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New Syllabus, New Approach: Preparing Physics Students for University Studies with a Structured Approach to the Year 11 Course

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About the Authors

Dean Johnston is a Science teacher, specialising in Physics, and recently was appointed as Assistant Coordinator of Science (Stage 4) from 2019. He holds a Bachelor of Science (Physics) and Diploma of Education from Macquarie University. Dean was excited to join the teaching staff in 2017, particularly as he is a former student whose character and intellect was substantially developed by the teaching and guidance he received whilst at Barker. He is passionate about instilling a deeper appreciation of science in young students and is continually seeking ways to challenge the status quo of science education in secondary school.

Dr Matthew Hill is currently Developer of Hearts and Minds Research at Barker College. His PhD promoted the importance of students' developing representational fluency for learning and communication in order to be able to succeed in science education. He has worked in research, teaching and educational leadership at The University of Sydney and the University Western Sydney, publishing in academic journals related to each of these areas before coming to Barker in 2016. While maintaining a specific interest in physics' education research, his work now focusses on developing student capacity in thinking, discussion, philosophical reasoning and personal development.

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Abstract

When students reach university, many classes are optional which will often result in dwindling attendance and, consequently, attrition from the course (Baik, Naylor, & Arkoudis, 2015). In 2018, three Year 11 Physics classes had the opportunity to participate in an initiative whereby their classes were structured in a similar format to a first-year university Physics course with lectures, tutorials and experimental work. Students benefitted from the new structure as they were aware of what to expect in upcoming classes and their revision of the course was simplified due to content being divided into week-by-week topics. In an anonymous survey (n = 39), 79.5% of students stated a preference for this structure in their science classes as compared to a more typical lesson-by-lesson approach. By implementing this method of course delivery, it is the intention of the coordinating teachers that students would learn physics effectively, that they would see the value of the structure and therefore be more prepared for university studies and that teachers' skills and expertise could be best utilised for the benefit of the students.

Key Terms

Experiment

A scientific test including an aim, method, results, analysis and conclusion.

Lecture

A lesson that is delivered to a group of students larger than the typical class size (< 25 students). This is not meant to imply mere transmission of knowledge or inactive attendees (e.g. Sharma et al., 2010). There is no limit to the method of teaching and engagement, merely the ability to deliver the lecture to a larger numbers of students.

Team-teaching

A coordinated approach among multiple teachers taking responsibility for a group of students. It usually involves different teachers facilitating different parts of the course.

Tutorial

A lesson devoted to guiding students through problem solving. May involve practical, conceptual, or numerical problems or activities.

Tutorial Problems

A set of problems written for the students to allow them to grow in their understanding of physics and develop their problem-solving skills. At least some of these problems should be done during a tutorial lesson but all are to be completed before the start of the following week.

Introduction

To assist students with their learning, a new initiative was trialed with three Year 11 Physics classes involving a university-style structured week. At the start of the year, the teaching team consisting of the two authors of this article divided the new NSW Physics syllabus outcomes into weekly topics. The practical component of the course was then aligned such that the most appropriate experiment would occur each week to either allow students to inquire about upcoming content or consolidate material from that week. The two staff members involved were assigned alternate weeks to prepare a lecture and tutorial problems for the students.

The structure of the course: A university-style format with school-level personal relationships

Each week one topic area of content was presented Year 11 Physics students. The weekly structure consisted of an interactive lecture, a problem-solving tutorial and an experiment or practical tasks.

Students from three classes were involved in this initiative. Two were assigned to be taught by Dr Hill and one by Mr Johnston. One of Dr Hill's classes was synchronised (timetabled concurrently) with Mr Johnston's class, allowing for one lecture to be delivered to two classes simultaneously in a lecture theatre and this lecture was repeated by Dr Hill for his second class.

Lesson 1 (Monday)	Lesson 2	Lesson 3 (Friday)
Interactive lecture	Tutorial	Experiment
Students attended an interactive lecture designed to cover all content required for the week.	A set of practical, conceptualand numerical problems were completed by the students and various techniques were used to provide in-class support	Students completed a scientific investigation with aim, method, results, analysisand conclusion to apply their understanding and continue to develop their scientific inquiry skills.

The 2018 fortnightly timetable involved seven 1-hour classes for Year 11 physics. This meant that every second week there was an additional class alongside the above structure. This additional class was therefore a discretionary class to allow for more time to be spent on any activities as directed by the teachers. It was particularly helpful as the new syllabus introduced for Year 11 in 2018 required substantial class time to be given over to a "depth study", where students investigated a topic of their choosing.

The purpose of the structure: most effective learning, preparation for university, maximum utilisation of teacher resources.

Various pedagogical factors impacted the decision to adopt this particular structure. The staff wished to balance the limitations of working memory and the need for students to complete sustained, deliberate practice to develop knowledge in long term memory. Cognitive Load Theory explains that working memory is limited, meaning that students are unable to process too many new pieces of information at one time (Paas, Renkl, & Sweller, 2003; Sweller, 1988). By communicating to students the content topic of the entire week, they were able to find continuity between classes and use repetition across multiple occasions to more fully integrate new ideas into long term memory. This structure avoided students distracting themselves (and others) with the oft-asked question, "What are we doing today?" because they had already been made aware and could see the connection of the particular class and associated activities with the topic of that week.

A second reason for adopting the structure was to expose students to a model that is frequently used at universities, especially in the sciences. This purpose was vindicated in the first lecture as it was apparent to the teachers that students were unfamiliar with how to effectively participate in a lecture-format lesson. For example, many were trying to write down every single word from the projected presentation, even though students knew the presentation was made available online at the end of each class. Lecture participation was a skill that was taught, both explicitly and implicitly, throughout the year.

Finally, the staff decided that this was an effective use of teacher resources. Rather than each teacher preparing content for their own class every week, by taking responsibility for every second week they were able to devote up to twice the time investment producing an even higher calibre of learning activities for the students.

Student responses

During Term 3 (the final term of Year 11), participating students were surveyed to gauge the level of support for the new format. Responses were collected voluntarily and anonymously using Google forms, increasing the validity of the responses and 39 out of the 58 students responded.

Students were overall supportive of the format, with 79.5% indicating that they preferred it (at least in the context of learning Physics) over a typical lesson-by-lesson format that they were used to in high school: "You always know what's coming up."; "It's habitual rather than random lessons... Missed work is easily caught up on, because we have a structured idea of what the lesson was on e.g. tutorial, prac or lecture." They were able to recognise the benefits to their planning and individual work habits, resulting in an increased understanding of how repeated practise allowed consolidation of difficult ideas:

- "I am able to plan my work more effectively so that I have an understanding of the content through the lecture before I tackle the exercises in the tutorial. This is then backed up by experience in application of these skills.",
- "I also found the order of learning the content and then answering questions on it and then doing a prac very helpful for ensuring that I understand everything and it is all committed to memory."
- "The week-by-week (structure) allows for me to have a much better structure in terms of learn → review → revise. I think it creates a better understanding."

Standard practice of most university courses is to provide students up-front with most (if not all) necessary reference material and sources of additional information. We attempted to emulate this by publishing lecture slides, tutorial problems (with solutions), practical investigation guides and supplementary resources (e.g. internet-based simulations, comprehensive websites), all organised in the same week-by-week structure for ease of navigating. One student said, "I am able to access any topic easily under the corresponding week and have access to all the content we have covered. This makes revision much easier."

Students who preferred a more traditional method of high school instruction explained that they preferred to be able to better internalise the information immediately upon receiving it through class discussions, asking questions, or solving problems rather than needing to wait to do this comprehensively in the tutorial lesson: "I prefer having more time to ask questions/have discussions while the content is first being taught". The authors have begun

to address this for Term 4, 2018, through continually increasing the degree of interactivity during lectures, along with supplying a whole booklet of the weekly tutorial questions at the start of the module. This allows students to begin working on the tutorial problems immediately (even sometimes during the lecture with support from the teacher and fellow students) while still having a dedicated tutorial period later in the week. The students were pleased with this development of the structure for Term 4.

Teacher reflections

Typically, teaching in secondary schools has taken the format of one teacher being assigned a particular class and that teacher having responsibility for ensuring that these students are taught the relevant mandated content (as prescribed by a syllabus) and given guidance to develop and then demonstrate, the necessary skills and applications of the acquired knowledge. In and of itself, this mode of teaching is not flawed and — as evidenced by its continuation — remains a standard framework. The authors, however, contend that this is an example of an inefficient and limiting structure.

Increasingly, teachers are required to develop their professional practice through attendance at external development conferences and activities. There are benefits of such professional development activities but what is often overlooked is the myriad opportunities for the teacher within the routine of their regular teaching schedule. For example, the teacher who was not scheduled to prepare and deliver a lecture in a particular week would still be in attendance. This offered not only the ability for the lecturing teacher to 'throw' to the other teacher for additional input and/or alternative perspective but also the opportunity for the observing teacher to observe their colleague teaching; the observing teacher would experience the different nuances and emphases of the other teacher, as well as any alternative methods of explanation and analogies that may be employed. Often, the lecturing teacher would receive immediate feedback and insights from the observing teacher following the lesson and professional discussion benefitting both teachers would ensue.

By taking turns to prepare (and deliver) content each week, the staff were able to use additional time to provide instruction of an even higher quality, which was especially important this year as it was expected that teachers would be more heavily burdened due to the implementation of a new syllabus. In particular, there were opportunities for teachers to focus more on individual student needs, both in and out of class, resulting in heightened relationships rather than diminished ones due to the introduction of the lecture format.

Improvements for 2019 and Future

The pledge of any practitioner should be an ongoing striving to better that which has already been achieved; our desire is to facilitate the most effective, engaging and student-centred Physics course of any secondary educational institution.

To that end, we have identified several areas for improvement and/or expansion:

- Involving more teachers to bring in additional collaboration and synchronised delivery of the course to more students. (The authors acknowledge the difficulty of this given timetabling constraints, though believe that this in and of itself should not be reason enough to discount the possibility of having all Physics classes scheduled simultaneously for at least the weekly lecture.)

- Providing students, at the beginning of the course, with a booklet containing tutorial questions (both mandatory and extension work). The problems would be ordered in progressive difficulty and fully-worked solutions would be available, either in digital or hardcopy.
- Weekly, short quizzes (utilising the online platform of Canvas) whereby students will demonstrate a base competence in each concept.
- A common style and format for all digital and printed materials.
- Filming of each lecture and uploading to Canvas, allowing students in attendance to review but also providing those students who were absent an easy means of catching up.
- Increased interactivity of lectures, for example utilising Interactive Lecture Demonstrations which are a proven method of effective lecture-style teaching in the physics discipline (Sharma et, al., 2010).
- While not all subjects have the same content requirements and student candidature as Physics, we believe that there are lessons that can be learned for teachers throughout the school. In particular, this article demonstrates the benefits of staff collaboration, communicating clear structure to the students, and modelling practices helpful for university study which can be considered for all courses across various year groups.

Conclusion

This article has demonstrated how innovation, collaboration and reflection can result in an exciting development in teaching at Barker and beyond. There are great opportunities for teacher professional development, along with facilitation of greater time invested in each lesson despite reducing the preparation time commitment for increasingly busy teachers. Most importantly, the students have appreciated the changes and all of this contributes to increased outcomes for students, particularly in the area of learned content, skills and self-regulatory behaviors.

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