SENIOR PHYSICS SHORT COURSES

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KEYWORDS: senior physics, short course, Year 11, Year 12, ATAR, secondary school, teacher education, professional learning

ABSTRACT

To mitigate a shortage of qualified senior physics teachers, the Western Australian (WA) Department of Education funded six Year 11 and three Year 12 Australian Tertiary Admission Rank (ATAR) physics short courses for out-of-field secondary school teachers. These intensive five-day courses were delivered at the Joondalup campus of Edith Cowan University (ECU) from 2015 to 2019. The courses included lecture, tutorial and laboratory components. While aimed at secondary science and mathematics teachers with some past knowledge at senior physics level, teachers with no previous physics or university level physics were also able to enrol. The Department of Education funded course fees, textbooks, travel and accommodation for participants as well as relief teachers for schools during participant absence. This paper will provide an overview of the Year 11 and Year 12 courses, key features of the teaching and learning environment, and evaluation by teachers. A total of 131 teachers have completed the nine courses offered, with end of course surveys of the teacher participants consistently showing high satisfaction ratings.

Proceedings of the Australian Conference on Science and Mathematics Education, 29 September - 1 October 2021, pages 59-63, ISSN 2653-0481

INTRODUCTION

There is a shortage of physics teachers and the active recruitment of physics teachers for secondary schools needs to be a priority (Dow, 2003; Goodrum, Druhan, & Abbs, 2011). Two recent publications from the Australian Council for Educational Research (Wheldon, 2015; Wheldon 2016) on the Australian teacher workforce found that in 2013 about 20% of physics was being taught by out-of-field teachers. As a comparison, the figure was less than 10% for both biology and chemistry. If teachers without both a second year tertiary physics unit and some tertiary study in physics teaching methodology are also included in the out-of-field definition, then the figure for physics doubles to about 40%. In addition, the proportion of teachers in physics over 50 years old was reported at about 40% indicating that the national shortage could worsen in the near future as these teachers retire.

In response to shortages of qualified teachers in some subject areas, the WA Department of Education has been introducing short courses in key areas, including physics. In 2015, funding was provided for Edith Cowan University (ECU) to develop and deliver a Year 11 ATAR Western Australian Certificate of Education (WACE) Physics short course as part of the WA Department of Education “Switch” program (now “Leap”) for out-of-field teachers. The first Year 11 physics course ran in November 2015, with a further two courses in 2016. In 2017, the short course offerings were expanded to include Year 12, with both Year 11 and Year 12 courses in ATAR physics being delivered in 2017, 2018 and 2019. The senior physics short courses were developed and taught by the author, who has previously been employed as a physics academic at ECU, with earlier experience as a secondary school teacher of physics, science and mathematics.

Although the intention of these courses was to provide a physics content refresher for teachers who had completed some senior secondary physics in the past, teachers with a range of backgrounds, from no physics to university physics, were also enrolled. The courses were categorised as 30 hours of professional learning; not formally assessed and not counting for credit as part of any university qualification. Back in 2015, consideration was given to run the course over a period of 10 weeks with online components and on-campus face-to-face time of three hours per week that would allow time for reflection and consolidation. However, this was not a practical option given the various requirements of the Department of Education, public schools, and in particular, the location of teachers in country and remote areas. Hence, the decision was made to offer short, intensive one week-long courses.

In total, six Year 11 and three Year 12 physics courses have been completed with the most recent Year 11 and Year 12 courses both delivered in November 2019. Almost all participants were science or mathematics specialist teachers coming from all over the state, with many teachers from country and remote schools. The WA Department of Education provided all funding to cover course fees, textbooks, travel and accommodation for participants as well as relief teachers for schools during their absence. This paper will provide an overview of the physics short courses, discuss the teaching and learning environment, report on the evaluation of the courses by teachers and conclude with implications for the future.

COURSE OVERVIEW

Each course ran for five consecutive days from 9am to 4pm with each day broken up into four sessions. While the nominal allocated time for each session was 90 minutes, actual session times ranged from 60 minutes to 120 minutes. This flexibility was built in to maintain high teacher engagement and to better allow for logical starting and stopping points within each topic. Both the university physics laboratory and a tutorial room were booked for the duration of the course as the physics laboratory was unsuitable for lecture and tutorial work.

Given the time constraints of the course, the primary focus was to cover the science understandings strand of the WACE Year 11 and 12 ATAR physics courses, and make references to science inquiry skills, science as a human endeavor, general capabilities, and cross-curriculum priorities when particularly relevant (School Curriculum and Standards Authority, 2014). The main priorities were to ensure that teachers had the correct physics conceptions as well as the tools, including confidence, to build on their knowledge and skills both during the course and in the future.

The topics covered in the Year 11 course are:

- Heating processes
- Ionising radiation and nuclear reactions
- Linear motion and force
- Electric circuits
- Waves

Roughly a day is spent on each topic. Year 11 physics is highly conceptual and the daily laboratory sessions typically include several experiments to develop and consolidate teachers’ conceptual knowledge.

The topics covered in the Year 12 course are:

- Gravity and motion
- Electromagnetism
- Wave particle duality and the quantum theory
- Special relativity
- The standard model

‘Gravity and motion’ is the longest topic, while ‘special relativity’ and ‘the standard model’ are fairly short. The Year 12 course includes two three-hour laboratory sessions.

TEACHING AND LEARNING ENVIRONMENT

The teaching and learning environment was mostly expository in nature with a mixture of lecturing and tutorial learning activities. Microsoft PowerPoint slides included outlines of the theory, interactive multimedia simulations, short videos, and examples. Short small group discussions of relevant concepts and alternative conceptions were particularly important in the Year 11 course. The whiteboard was used to aid in conceptual development and for worked solutions to some problems. A multimodal and varied approach was taken for working with the content.

There was insufficient time for teachers to do sufficient problems to gain mastery over the content, so particularly illustrative examples were given and tutorial questions carefully selected for teachers to attempt in class. Much confidence was gained by teachers successfully answering these questions and this was particularly true with the use of recent exam questions in the Year 12 course. Teachers were given additional problems (with worked solutions) for them to consolidate their knowledge in the weeks following the courses, if they get the opportunity.

These courses were all about preparing teachers to teach physics. In all topics there were occasions when higher level physics content was introduced; all good teachers need to have some content knowledge beyond that explicitly stated in the secondary school syllabus. One example of this would be some understanding of Kirchhoff's rules in Year 11 electrical physics (Giancoli, 2016). Teaching methodologies were modelled, and personal secondary school and university examples of teaching physics discussed. Teachers clearly wanted to gain both physics content knowledge as well as pedagogical content knowledge (PCK) which, in addition to curricular knowledge, are key requirements for all good teachers (Shulman, 1986).

In the Year 11 course, the daily laboratory sessions were based primarily on teachers doing a series of short experiments in groups of two or three. The experiments generally corresponded to the day's topic and the material covered in workshops in the morning sessions. They were aimed to assist teachers in gaining a conceptual understanding of physics and followed a Predict-Observe-Explain (POE) methodology which is commonly used in science to encourage conceptual change (Venville & Dawson, 2012). There were also some demonstrations (e.g. Van Der Graff generator), whole class experiments (e.g. finding absolute zero temperature) and development of various skills (e.g. graphing with Microsoft Excel).

In the Year 12 course, the experiments were more substantive and consolidated into two three-hour sessions on Tuesday and Thursday afternoon. Participants used a mix of expensive (e.g. PASCO Data loggers) and inexpensive (e.g. Conical pendulum) equipment. Six Planck's constant boxes (manufactured by Industrial Equipment & Control), with seven LEDs in the visible and near infrared parts of the spectrum, were purchased specifically for the Year 12 courses in 2018. Measuring the voltage required for LEDs to have a current of 2μA (i.e. begin to light up) is a simple and elegant way to measure Planck's constant. At $99 each, this experiment is very affordable for schools on limited budgets and teachers were all highly satisfied with this authentic secondary school activity. The other experiments in both Year 11 and Year 12 courses used existing equipment in the physics laboratory.

In addition to a copy of lecture presentation slides and a laboratory manual, teachers were also given textbooks. The main textbook (Giancoli, 2016) is a popular algebra-based physics textbook for first year university students without a physics background that covers both Year 11 and 12 physics content well, but at a slightly higher academic level in terms of both physics and mathematical content. The additional textbook for the Year 11 course (Hewitt, 2015) is an outstanding and easy to read book on conceptual physics, although it does lack sufficient mathematics in some topics for senior secondary school physics students. Many of the Year 11 physics concepts are actually introduced in some form in lower secondary level science and this book was intended to be used by teachers as their introductory physics textbook. The additional textbook for the Year 12 course (Halliday et al., 2014) is a highly popular first year university level calculus-based book and this was packaged with the students' solution manual supplement. Given some of these teachers will end up teaching senior physics in locations with little support, the author thought it particularly important for these teachers to have easy access to high quality resources for their future professional learning, and ultimately for the sake of the kids!

EVALUATION AND DISCUSSION

A paper based anonymous survey instrument was used at the conclusion of each course with 126 out of a total of 131 teachers enrolled being present to complete the evaluation. In summary, the evaluation of the six Year 11 courses and three Year 12 courses was very positive, with 96% of the 126 surveyed participants being satisfied overall; the other 4% being neutral (see Table 1). In addition, 100% were satisfied with the resources provided (textbooks and printed notes) with 87%

confirming they had gained pedagogical and curricular knowledge for teaching physics. Although just 2% of teachers were not satisfied with the laboratory sessions, these 3 teachers were all from the first Year 12 course in 2017, hence improvements (e.g. introduction of Planck's constant experiment) were implemented for the remaining two Year 12 courses resulting in no further dissatisfaction.

Table 1: Teacher Responses to "Overall, I was satisfied with the course"

Year Level	Number of courses	Number surveyed	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
11	6	88	69%	28%	3%	0%	0%
12	3	38	50%	45%	5%	0%	0%
Total	9	126	63%	33%	4%	0%	0%

Some physics aspects beyond the year level were included and 87% of teachers thought this was appropriate. Conversely, 92% of teachers believed that the Year 11 course would improve their ability to teach Year 7 to 10 physical science. This is a particularly important result given that almost all science teachers will teach lower secondary science. Only 11% of teachers were not satisfied with the one week intensive course format. While this format may not be ideal from an educational perspective, it suits the practical needs of teachers and schools. This is particularly true for teachers from country schools who arguably need the most support.

The survey results are completely consistent with my observations during these courses. Teachers were overwhelmingly highly engaged with the material throughout the week and were achieving success. I believe the participants had a strong intrinsic motivation to learn, because many teachers expect to be teaching Year 11 and/or 12 physics in the future and these courses are a one-off convenient opportunity to learn the physics content and teaching methodologies they need. Research shows a strong link between intrinsic motivation and engagement and success (Deci & Ryan, 1987; Hardre & Reeve, 2003). In addition, the WA Department of Education recognises teachers who complete these courses as able to teach senior physics in WA secondary schools.

The survey also sought some background information, with 26% of teachers not having completed physics higher than Year 10, 52% no higher than Year 11 or 12 or university foundation physics, and 22% having completed some university level physics above Year 12. For the most recent six courses (2017 to 2019), Biology or Human Biology (55%), Chemistry (25%) and Mathematics (13%) were the three most common specialist senior secondary backgrounds. Although the backgrounds of the teachers were diverse, overall satisfaction with the courses was overwhelmingly positive.

CONCLUSION

These short university run physics courses have been highly successful in providing much needed support to out-of-field current and future secondary school teachers of physics. Although the courses have focused on teacher physics content knowledge (i.e. physics understandings); the pedagogical content knowledge, curricular knowledge, and experience in the secondary classroom allows for a more comprehensive, authentic, and relevant course for secondary school teachers. Finding suitable staff with secondary teaching qualifications and experience is key to optimising this model to meet the needs and expectations of secondary teachers.

This short course model for secondary teachers' professional learning could readily be adapted and implemented at most, if not all universities in Australia. University physics departments already have the laboratory facilities with a range of senior school level physics experiments in their physics foundation units as well as more advanced equipment suitable for educating teachers. A similar situation exists for science, mathematics and various other university departments. There is an opportunity for universities across Australia to make their physical and human resources more widely accessible for professional learning, and in particular, teacher education through targeted short courses.

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