Physics in a week

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Category: Refereed research

Introduction

It has been evident for some time in the Australian education profession that 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 2015, the WA Department of Education provided funding for Edith Cowan University (ECU) to provide a Year 11 Western Australian Certificate of Education (WACE) Physics refresher course for Department of Education science teachers. The intention of this course was to provide a physics content refresher for teachers who had completed some senior secondary physics in the past, but had not carried on to physics at university level. The course was categorised as professional development; it was not assessed and did not count for credit as part of any university qualification. Initially, the intention was 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. 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 a one week intensive short course to refresh teachers' knowledge of Year 11 WACE Physics. This course was offered and ran on the Joondalup campus of ECU from 23-27 November, 2015.

WACE Year 11 ATAR physics (School Curriculum and Standards Authority, 2014) is a broad and concept rich physics course. Teaching this over a year, or even a semester, allows time for reflection and consolidation that helps facilitate a deeper understanding of the material. Despite having over 20 years of experience in teaching physics at this level, both as a secondary school teacher and as a university lecturer, I have never been asked to teach physics in such an intensive manner. This was a new challenge and raised a series of questions. How might an intensive course be structured? Will I be able to teach all the content I would like the teachers to learn? Can I successfully use the tools of the teaching profession to keep teachers motivated, engaged, and in Vygotsky's zone of proximal development to maximise learning outcomes (Churchill et al, 2016)?

Is it possible to successfully teach Year 11 physics in a week? What factors would be important in making such an intensive physics course a success? In a broader context, should universities be expanding their provision of non-award professional development courses for teachers? These were my main questions. This paper is a case study that outlines the course and attempts to answer these questions.

Course organisation and structure

The course ran for five days from 9am to 4pm during the last week of November in 2015. The university physics laboratory and an adjoining tutorial room were booked for the duration of the course. The course was designated as 30 hours of professional development with 23 Department of

Education science teachers in attendance. There was a mix of teachers from all over the state which included teachers from metropolitan, country, and remote schools. The Department of Education funded flights and accommodation for teachers from country and remote locations.

Given the time constraints of the course, the primary focus was to cover the science understandings strand of WACE Year 11 ATAR physics course, and make references to science inquiry skills, science as a human endeavour, general capabilities, and cross-curriculum priorities when particularly relevant (School Curriculum and Standards Authority, 2014). My two main priorities were to ensure that teachers had the correct Year 11 physics conceptions, and to give teachers the tools, including confidence, to build on their knowledge and skills at a later date. Each day was allocated one of the five major topics:

- Monday: Thermal physics
- Tuesday: Nuclear physics
- Wednesday: Linear motion
- Thursday: Electrical physics
- Friday: Waves

There were four sessions every day, with three workshop sessions in a tutorial room, and one experimental session in the physics laboratory. Unfortunately, the physics laboratory had significant equipment storage on top of fixed benches that prevented students having clear vision of their instructor or the whiteboard, so it was not possible to integrate all the lecture, tutorial, and experimental learning activities in the one room. Each day followed a standard format:

- Session ONE: Workshop (Combination of lecture and tutorial activities)
- Short break of approximately 10 minutes
- Session TWO: Workshop (Combination of lecture and tutorial activities)
- Lunch break of approximately 40 minutes
- Session THREE: Laboratory (series of concept illuminating short experiments)
- Short break of approximately 10 minutes
- Session FOUR: Workshop (Combination of lecture and tutorial activities)

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 student engagement and to better allow for logical starting and stopping points within each topic. The first two sessions introduced most of the concepts for the topic and usually carried the highest cognitive load for the day. The third session was usually the longest session of the day with approximately nine hours spent in the physics laboratory over the week. The final session of the day was usually the shortest.

The teaching and learning environment

Three of the four sessions each day were workshops. Each workshop was 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 common misconceptions were frequent as well as individual and group problem solving. The whiteboard was used to aid in conceptual development and for worked solutions to problems. A multimodal and varied approach was taken for working with the content. Teachers were constantly being asked to link the material covered to their previous experiences and to share illuminating experiences with the rest of the class.

The laboratory sessions were based primarily on teachers doing a series of short experiments in groups of 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). Space was

provided in the laboratory manual for teachers to record their observations, results and explanations as they proceeded through each experiment; no separate log book was necessary. 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 addition to a copy of lecture presentation slides and a write-in laboratory manual, teachers were also given two textbooks. The first textbook (Hewitt, 2015) is an outstanding easy to read book on conceptual physics, although it does lack sufficient mathematics in some topics for senior 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 second textbook (Giancoli, 2016) is a popular algebra based textbook for first year university students 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. This was intended to serve as the more significant resource for teachers to increase and consolidate their knowledge of year 11 or 12 senior physics after completing the course. Both textbooks were used during the course.

The sessions were run in a highly interactive and supportive environment. In workshops, teachers would rarely go more than five minutes without having to write, draw, use their scientific calculator, or say something. This course was all about preparing teachers to teach physics; it was not just a Year 11 physics content course. 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 electrical physics (Giancoli, 2016). Teaching methodologies were modelled and personal secondary school and university examples of teaching physics were given. There were many educative discussions on both the physics content and how to teach physics with teachers frequently giving their own related examples from lower secondary science. This approach very much suited the needs of teachers who clearly wanted to gain both physics content knowledge as well as pedagogical content knowledge which are both key requirements for all good teachers (Shulman, 1986). Sharing experiences of teaching science and physics in secondary schools was critical in creating a rich, authentic and engaging learning environment for teachers.

Teacher evaluation

An anonymous written course evaluation was completed by all 23 teachers during the final session of the course. The highest physics level completed for the cohort was Year 11 or 12 physics except for four teachers with no senior secondary physics and five teachers who had completed some university level physics. Although only three teachers had previously taught senior secondary physics, 20 teachers reported that they intended to teach senior physics in the future with 12 at Year 12 level. Several teachers had already been given senior physics classes for 2016.

Teachers also reported extremely high satisfaction rates with the course. On a five point scale (strongly agree, agree, neutral, disagree, strongly disagree) all teachers were satisfied with the workshop sessions, laboratory sessions, resources and learning outcomes for the course. Only four teachers did not agree or strongly agree that they were satisfied with the one week intensive course format, although three of these teachers were neutral.

There were two particularly interesting and noteworthy results from the survey. Firstly, almost all teachers (21) strongly agreed that this course would help them teach Year 7-10 physical science. The Year 11 physics course does have significant overlap with physical science content in Years 9 and 10 in particular. Secondly, all but one teacher strongly agreed that they were interested in a Year 12 WACE Physics refresher course. This question was only put on the survey at the request of the teachers and was indicative of the reality that many of these teachers could end up teaching Year 12 physics.

Discussion and conclusions

The survey results were completely consistent with my observations during the week. Teachers were highly engaged with the material throughout the week and were achieving much success based both on my observations and those of the teachers themselves who are all education professionals. I believe they had strong intrinsic motivation to learn for two reasons. Firstly, many teachers would be teaching Year 11 or 12 physics the following year which made this a timely and one-off opportunity to learn the physics content and teaching methodologies they would need. Secondly, the course had clear benefits in helping teachers teach physics in junior science at lower secondary level. Research shows a strong link between intrinsic motivation and engagement and success (Deci & Ryan, 1987; Hardre & Reeve, 2003). They seemed happy and keen to learn as much as possible. Every single teacher participated in all of the 20 sessions over the week. In over 20 years of teaching, I have never had a 100% attendance record! In addition, all but one teacher were interested in a Year 12 WACE Physics course.

So the answer to the first main question is yes, it is possible to successfully teach physics in an intensive format. This is clear from both my observations and the teachers' evaluation of the course. Answering the second main question is more difficult, but there are probably several important factors which contributed to a successful course outcome. Firstly, the timing was right for the teachers. The last week in November found most teachers having just completed their student reports so they were free to concentrate on this physics course. Secondly, the motivation and engagement of teachers was extremely high. They were very keen to learn as much as they could from this course and I believe that this is an essential component for the course's success. Thirdly, I believe that 20 years' experience of teaching physics at this level has been crucial in allowing me to design and conduct an intensive course that was able to achieve good outcomes for the teachers.

With a shortage of secondary teachers with physics content knowledge and physics pedagogical content knowledge, it is imperative that professional development be available for existing teachers to gain this knowledge. Universities, with highly qualified staff and specialised facilities, are well placed to develop and deliver a range of flexible non-award professional development courses to suit the needs of teachers in metropolitan, country and remote locations. This case study has shown that it is possible to do this for WACE Year 11 physics with an intensive short course format which might also be adapted to suit other disciplines. Following the success of this course, the Department of Education funded two additional WACE Year 11 physics courses in 2016, which resulted in similar teacher outcomes.

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Please cite as: Swan, G. I. (2016). Physics in a week. In *Innovation: Multiple dimensions in teaching and learning. Proceedings of the 26th Annual Teaching Learning Forum*, 2-3 February 2017. Perth: Curtin University. http://ctl.curtin.edu.au/events/conferences/tlf/tlf2017/refereed/swan.pdf