on from this, a case will be made on the advantages of traditional lecture style in teaching Signals and Systems. The methods adopted in Signals and Systems to refine the traditional 'chalk-and-talk' to best utilise modern lecture theatre technology will then be described. The effectiveness of these changes will be reflected in the results from student evaluations and questionnaires, which will be presented and discussed.

The final section will conclude as well as detail further work that will be investigated in future offerings of the course.

Literature review

The debate over traditional 'chalk-and-talk' versus slideware (e.g. PowerPoint) has been continuing ever since the introduction and popularisation of Microsoft PowerPoint™, which is estimated to be used in 20 to 30 million presentations every day and up to 400 million users around the world (Alley and Neely, 2005). Universities and the majority of engineering academics have embraced the use of PowerPoint as it "provides the lecturer with the opportunity to clearly present their work in a variety of written, graphical and visual formats" (Grainger, et al., 2011). Studies have also reported that PowerPoint-based lectures increase the interest level of the students as well as the likeability of the teacher (Apperson et al., 2006). There are also critics on the use of PowerPoint for presentations, most notably Edward Tufte, who in his book "The Cognitive Style of Powerpoint", claims the software "weakens verbal and spatial reasoning, and almost always corrupt statistical analysis" and its reliance on bullet points without the in-between narrative "ignores and conceals the causal assumptions and analytic structure of the reasoning" (Tufte, 2003). Several past studies have attempted to correlate the use of PowerPoint with student performance. DeBord et al. (2004) found that computer-assisted instruction (PowerPoint slides) had no effect on student performances in introductory psychology classes in comparison to traditional overhead projection methods. Similarly, Apperson et al. (2006) found that PowerPoint also did not enhance the final student grades. On the other hand, Amare (2006) reported that while students preferred PowerPoint, their performance scores were higher when taught in the traditional lecture format (i.e. chalkboard, handouts, teacher at the podium). Similarly, the study by Savoy, et al. (2009) found that although PowerPoint was the preferred format, students retained 15% less information delivered verbally during PowerPoint presentations.

We note that many of these past studies were based on data collected from students enrolled in non-technical courses, such as Psychology (DeBord et al., 2004), Sociology, History and Political Science (Apperson et al., 2006), Technical writing (Amare, 2006) and Human Factors in Engineering (Savoy et al., 2009). There is not as much literature on the effectiveness of traditional lectures versus PowerPoint in the technical and mathematics-based disciplines, such as engineering. Button (2011) discusses the problems encountered with teaching mathematics using PowerPoint, where he points out that it "reinforces a view of mathematics that it series of algorithms to be rote-learned [sic]" and it is "usually a static form of mathematics". Ressler (2004) argues the case for chalkboards in the context of engineering lectures, noting that the written information is persistent and remains visible to students, even after moving on to a new topic. In the case of using PowerPoint, flipping through past slides to refer to previously discussed topics detracts from the learning experience, because "the learning process is about making connections" (Ressler, 2004). He also argues that traditional lecture formats are "self-paced" and encourages students to take notes, which has been shown to "promote student learning". This is reinforced by the study done by Kiewra and Benton (1988), where they found that "the ability to hold and manipulate propositional knowledge in working memory" was related to the amount of notes recorded by the student. Finally, Ressler (2004) argues that note-taking develops the students' skill in graphical communication, which is an important skill in engineering education.

The case for traditional 'chalk-and-talk' in teaching Signals and Systems

Signals and Systems is a course that is highly reliant on algebraic manipulations and high-level mathematics, such as differential equations, integration, and complex numbers, as well as drawing and visual ability (reading and sketching signals, block diagrams, frequency spectra, pole-zero plots, etc.). Furthermore, mathematical derivations and line-by-line examples play an important part in promoting the understanding of the concepts. The

process employed in derivations and examples is not communicated well by PowerPoint slides, since the content is effectively static. The PowerPoint slide example from the Signals and Systems course prior to 2008 (as shown in Figure 1) presents long and complicated equations to students in a single instant, rather than a gradual progression of individual steps. Some intermediate steps were left out so that the example could fit on one slide using a reasonably-sized font. The lecturer would typically fill in the missing bits of information verbally and expect the student to watch and listen attentively at the same time. However, some studies have reported that students tend to pay more attention visually to the slide contents rather than listening to the presenter (Driessnack, 2005, Savoy et al., 2009). On the other hand, when performing derivations or solving examples in a traditional lecture setting, each step can be written separately, allowing the lecturer to pause and explain, while posing questions to the students on what the next step should be. Students can see the process of the solution uncover itself gradually without the clutter, as well as be given the opportunity to think and ask.

Another important aspect to consider when teaching Signals and Systems is for students to see the connections between various concepts, such as the derivation of the Fourier transform from the Fourier series and also its relationship with the Laplace transform. Ressler (2004) argues that the traditional lecture format enables students to "construct meaning—by making personally meaningful connections between newly acquired information and a complex web of prior-learning". This is possible since written information on the blackboard is persistent. In PowerPoint, the lecturer has to either rewind the slideshow back to the previous topic on Fourier transforms to show the comparison or use a separate slide to show the relationship, but with formulas that are detached from the derivations.

Refining the traditional lecture style with use of modern lecture theatre technology

Most Universities in Australia now have modern lecture theatres that are equipped with various PC and multimedia technologies for delivering and recording lectures. These include multimedia projectors, DVD players, visualisers, screencasting and podcasting (Grainger et al., 2011). At Griffith University, academics are highly encouraged to utilise these lecture theatre technologies instead of 'out-of-fashion' and 'technologically-unsophisticated' facilities such as overhead projectors (OHPs) and blackboards/chalkboards, which have been gradually phased out. Even whiteboards themselves are making way for PowerPoint projections, where they are either diminishing in surface area or are partially covered by the projector screen. Furthermore, in order to facilitate those students who work part-time and therefore are unable to attend every lecture, the University is encouraging the use of Lectopia™ screen capturing, which captures the audio as well as what is projected on the screen.

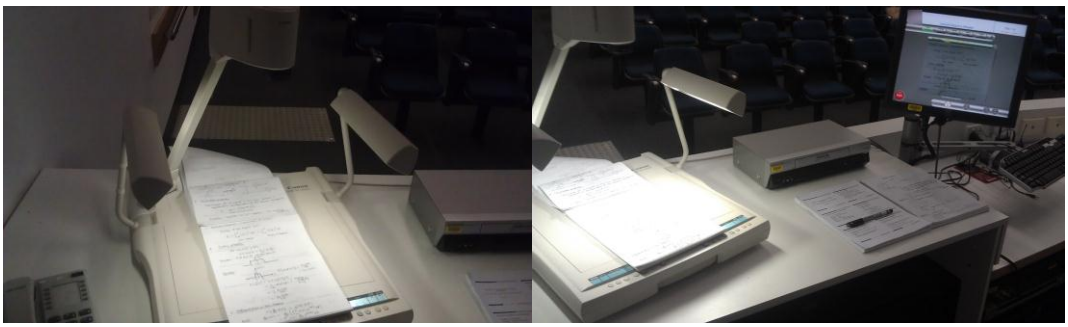

Figure 2: Delivering 'chalk-and-talk' lectures using a lined A4 pad under a visualiser

Therefore, it is not possible to perform a useful screen capture if the lecturer is using the whiteboard for explanations. Since 2008, lectures in Signals and Systems are delivered

using a refined ‘chalk-and-talk’ method, where the lecturer writes on a lined A4 pad that is projected onto the screen using a visualiser, as shown in Figure 2. This method is not considered particularly novel, since it is not uncommon for other academics to use the visualiser for showing the class a quick handwritten solution, but its extensive and predominant use in delivering entire lectures in Signals and Systems is unique at the Institution. This refined method brings together some of the advantages of the traditional method, such as showing process and connection to promote understanding; encouraging students to do note-taking, which reinforces information retention and improve critical drawing skills; and is self-paced to allow the class to write, stop, and ponder on what was covered. In addition, it also overcomes some issues with writing on a real blackboard, such as having the lecturer’s back facing the students while writing, which results in a loss of eye-contact; obstructing a portion of the board; and writing too small for a class in a large lecture theatre to read (Ressler et al., 2004).

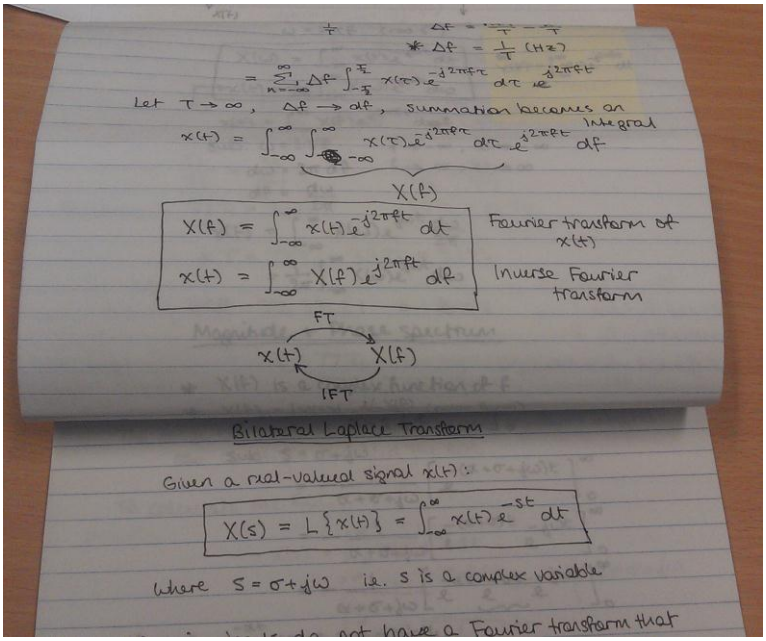

Figure 3: Referring back to previous topics to make the connection between Fourier and Laplace transform

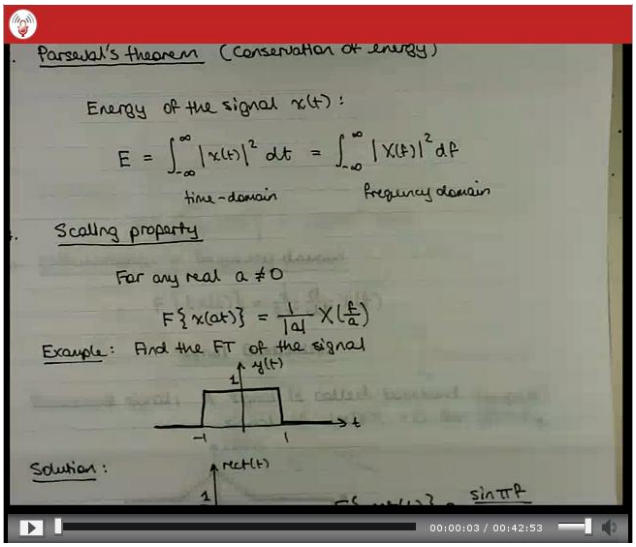

Figure 4: Streaming Lectopia™ screen capture of a Signals and Systems lecture

Writing on the visualiser can be done while facing the students (as shown in Figure 2) and normal handwriting can be enlarged by the zoom functionality on the visualiser. Previous

topics and equations can be easily referred to by folding the previous pages so that they are in the same view, as shown in Figure 3. Complicated diagrams and graphs can be printed onto A4 paper and shown, when required, using the visualiser. The projector can be switched to the PC view for software-based demonstrations of concepts like convolution, Fourier series, etc. All of these features are used in a common framework that is able to be recorded by Lectopia™ screen capture, as shown in Figure 4. Finally, the A4 pad forms a complete set of notes that can be used as a reference for future deliveries of the course, therefore enabling a consistent and organised structure.

Evidence of success

Student grade distributions

Figure 5 shows the student grade distributions from 2004 to 2010. It can be observed that starting from 2008, when the changes to the lecture delivery style were made, the number of high distinction (HD) students increased rather dramatically. Major structural changes to the first year program were made in 2011 that adversely affected the prerequisite knowledge of the students coming into this course. Therefore, we have not included grades from 2011 onwards since they were affected by external issues.

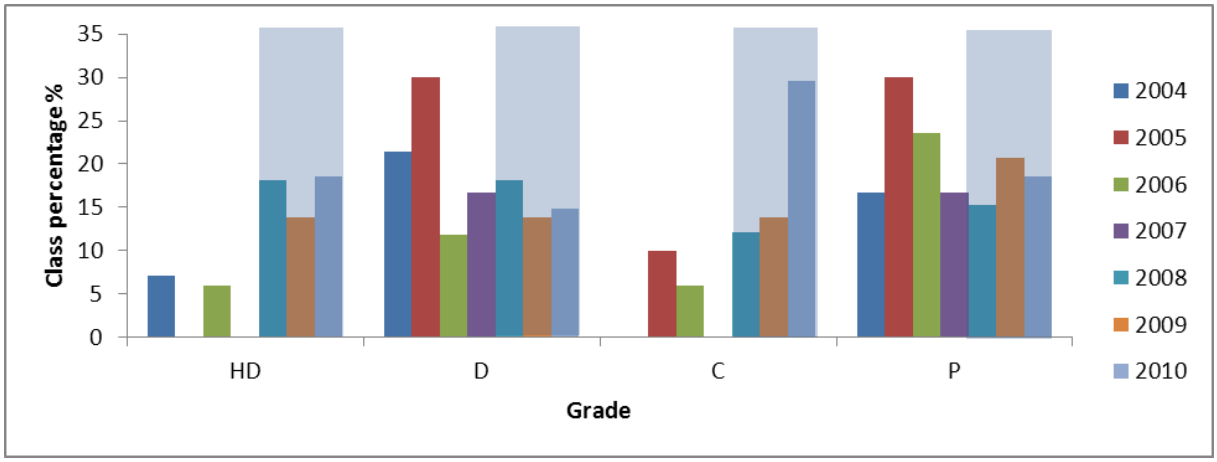

Figure 5: Grade distributions in Signals and Systems from 2004 to 2010 (Shaded region indicates when lectures were delivered in the refined 'chalk-and-talk' lecture style)

Student feedback (quantitative)

Quantitative feedback from the student questionnaire is presented in Table 1. The participation rate was approximately 36% (from a class of 59) and was taken from the Signals and Systems class of Semester 1, 2012. It can be observed that the majority of the participants strongly agreed with questions 1, 2, and 4. More specifically, a majority of the participants recognised that for this particular type of course, the 'chalk-and-talk' delivery style allowed them to see and understand the process (Q1) and the notes taken were a more concise resource than PowerPoint slides (Q4). There was, however, less agreement on the question of 'chalk-and-talk' better assisting in the retention of knowledge (Q3). The participating students also studied three other courses (Analog Electronics I, Mathematics 2A, Digital Systems) in the same semester, all of which utilise PowerPoint presentations for lecture delivery. The first two courses have similar content (e.g. electric circuit analysis, frequency response, etc.), as well as mathematical complexity and process (e.g. integration, ordinary differential equations, Fourier series and transform, etc.). Therefore, the students could easily compare the effectiveness of different delivery styles in the same discipline-specific context.

Table 1: Five-point Likert scale results from student feedback (Legend: SA – strongly agree; A – agree; N – neither agree nor disagree; D – disagree; SD – strongly disagree)

Question	SA	A	N	D	SD
Q1: *I find that 'Chalk-and-talk' delivery is more suitable and effective in this course than PowerPoint presentations*	47.6%	38%	4.8%	8.5%	0%
Q2: *The 'Chalk-and-talk' delivery allows me to see and understand the process of solving examples and problems better than PowerPoint presentations*	52.4%	38.1%	4.8%	4.8%	0%
Q3: *The 'chalk-and-talk' delivery of this course better assists in the retaining of knowledge in this course than PowerPoint presentations.*	28.6%	57.1%	4.8%	9.5%	0%
Q4: *The notes taken down in the lectures provide a more detailed and concise resource for studying the course than PowerPoint slides.*	52.4%	23.8%	9.5%	14.3%	0%

Student feedback (qualitative)

Table 2 lists typical student responses obtained from both the student evaluations and student questionnaire. Responses from the latter tended to be in depth because the questionnaire was more focused on the topic of lecture delivery. The qualitative section of the student questionnaire also provided an opportunity for students to write about what they thought about difference in lecture delivery styles in an unconstrained and open-ended fashion. This is important in reducing the effect of acquiescence bias, as Likert-scale questions, by their very nature, are often leading (Johns, 2010). Students appreciated the benefits of traditional lecture delivery in a mathematically-intensive course and some have described the problems associated with the use of PowerPoint slides. Some have noted the act of writing helps in the understanding and retention. Also a student noted that the 'chalk-and-talk' method improved their motivation to attend lectures and others commented that it moderated the pace of lectures. The common theme from the written feedback is that 'chalk-and-talk' encourages more activity from the students during lectures and this 'activeness' leads to better understanding and retention. These comments and feedback provide sound evidence of the effectiveness of the 'chalk-and-talk' method in Signals and Systems.

Table 2: Student responses from student evaluations and questionnaire

Responses from the student evaluations for the questions: • ***What aspects of this staff member's teaching were most valuable to your learning?*** • ***What did you find particularly good about this course?***
"Writing by hand drills in concepts better than with pre-printed notes or lecture slides"
*"*Clear Handwritten overheads none of that powerpoint crap"*
*"*Use of overheads rather than slideshows"*
"The use of hand writing a lot of the material did help enforce the information..."
"Lecture notes are awesome"
Responses from the student questionnaire on the lecture delivery style
"Taking notes in class forces the student to actively learn and not just think that they understand the content of slides, the content is remembered better through this approach. Even if the content is not

understood completely it can be wrote down, which is better than blankly staring at slides without a clue, the act of writing aids in the understanding of the material, allowing each problem to be solved step by step."

"This style also increases attendance for the whole semester and motivation to attend, i find myself never missing a class, its good the notes arnt put on the internet, but it is a lot better with the expanded notes to look at if the class is missed. and just writing the information down while hearing it helps it sink in even if i am not paying full attention (as well as stops the mind from wondering). it works well with a lecturer that is organised. it is very suited to signals and systems. i find that it has made the hardest class (in content) of my semester seem easier then others"

"I believe that the 'chalk and board' method is best for this course because the process of solution is seen, rather than viewed briefly. Also while you work through the solutions the methodology can be observed, ideal for learning the approach to problems presented."

"For this particular course, using Powerpoint presentations is probably as good as having no lectures and just getting us to read through a textbook. Powerpoints would most likely lead into the lecturer just reading off the slides, whereas a chalk-and-board presentation would basically force the lecturer into explaining what is going on while the content is being delivered. (Chalk-and-board = Very Good)"

"I find that courses that involve this method of teaching makes it much easier to learn the subject at hand, as if you have a problem, you can just go back in your book and find it. If a powerpoint presentation is used, the lecturer may go too fast for the students to write down all that is necessary, but with this method, the lecture must go through the same steps, to give a fairly accurate time frame of how long a particular question could take in an exam situation."

"Writing down and going through examples is very helpful in learning and retaining knowledge as well as for future reference."

"Chalk-and-board is an effective method for getting students to write down the information in a hope that it will be more absorbed than just listening to it. For myself, though, I found it came at a cost of listening to what you are actually saying while writing, my mind was so fixated on coping everything you had written exactly that a lot of what you said went 'in one ear and out the other'. I would probably say at this point in time I know a lot less than I should about the course content ..however, when it comes to studying for the exam, I now have an entire book written with my own notes, comments and examples in it, that's perfectly structured to this course. At first I very much disagreed with this method, but now (after having to study a lot), I'm finding how valuable it is to having this structured study book. If I get stuck on a problem I know exactly where to go, its written in my notes with my own little comments to the side, and there are several examples. Overall I'd have to say I'd be happy to be taught like this again, in fact it's now probably my preferred method."

Conclusion and future work

For engineering subjects that are by nature abstract and highly mathematical, the desired objective is for students to gain a solid and deep understanding of the content; and presenting to students in a way that highlights the step-by-step process in deriving equations or solving problems is central to achieving this. Changes were made in Signals and Systems to a refined and balanced 'chalk-and-talk' lecturing style, which inherit the advantages of traditional 'chalk-and-board' teaching while being complemented with an appropriate use of modern lecture technology, such as visualisers and Lectopia™ screen capture. According to the feedback obtained through the University's student evaluation system as well as the questionnaire, many students identified the advantages of 'chalk-and-talk' lectures over PowerPoint-based lectures, the latter of which is probably the most common style of delivery in the Engineering program.

It is recognised though that a more rigorous and controlled study is needed to validate the question of whether 'chalk-and-talk' is better than PowerPoint in promoting student learning in Signals and Systems. In the current study, students could only compare with their PowerPoint experience in other analytical courses. Further research is being planned in order to achieve a better answer to the research question. Signals and Systems students would be taught using both modes of lecture delivery in a semester (half and half). The effect

of each mode on student performance and knowledge retention would then be measured via a series of quizzes and questionnaires.

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