Intensive mode delivery of courses in engineering, computer science and mathematics

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Extended Summary

In early 2014, the Faculty of Engineering, Computing and Mathematics (FECM) at the University of Western Australia (UWA) tabled a proposal to deliver its Master of Professional Engineering (MPE) as an intensive mode programme. This will require all units in the programme except external electives to be replaced with intensive courses of eight weeks or so duration. To assist in this process and validate the proposed model, an investigation of existing models for intensive mode delivery was undertaken. The aims were to evaluate the FECM proposal against existing models, identify successful pedagogical practice for intensive units in engineering, computing science and mathematics (ECM), and to focus on the issue of scalability of these methods to large class sizes. This report covers the above points and also includes a general discussion regarding intensive delivery of units.

A growing body of research provides evidence that well-designed intensive courses (units) can achieve the same or superior student outcomes when compared to semester-length units. They can also improve the student experience by allowing students to immerse themselves in a subject and this can lead to higher course satisfaction scores. These findings are based for the most part on intensive courses with small class sizes and in situations where students are taking only one or two units concurrently.

Intensive courses currently offered at tertiary level are usually scheduled outside of standard semester teaching periods and range in length from one to nine weeks. Two studies suggest that four to six weeks may be the optimum course length for student outcomes; however, further research is required to validate this finding. A small number of universities have designed their programmes around compressed delivery, offering single units sequentially in three and a half week modules or multiple units concurrently over eight to nine weeks. Both Oxford University in the UK and Chalmers University in Sweden have adopted eight weeks as their standard teaching period and offer undergraduate and postgraduate programmes in ECM. ECM units are also offered during summer sessions at many tertiary institutions, and are usually delivered over a period of six to nine weeks. A few units in mathematics and computer science are taught across a shorter time frame; however, there is some evidence to suggest highly compressed courses of less than four weeks may not be suitable for technical subjects.

Class time for intensive units is commonly scheduled as multiple blocks of two to four hours delivered each week. Current literature indicates that students prefer weekly classes and perform better in block schedules. A weekly timetable mitigates to some extent concerns regarding student and staff absences. In the FECM pilot programme, an 8-week study period with weekly one-day teaching blocks is being trialled. This format conforms to a large extent with current standard practice for intensive courses. The original proposal of a 9-week study period with three 2-day workshops is less common. Only a small number of intensive courses currently offered at tertiary level concentrate all contact hours into a single week or employ multi-day workshops. Surveying FECM students and understanding their external commitments and study preferences may identify the best class schedule for the MPE.

Traditional-length units need to be adapted for intensive mode delivery in order to accommodate the change in pace and different class format. Attributes identified in the literature as best practice for high quality intensive courses include organisational aspects as well as course design. Due to the compressed nature of intensive courses, they need to be highly organised, structured, and be supported by effective and responsive unit administration and student services. Class activities should focus on learning outcomes rather than content delivery, create situational interest in the subject by relating course material to students’ personal experience, adopt active learning strategies to encourage deep learning, and include variation to keep everyone motivated. Research has shown that active learning improves student outcomes in ECM subjects. Content should be challenging but well supported and help students to develop as self-regulated learners. Clear expectations of student performance for course activities inside and outside the classroom need to be articulated. Study guides should be provided and time management should be discussed with students to ensure they remain on track. Assessment methods also need take into account the compressed time frame. Progressive assessment is recommended, with large assessment pieces broken down into smaller tasks spread across the course. Assessment and feedback should start early, and both formative and summative assessments should be included.
Teaching quality is emphasised in intensive courses, because students spend extended blocks of time in class. Students report that they learn more effectively when the instructor is enthusiastic and knowledgeable and has good communication skills. Students also feel they learn more from instructors who are open, caring and willing to learn from and with them. While the aforementioned course and teacher attributes are important for the success of any unit, independent of delivery length, the literature suggests that they are critical for the success of intensive courses.

Macquarie University and the University of Canterbury have developed resources and guidelines to assist faculty with the design of intensive courses, and links to these are given at the end of this report. Training literature may also provide useful information on designing session plans, as many training workshops are delivered in intensive mode. It is recommended that academic staff with little or no experience in teaching intensive courses be guided as they re-design their units. This includes having access to experienced practitioners of this mode of delivery. Three Australian studies recommend that academic staff not be forced to deliver intensive units until they feel confident to do so.

Surveys conducted at other tertiary institutions have shown that most students like intensive courses once they are familiar with the format, but are they also concerned about workload and time management. A number of universities recommend or limit concurrent enrolment in intensive courses to a maximum of two in order to minimise the risk of overloading students. The FECM proposal when fully implemented will conform to this limit. Some studies have shown that mixing intensive courses with semester-length units may lead to problems. As such, fulltime students who enrol in one of the FECM pilot units may experience difficulties with the compressed workload. Implementation of the FECM proposal will also need to be carefully managed to ensure students enrolled in the MPE Preliminary, who will have to juggle regular undergraduate units with intensive postgraduate units, and those enrolled in the MPE who take regular electives outside of FECM are not disadvantaged.

The immersive experience of intensive courses may assist EFL (English as a Foreign Language) students to improve their English language skills. Pre-recorded lectures and pre-reading is recommended to allow these students extra time to absorb content before attending class. The Centre for English Language Teaching at UWA currently offers a five-week intensive programme that introduces EFL postgraduate students to English for academic purposes. This course could be customised for EFL students entering the MPE and provide early identification of students at risk due to poor language skills. Support strategies could then be developed.

The literature recommends small class sizes in intensive courses to encourage high levels of student participation. This can be mitigated in large classes to some extent by employing small group strategies, active learning, breakout classes and team teaching. The latter requires tutors or more than one academic staff member to be present for all classes. Academic staff involved with large intensive courses may need assistance with marking in order to provide early and ongoing feedback to students. Self, peer and online assessments are recommended to reduce the workload associated with marking. Time and expertise are required to develop high quality self and peer assessment protocols and effective blended learning resources. It is recommended that incentives, guidance and on-going support be provided to encourage adoption of these methods. The time taken to re-design courses and prepare resources also needs to be accounted for in workload models.
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1. Introduction

“Student learning is the major test of a program’s (sic) quality, regardless of whether it is delivered in a traditional or accelerated format” (Swenson, 2003, p. 83).

Intensive Mode Delivery (IMD) of courses in tertiary education is a rapidly growing trend (Burton and Nesbit, 2008; Guertler, 2010; Collins, et al. 2013), with universities embracing a wide range of delivery patterns for their programmes (Davies, 2006). In the literature, IMD usually means the delivery of a standard semester unit or course over a shortened timeframe. For example, a 14-week semester unit may also be offered as an eight-week summer course. Such courses are often described as compressed or time-shortened. The term accelerated-learning is becoming increasingly popular and is used to denote either a compressed course that has fewer formal contact hours than a traditional semester unit (Wlodkowski, 2003) or a fast-tracked degree. IMD may also refer to concentrated or block delivery of formal contact hours within a semester-long course. In 2014, the UWA unit CHPR5522 Gas Processing 2 ran across a full semester of 14 weeks with all contact hours timetabled over six Saturdays. This unit would be considered intensive in certain contexts. In this report, unless otherwise stated, IMD will refer to a time-shortened course with approximately the same contact hours as a standard semester unit. The contact hours may be evenly distributed across the course or concentrated into blocks. The words unit and course are used interchangeably.

IMD courses at post-secondary level have been offered in the United States (US) for many years, with Harvard University and Johns Hopkins University introducing compressed summer sessions in the mid to late 1800s (Scott & Conrad, 1992). This has resulted in the majority of research to date on this topic coming from the US (Davies, 2006). Most Australian universities today offer intensive courses in some form or other (Burton & Nesbit, 2008; Collins et al., 2013) and a small number of local studies have also been published. The rationale for introducing these types of courses includes increased flexibility to accommodate a growing non-traditional student population, as well as economic drivers (Davies, 2006; Burton & Nesbit, 2008; Collins et al., 2013). Smith et al. (2008) identified similar reasons for the adoption of blended learning.

In his review of intensive teaching formats, Davies (2006, p. 2) noted that “at post-graduate level in particular, students are increasingly professionals undertaking study on a part-time basis, either by distance or on-campus learning, while they balance demands of family, work and their studies”. In 2010, fifteen higher education providers across Australia and New Zealand took part in the Postgraduate Survey of Student Engagement (POSSE). The POSSE is managed by the Australian Council for Educational Research and is designed to assess the level of engagement of students undertaking postgraduate coursework. Edwards (2011) reported that over 78% of respondents to the 2010 POSSE were employed while studying, with 76% working 16 hours or more a week and 53% working more than 30 hours. To support these students, tertiary institutions are offering block schedules and evening and weekend classes, as well as compressed courses.

The majority of compressed courses are delivered outside of standard semester teaching periods, with the introduction of summer sessions or extra terms. The extra study periods offer students more flexibility when planning their studies by allowing students to spread their course load across a full year. They also provide students with the opportunity to repeat failed units or accelerate the completion of their degrees. Early completion is highly desirable to a growing number of students (White, 1999; Martin & Culver, 2009, Collins et al., 2013). Extra study periods also make more efficient use of campus resources.

Intensive delivery of courses may be advantageous in other ways. Compressed courses can assist academic staff by providing larger blocks of non-teaching time to focus on research (Welsh, 2012). Two engineering academics (Kealey, 2014; Rufford, 2014), who currently deliver units in intensive mode, noted this advantage of IMD courses during informal interviews with the author of this report. IMD courses may also benefit students by requiring academic staff to focus on teaching in a concentrated block, rather than juggling research and teaching concurrently (Kuzmar, 2013). Pritchard and MacKenzie (2011) studied the experiences of a group of academic staff invited to teach in a residential IMD study centre. They reported that in this environment many of the academics became “more aware of their students as learners” (p. 339), which prompted discussion and reflection on their teaching practice.
In early 2014, the Leadership Team of the Faculty of Engineering, Computing and Mathematics (FECM) at UWA tabled a proposal to deliver the Master of Professional Engineering (MPE) in intensive mode. To guide the re-development of units for this format, a set of overarching principles was provided:

- The total student commitment to study should exceed the standard undergraduate load, which is currently 150 hours per unit;
- Face-to-face teaching time and staff workload should remain comparable with existing semester-length units;
- The total elapsed time for a unit should not be less than seven weeks in order to allow students sufficient time to consolidate their learning and complete assessment tasks; and,
- Each unit should include at least three separate blocks of face-to-face teaching to allow students to receive feedback on their progress and encourage double-loop learning.

The original proposed length for the intensive units was nine weeks with formal contact hours concentrated into three two-day workshops. A fulltime student would be expected to study two IMD courses concurrently. The nine-week model equates to a student study commitment of approximately 180 hours per unit, based on two units per nine-week block and a total commitment of 40 hours per week for a fulltime load.

A pilot programme has been set up for 2015 with a number of academic staff agreeing to trial their units in IMD format. The pilot programme will use a different delivery model in order to work around timetabling issues and accommodate students enrolled in regular units as well as a pilot unit. The issue of juggling regular units and IMD courses concurrently will be discussed later in this report. All pilot units have been timetabled for one full day every week for eight weeks. The first week will be used for an introductory lecture and pre-loading of material, and the last week is for final assessments.

The impetus for this study arose from academic staff feedback on the FECM proposal. The aims are to:

- Identify models of intensive mode teaching in engineering, computer science and mathematics (ECM), and then compare them with the proposed model;
- Identify pedagogies that have been successfully used in intensive mode teaching of ECM subjects; and,
- Focus in particular on the issue of scalability of these pedagogies to large class sizes.

Before addressing these points, the question of whether IMD courses are as effective for student learning as semester-length units is discussed.

2. **Can intensive courses be effective?**

“From the perspective of the learner or educational researcher, it is not straight forward to discuss the benefits and disadvantages of shortened or accelerated semester courses for numerous third variable issues come into play” (Shaw et al., 2013, p. 3).

An extensive search of the literature has uncovered very few studies that explicitly address intensive mode teaching of ECM subjects. There are, however, studies that investigate the effectiveness of IMD courses in other subject areas and a small number of reviews collating results across disciplines or institutions.

While improvements to pedagogy and the student experience are not often cited in the literature as drivers for the adoption of IMD courses, a growing body of research suggests that intensive courses can improve the student experience and be as effective as or better than traditional length units in terms of student learning outcomes (Scott & Conrad, 1992; Daniel, 2000; Scott, 2003; Hermida, 2014). Scott and Conrad (1992) conducted one of the first and most comprehensive reviews of the IMD literature. Their aim at the time was to synthesise a scattered body of research and recommend future directions of inquiry. They located approximately 100 publications on the topic. Course lengths considered in the review ranged from one to nine weeks. Delivery formats varied and included compressed semesters, weekend blocks and multi-day workshops. Forty-two studies compared courses of different delivery lengths, and all but one reported that students in IMD courses attained the same and in some cases superior short-term outcomes, based on average unit marks, when compared with traditional semester-length courses. Only one study concluded
that the semester-length format was better. Richey et al. (as cited in Scott & Conrad, 1992) compared eleven matched units that were offered across full semesters or as 13-day intensive sessions. The same instructor, class format and assessment were used for each set of matched units. One of the eleven sets, a graduate class in education, resulted in inferior outcomes for students in the IMD unit. Richey et al. identified teaching practice as the problem and concluded that IMD courses could be as effective as semester-length courses, but “should be taught by enthusiastic, experienced and competent instructors, who are able to adapt themselves to the concentrated nature of [IMD], and who have positive feelings towards teaching in a short term” (as cited in Scott & Conrad, 1992, p. 420).

Ten of the forty-two studies investigated courses in mathematics, computer science and science, with most comparing 3-week to 8-week IMD courses against matched semester-length alternatives. Nine reported no significant difference in terms of student outcomes between delivery formats and one reported superior outcomes for an intensive course in computer science (Boddy as cited in Scott & Conrad, 1992). Boddy (as cited in Austin and Gustafson, 2006) found students performed significantly better in terms of exam scores when they completed the computer science unit in a 5-week or 8-week IMD format instead of as a semester-length course. No studies investigated engineering courses.

The majority of papers reviewed by Scott and Conrad (1992) were based on case studies, and they observed that many suffered from ‘serious methodological and conceptual limitations’ (p. 444). Daniel (2000) also questioned the validity of a number of studies in her review of IMD courses across discipline. She only referred to one study that investigated outcomes in an ECM unit. The study was conducted by Caskey (1994) and compared the average unit marks for two delivery formats (simply identified as ‘intensive’ and ‘semester-long’) of the same algebra unit, as well as follow-on marks for units that required the algebra unit as a prerequisite. Caskey chose 30 students at random from each format but noted that the instructors were different for each class. It is not clear whether any analysis for demographic equivalence was conducted. The study found no significant difference between the two groups with respect to the average marks attained in the algebra unit, or in the follow-on marks for the higher-level units. The only significant factor identified by Caskey was age: the students in the IMD course were on average six years older than those in the full semester unit.

Some researchers have tried to address the concerns raised by Scott and Conrad (1992). The following studies do not consider ECM courses, but offer more robust findings on the effectiveness, or not, of IMD courses. Van Scyoc and Gleason (1993) compared data from a 3-week IMD course in principles of microeconomics with its matched full semester equivalent over successive years. They controlled for “contact hours, course content, important student characteristics, instructor, and time of day” (p. 16). The student groups were not significantly different in terms of gender, age, Grade Point Average (GPA) and prior knowledge of economics, which was measured using a standard test at the start of each course. The IMD group met five days a week for three hours each day, the full semester group met for one and a half hours twice a week. All classes began at 9am and student numbers varied from 50 to 60 for both formats. The total number of students included in the study was 561. The analysis showed that student performance was positively linked to GPA and prior knowledge of economics. Performance was also weakly linked to instructor (two instructors were used in the study) and student gender. Students in the IMD format performed better than those in the full semester course in terms of average unit marks. Long-term retention of knowledge was measured by testing students at the start of a higher-level microeconomics unit, for which the principles unit was a prerequisite. Van Scyoc and Gleason noted that some students took the higher-level unit two years after completing the principles unit. They found no significant difference in the test results between students who took the principles unit in IMD format and those who completed the unit across a full semester. Austin and Gustafson (2006) conducted a similar study across a range of subjects, including mathematics. They also found no significant difference in outcomes for the higher-level units between students who had taken prerequisite units as semester-length courses and those who had completed the units in intensive mode.

Seamon (2004) compared student performance in a pair of matched educational psychology units; one delivered over three weeks and the other over a full semester. Students met for three hours a day, five days a week during the IMD course and three hours per week for the semester-length course. The same instructor taught both courses and kept the same teaching methods, assessments and grading systems. Students did not differ significantly between the two groups in terms of age, GPA or affinity for learning. The latter attribute
was determined using the Need for Cognition Scale, an instrument developed by Cacioppo and Petty (1982) that is reported to have high reliability. The scale quantitatively measures “the tendency for an individual to engage in and enjoy thinking” (Cacioppo & Petty, 1982, p. 116). Seamon found that students in the IMD course performed significantly better in tests covering course content and also in questions that tapped into higher order learning. However, when the students were re-tested three years after the course, there was no significant difference between the two groups. Seamon concluded that any short-term gain from IMD was not long lasting if not maintained.

Anatasi (2007) investigated student outcomes in three psychology units. The units were offered as both full semester and summer courses. The number of weeks in the summer course was not identified, but the university where the study was conducted currently offers a six-week summer session. Anatasi ensured that the instructor, teaching style, number of contact hours, and assessment tasks were the same for each set of matched courses, and analysed a number of years of data. The total sample size was 506 students. The mean GPA of students entering the summer courses was lower than that of students entering the full semester units; however, the average unit mark for the summer courses was found to be higher. Assessment within the units included items such as in-class quizzes, daily journals, homework assignments, research reports and multiple choice or written exams. Teaching evaluations revealed that both groups of students gave equivalent ratings for the amount of effort required to complete the units, but more students in the summer courses agreed or strongly agreed with the statement ‘The instructor demanded high standards of student performance’. Anatasi offered three possible reasons for the superior grades in the summer sessions: most students take fewer units in the summer session and therefore may experience less interference and conflicting priorities from other courses; the types of students who take summer courses may differ from those who enrol in full semester units and may be more proactive about their learning; and, smaller class sizes may improve the learning environment in the IMD courses by increasing student participation. Small class size is a recurring theme in discussions about IMD courses and may contribute to their success.

A few studies were located that consider IMD courses in engineering, science and research methods. Tan (1996) compared data across a range of years for two versions of a graduate research methodology course; one was delivered as a one-week intensive and the other across a full semester. Both courses had the same instructor, covered the same content, and expected students to complete the same reading, class exercises, and mid-course and final exams. The content covered methodological and sampling issues, and a small section on statistics. Tan reported that there was no significant difference in academic performance between students enrolled in the IMD course and those in the semester-length unit. He suggested several factors that may have been responsible for this result: students in the IMD course may have pre-read the textbook and come to class better prepared; the course content was technical in nature and therefore students did not need extra time to locate and read peripheral material; and, student participation in the IMD classes was highly structured due to time constraints and this may have increased their focus.

Hall et al. (2012) compared two delivery modes for an introductory chemistry unit at a large US university. The unit was delivered across a full semester or compressed into three weeks. Four years of data were examined. Over this period both formats had the same instructor, course objectives, teaching style, classroom activities, assessment and grading systems. The course included lectures and laboratories, and class sizes were relatively small for both formats (25 – 40 students). After controlling for student academic ability, including GPA, the American College Testing score and pre-test scores, Hall et al. found that students in the IMD course performed better than those in the semester-length unit. Academic experience, life experience, academic major and gender were shown to have no significant effect on student success.

Karaksha et al. (2013) compared two matched units in introductory pharmacology at Griffith University; one delivered over three weeks and the other across a full semester. Three years of data were analysed. There was no significant difference in age or gender between the two groups. The mean GPA of students entering the IMD course was significantly lower than that of students entering the semester-length course, however no significant difference was found between the two groups when comparing their final unit marks for the introductory pharmacology unit. Karaksha et al. concluded that IMD courses have the potential to improve (short-term) student performance. A critical difference between the two course formats was class size: the IMD courses had 17, 16 and 10 students, respectively, and the semester-length courses had 79, 62 and 77 students.
Whillier and Lystad (2013) trialled a seven-week IMD summer course in neuroanatomy at Macquarie University. The unit was based on an existing full semester introductory course, and comprised the same number of lectures, tutorials and laboratories. Unit marks and the responses to a student questionnaire were used to evaluate both the compressed course and the semester-length unit. The average unit mark for the IMD course was significantly lower than that for the semester-length unit and the entire mark distribution shifted downwards. Just over 20% of students in the IMD course failed, as compared to approximately 5% in the full semester class, and 60% of students in the IMD course were awarded a Pass, as compared with approximately 34% in the full semester class. Only a small number of students in the IMD course received a grade higher than a Pass. Surprisingly, students rated both delivery modes as satisfactory, with students in the IMD course expressing slightly greater satisfaction with the laboratory components of the course. These results are concerning. Whillier and Lystad concluded that intensive delivery might not suit subjects that are “content and comprehension rich” (p. 292). They also noted “It has been shown that working memory is incapable of highly complex interactive and integrative activity when elements required to do so have only recently been studied, and are therefore novel” (p. 291). These findings suggest compressed delivery might be better suited to courses that draw on students’ existing knowledge and experience, and may explain why accelerated courses are promoted for adult learners.

Two important changes were made to the neuroanatomy course when it was offered in compressed mode, which may have influenced the outcomes of Whillier and Lystad’s (2013) study. Firstly, students enrolled in the IMD course were only able to watch the lectures online, while students in the semester-length unit could attend the lectures in person. Whillier and Lystad do not report whether the lecturer was available to the IMD group to answer questions, although it is noted that the usual tutors and lab demonstrators were employed. Secondly, the assessment mechanism was modified. In the full semester version of the unit, students had weekly quizzes, an assignment, a mid-semester test, a practical exam and a final theory exam. For the IMD course, the weekly quizzes were removed and extra weighting was given to the assignment and mid-session test. The written report for the assignment was also replaced with a seminar presentation. Although the weekly quizzes were only worth 10% of the unit mark, readiness assessment tests or short quizzes are commonly used to drive student preparation and learning. Without them, and with access to online lectures only, it would be very easy for students to mismanage their learning and fall behind.

Kuzmar (2013) reported on his experience in delivering four civil engineering units in a 2-week intensive format called a mini-session. The compressed units covered the same material as their matched semester-length versions. Kuzmar presented the units in this format for four years, and observed that the average unit marks for the mini-sessions were consistently higher than those for the standard semester units. He suggested that this might have been due to students taking only one course at a time during the mini-session. This allowed students to focus fully on the course content. He did not investigate whether there was any variation in student demographics between the two groups. Kuzmar found some subjects were more challenging to deliver in compressed mode than others. “The Strength of Materials course was a difficult course to teach by the instructor as well as undertake by the students. It contains many concepts and applications for which more time was needed to deliver and comprehend” (Kuzmar, 2013, p. 6). He concluded that two-week intensives were a viable option, but not suitable for all engineering topics.

Other studies have also suggested that highly compressed courses may not be suitable for all subjects (Daniel, 2000). Tracey, Sedlacek and Patterson (as cited in Daniel, 2000) surveyed academic staff who were teaching during a summer session at a large US research university. They found that many academic staff did not approve of IMD courses that were shorter than five weeks. Disadvantages associated with the shorter courses included student and staff fatigue, inadequate preparation time, and insufficient time for students to synthesise course content.

Tatum (2010) reviewed the literature on memory and learning and discussed the implications for accelerated courses. While much of the research has no direct impact, some of the findings add weight to concerns about highly compressed courses. Incubation, a process of ruminating on a problem for an extended period of time, can be useful when dealing with difficult problems or course content. Highly compressed courses may not provide sufficient incubation time for some topics. There is also evidence that retention of learning is enhanced by distributed practice (Cepeda et al., 2008). If the time between initial delivery and testing is too compressed, short-term performance may be improved but long-term retention is compromised. To ensure long-term retention, important concepts need to be revisited and revised within
units, as well as across units and years. Therefore, there may be a limit to how much a full semester unit can be compressed (Cepeda et al., 2009), and the limit may depend on a unit’s subject matter. Tatum (2010) concluded that more research was required in this area.

Hermida (2014) includes two examples that focus on changing attitudes as a learning outcome rather than unit marks. Ray and Kirkpatrick (as cited in Hermida, 2014) employed two standard test instruments to measure the change in students’ anxiety level, knowledge and attitudes regarding sexuality after a full semester or equivalent 3-week IMD course in human sexuality. They found both groups left the courses with similar levels of knowledge, but a greater attitudinal change was measured in the IMD students. They demonstrated greater tolerance towards a range of sexual behaviours and became less biased in their views. The second example is anecdotal, with Hermida sharing the experience of a colleague who taught a philosophy of law unit in both IMD and full semester formats. He reported similar results, with more students in the IMD course changing their attitudes towards the meaning of law and how it impacts our interactions with others. The reason suggested for this was the opportunity for longer and more engaged class discussions in the IMD course.

Two studies were located that investigate student performance under different delivery models across a whole institution. Logan and Geltner (2000) reviewed student performance across all teaching formats over a five-year period at Santa Monica College in the US. Over 400,000 student enrolments were analysed, with 77% of the sample corresponding to regular 16-week courses, 8% to 8-week summer sessions, and 15% to 6-week winter and summer sessions. They discovered that more students were successful, in terms of passing the unit and improving their GPAs, in 6-week courses. Also, more students were successful in 8-week courses when compared to semester-length courses. This was found to hold true independent of student ethnicity, subject (a selected number of subjects including mathematics were studied individually), time of day of classes (day or night), and student maturity. The study also showed that the student dropout rate was lower in the 6-week courses when compared to the 8-week courses and significantly less than the semester-length courses. While acknowledging that these results may suggest more motivated students were taking the compressed courses, Logan and Geltner concluded that overall students appeared to perform better in IMD courses. Perceived (not necessarily actual) ability has been found to affect student choices and their confidence in taking IMD courses (Burton & Nesbit, 2008).

Austin and Gustafson (2006) reviewed student performance across all teaching formats over a period of three and a half years at the University of West Georgia in the US. Their data set included 11,795 students and compared four delivery models: 3-week IMD, 4-week IMD, 8-week IMD and a traditional sixteen-week semester. Controlling for a number of past performance and demographic variables, Austin and Gustafson found students performed best in the 4-week IMD format. Students also performed better in all IMD formats when compared to semester-length courses. Student demographics that were significantly and positively related to student outcomes included: white, female (for some subjects), age, starting semester hours, starting GPA and load (the number of units a student was concurrently enrolled in). The study confirmed that improved grades in IMD courses do reflect greater learning, with student grades predicting future performance. It is interesting to note that the 16-week traditional course model was found to be the least effective in terms of student outcomes by both Austin and Gustafson (2006) and Logan and Geltner (2000).

Student and academic staff attitudes towards IMD courses have been the subject of a number of papers. Kirby-Smith (as cited in Scott & Conrad, 1992) investigated student attitudes towards mixing IMD and regular courses in the same semester. They surveyed students across 15 IMD and 12 regular courses. While 70% of the IMD students responded that more intensive courses should be included in the curriculum, they identified problems with juggling the two delivery formats concurrently. Kirby-Smith concluded that “it may be advisable for colleges and universities to limit enrolment in intensive courses to a select group of students who are enrolled in special programs in which all courses are being offered in the intensive mode” (Scott & Conrad, 1992, p. 435). Summer, interim and modular sessions automatically fulfil this criterion. Smith (as cited in Martin & Culver, 2009) and Welsh (2012) also question the wisdom of timetabling IMD courses concurrently with regular semester classes. Welsh surveyed 44 students and 21 academics at the Australian School of Petroleum. He reported that 75% of the students and over 70% of the academic staff agreed that mixing IMD and standard semester units was likely to cause difficulties.
Kucsera and Zimmaro (2010) evaluated the mean scores from a validated instrument used for student evaluations of teaching effectiveness to determine whether students rated IMD courses differently. Nine-week and 11-week IMD courses were compared with matched 15-week semester courses. They controlled for class size, as well as student course workload, GPA and ‘probable grade in course’. The latter was a student self-measure of their expected final grade. By controlling for these variables, Kucsera and Zimmaro aimed to address some of the common arguments put forward to explain the effectiveness IMD courses; these include smaller class sizes, more motivated students and the perception that IMD courses will be easier. The last point was addressed by comparing the same courses delivered by the same instructors in both semester and compressed formats. The results showed that students did not find IMD courses easier and there was no significant difference in how students rated instructors across the formats. However, students gave significantly higher overall course ratings for the IMD courses, with the 9-week format receiving the highest scores. Kucsera and Zimmaro concluded that future research should focus on two questions: “how can faculty create an ‘intensive’ atmosphere (in class) and how can instructors increase student interaction and active learning in a larger class spread over 15 weeks?” (p. 66). Both questions are pertinent to the aims of this report.

Ho and Polonsky (2007) compared students’ perceptions of an undergraduate management unit that was delivered in compressed mode over five weeks and across a full semester. In this case, the number of students (44) in the IMD course was greater than that (34) in the semester-length course. Both courses were taught by the same instructor and included the same assessment. There was no significant difference in student outcomes between the two formats. However, once again, analysis of anonymous course evaluations revealed that students in the IMD course gave the course a higher rating than those in the semester unit. They also felt that they had more access to the instructor and more opportunity for feedback. This is an interesting result, because it suggests that compressed delivery can change a student’s perception of the learning experience. If students view IMD courses as more responsive to their learning, then perhaps this improves their participation (Ho and Polonsky, 2007).

Collins et al. (2013) surveyed undergraduate pre-service teaching students who were enrolled in a 7-week IMD course. 68.8% of respondents indicated that they would be willing to undertake more intensive classes. Other researchers have also reported that, in general, students who have completed an IMD course are more likely to choose another (White, 1999; Burton and Nesbit, 2008). Lee and Horsfall (2010) surveyed students who had undertaken 6-week IMD courses at Swinburne University of Technology during a summer or winter session. The sample included engineering students. 76% of respondents rated their experience in an IMD course as a positive experience, 86% felt more or as confident about their knowledge of the course material in comparison to learning in a normal semester unit, and 74% reported an increase in motivation and effort when compared to performance in regular units. The above results suggest that students may need to be supported as they transition from one format to another, but once they have transitioned many students prefer IMD. Smith (as cited in Martin & Culver 2009, p. 63) found “non-traditional students overwhelming favored (sic) compressed courses.”

However, the format may not suit all students. White (1999) surveyed students undertaking summer sessions in the Department of Management at the University of Wollongong. A total of 613 students responded. While the majority of students indicated that they would take another IMD course, 12% of local students and 35% of international students were less likely to take another unit in this format. Welsh (2012) raised concerns that non-native English speaking students may struggle under the format as they were unable to review lecture material multiple times between classes. This observation may help to explain the results of White’s survey. Seven percent of respondents in the Lee and Horsfall (2010) study also rated their experience in an IMD course as negative. Collins et al. (2013, p. 16) noted that “[students who] tend to struggle with the demands of studying in a standard semester delivery pattern faced greater challenges in the condensed delivery format”. There is also evidence that students prefer some subject areas, including mathematics, to be delivered as weekly classes (Finger & Penny 2001; Burton & Nesbit, 2008).

Lee and Horsfall (2010) interviewed twelve academics with recent experience in delivering 6-week IMD courses. They were asked to comment on which units or subject areas were more appropriate for intensive delivery. The responses were contradictory: “Two faculty members felt that technical or skill-based content was not appropriate due to reduced time for familiarity, practice, and investigation. Conversely, three faculty members felt that conceptual content was inappropriate but technical content would be very
appropriate for acceleration. Seven faculty members reported no preference. Of these, four argued that accelerated courses were successful depending on the teaching methods utilized (sic)” (p. 197). Scott and Conrad (1992) reported similar findings. These results suggest that not all academic staff are comfortable with delivering their subject area in compressed mode and feel unable to adapt their semester-length units to this format. This may in turn affect student attitudes and student performance in these units (Richey et al., as cited in Scott and Conrad, 1992).

In summary, there is a growing body of evidence supporting the effectiveness of IMD courses and students’ willingness to learn under this format. These findings have also been extended to online IMD courses (Ferguson & DeFelice, 2010; Shaw et al., 2013). The IMD course lengths most often discussed in the literature are three weeks and six to eight weeks. These correspond to standard interim (winter) and summer sessions in the US. Some disciplines are embracing IMD; for example, many Australian law schools now deliver their master’s level units in intensive mode (Ramsay, 2011). However, there is still considerable debate on whether intensive mode is an appropriate delivery method for every discipline and subject (Logan and Geltner, 2000; Finger & Penny, 2001; Davies, 2006). A small number of studies have investigated intensive courses in ECM subjects. While the results are generally positive, it has been shown that concept-rich technical subjects may not be suited to a highly compressed mode of delivery (Tatum, 2010; Welsh, 2012; Kuzmar, 2013). Some students and academic staff struggle with IMD and need to be supported during the transition from semester-length units to intensive courses (Burton & Nesbit, 2008; Welsh, 2012; Collins et al., 2013). This includes during the course design phase. There may on-going issues for students who enrol in regular and IMD courses concurrently. Students enrolled in the MPE Preliminary, who will have to juggle regular undergraduate and IMD postgraduate units, and those enrolled in the MPE who take regular electives outside of the Faculty may need extra support. Future students also need to be considered: “Identifying and addressing student concerns about [IMD] teaching could be an important strategy for making the format more attractive to potential students” (Burton and Nesbit, 2008, p. 16).

3. Delivery models for intensive courses

“Traditional semester-length course schedules are not based on any empirical research on student learning; there are no pedagogical reasons to justify these conventional scheduling formats. They are used mainly as a matter of tradition in the instruction paradigm” (Hermida, 2014, p. 283).

A review of university websites reveals a wide variety of delivery models currently being employed for IMD courses. Commonly adopted models include compressed semesters, evening blocks, weekend blocks, and multi-day workshops comprising one or more consecutive days. Summer sessions are a typical example of a compressed semester. Classes in summer courses are often presented in the same or a very similar format to the equivalent semester-length unit, but delivered at a more intense pace and over a shorter timeframe. The majority of published research on IMD courses considers this format due to its popularity in the US. A couple of studies have tried to identify the optimum length for intensive courses, but they offer no insight into appropriate pedagogy for successful delivery. Student and staff perceptions of IMD courses and their preferred delivery models have also been investigated.

A small number of universities around the world and some US colleges use time-shortened semesters as standard practice. Oxford University in the UK divides the academic year into three eight-week terms (Oxford, 2014a) and expects students to prepare and revise material during the vacation periods. The Software Engineering programme at Oxford is delivered as modules (Oxford, 2014b), which span a term but concentrate teaching into a one-week block. A module comprises three parts: a pre-study period, a teaching week and an assessment period. Approximately three to four weeks before the teaching week commences, students are sent or can access online course material to read and preliminary exercises to complete. They may also be required to prepare a short presentation. This pre-study work represents a notional 10 hours of study time (Oxford, 2014b). The teaching week is scheduled for the second or third week of term and comprises a four-day workshop held on campus. During this time, students have full access to all course material and any associated online resources. Class sizes are limited to allow all members to contribute to workshop activities. On the last day of the teaching week, students are given a personal mini-project. This is completed during the assessment period that follows, and is submitted at the end of term.
The Faculty of Education at UWA and the Graduate School of Management at Macquarie University use the same delivery structure for a number of their postgraduate units. The University of Central Queensland has also successfully delivered a second year materials science unit in distance study mode using a similar format (Keleher at el., 2011). Students enrolled under this mode access all course materials online, including recorded lectures and various discussion forums, and attend a 3-day residential school. The three days comprise tutorials, quizzes, laboratory classes, and discussion of course content. The course is also offered on campus as a standard semester unit, with students following a weekly timetable of lectures, tutorials and laboratories.

The Faculty of Science at the University of Copenhagen (UCPH) in Denmark divides the academic year into four nine-week study periods, each period comprising seven teaching weeks and two weeks for exams (UCPH Science, 2014a). A course that has no exams can run across the full nine weeks. Full-time students are expected to complete two units (or one double unit) during each period. The standard weekly timetable is shown in Figure 1. A single unit is assigned a letter and number for timetabling purposes. A double unit is assigned a letter only. For example, a unit assigned the letter C would have classes timetabled in the C1 and C2 slots below. Session D is used for laboratory classes and to accommodate public holidays. Session E is used for short courses and continuing education. Under exceptional circumstances, Session E may be used for standard courses. Classes are scheduled in blocks of two to four hours. A standard unit has six to 10 contact hours each week, depending on whether Session D is utilised for laboratory classes. The Faculty offers programmes in Mathematics and Computer Science, as well as in other areas. The courses are designed for delivery to large student cohorts, with 9,000 fulltime equivalent BSc and MSc coursework students currently enrolled (UCPH Science, 2014b). This timetable offers an alternative to the FECM proposal.

![Figure 1: Weekly timetable for science students at the University of Copenhagen](http://studies.ku.dk/masters/downloads/http__studies.ku.dk_studies_academic_calender_Revised_guidelines_for_year_and_timetable_structure_2011-2016.pdf)

![Figure 2: Weekly timetable for students at Chalmers University](https://student.portal.chalmers.se/en/chalmersstudies/courseinformation/scedule_group_room/Block_schedule/Pages/default.aspx)

Chalmers University in Sweden divides the academic year into two terms, and then each term is further divided into two 8-week study periods (Chalmers, 2014). Each study period is independent of the next and comprises seven teaching weeks and one week for exams. Full-time students are expected to complete two units during each period. In 2011/2012, Chalmers University introduced block scheduling for units at Level 3 and above. The standard weekly timetable is shown in Figure 2. Again each unit is assigned a letter (A, B,
etc.), and classes are scheduled in blocks of two to four hours. A standard unit has 10 contact hours each week. Chalmers University offers undergraduate and postgraduate programmes in mathematics, science and engineering. For example, Figures 3 and 4 below show the two-year programmes for the Master of Structural Engineering and Building Technology and the Master of Software Engineering, respectively. The structures of these programmes are similar to the MPE.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Master’s Thesis</th>
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<tbody>
<tr>
<td>Structural Systems</td>
<td>FEM Basics</td>
<td>Profile course</td>
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<td></td>
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<td>Material Performance</td>
<td>Heat &amp; Moisture</td>
<td>Profile course</td>
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<td></td>
<td>Engineering</td>
<td>Profile course</td>
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</tbody>
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Profile courses

*Structural Engineering*: FEM Structures, Timber Engineering, Geotechnics, Structural Concrete, Structural Design, Steel Structures, Structural Dynamics, and Concrete Structures.

*Building Technology*: Indoor Climate & HVAC, Introduction to Sound & Vibration, Building Physics, Building Acoustics & Com. Noise, Building Technology Engineering, Sustainable Building – Competition (double), and Building Service Engineering Design.

**Figure 3**: Programme for Master of Structural Engineering and Building Technology (Chalmers University)

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Master’s Thesis</th>
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<tbody>
<tr>
<td>Project Management</td>
<td>Elective</td>
<td>Elective</td>
</tr>
<tr>
<td>Requirements Engineering</td>
<td>Empirical Software</td>
<td>Advanced Software Architecture</td>
</tr>
<tr>
<td></td>
<td>Engineering</td>
<td>Elective</td>
</tr>
<tr>
<td></td>
<td>Model-Driven Engineering</td>
<td>Elective</td>
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**Figure 4**: Programme for Master of Software Engineering (Chalmers University)
http://www.chalmers.se/en/education/programmes/masters-info/Pages/Software-Engineering.aspx

Brigham Young University in the US divides the academic year into four teaching periods: two 8-week terms and two 16-week semesters. The university offers ABET accredited engineering degrees and claims their Chemical Engineering undergraduate programme is one of the largest in the US (Brigham, 2014). Engineering units are offered primarily in semester format, but a range of undergraduate and postgraduate units are also offered in the shorter terms.

Cornell College and Colorado College in the US, and Quest University in Canada, divide their academic year into eight modules of approximately three and a half weeks each. Students complete one unit per module, accruing the equivalent of eight full semester units per year. Students at Quest University meet every day for three hours and class sizes are limited to 20 students (Quest, 2014). Cornell and Colorado also work with small class sizes. Quest University and Colorado College allow students to complete a major in Computer Science or Mathematics. Cornell College offers a cooperative engineering degree with the Institute of Technology at the University of Minnesota (ITUM). Students study for three years at Cornell and then transfer to ITUM for the final two years (Cornell, 2014).

Australian universities have diversified their delivery models in recent years. Most offer summer sessions and a few have formally introduced a third term into their academic year. The University of Canberra has lengthened the period between semesters to introduce a 7-week Winter Term (Collins et al., 2013). In 2011, Macquarie University introduced a third semester called Session 3, which is also seven weeks long (Whillier & Lystad 2013). The University of Adelaide has a 7-week summer school and a 4-week winter school. A variety of ECM units, including technical subjects, are offered during the summer session.
The University of Queensland (UQ) has a 6-week summer school and the University of Melbourne (UniMelb) model uses eight weeks. Both offer a small number of undergraduate and postgraduate engineering units in these study periods. UniMelb also allows units to be delivered in intensive mode outside formal teaching periods. For example, GEOM90039 Advanced Surveying and Mapping is a postgraduate coursework unit that is delivered over 14 consecutive days and scheduled to run between the summer session and Semester 1 (UniMelb, 2014).

The University of New South Wales (UNSW) offers two formats during semester, with courses delivered over twelve weeks or compressed into six weeks (half-semester). Contact hours can be weekly or concentrated into workshops. Two examples include: CVEN9610 Surface Water Hydrology (UNSW, 2014a), a unit compressed into a half-semester with contact hours concentrated into two 3-day workshops separated by a weekend; and, ELEC9781 Special Topic: Introduction to Nuclear Engineering (UNSW, 2014b), a full semester unit with contact hours concentrated into two 3-day workshops separated by five weeks. UNSW also has three summer teaching periods comprising four, six and eight weeks. A small number of engineering units are available during the summer session. For example, ELEC9721 Digital Signal Processing Theory and Applications is presented as both a full semester unit and an 8-week summer course (UNSW, 2014c). The summer version has an enrolment cap of 25 to keep the class size small.

Most Australian universities deliver one or more mathematics units in intensive mode. These range in academic level from bridging to postgraduate, and vary in delivery length. For example: James Cook University offers MA1020 Preparatory Math as a full semester unit or a 3-week IMD course (JCU, 2014); the University of South Australia offers MATH1064 Math for Engineers 2 across a full semester or as a 5-week IMD course (UniSA, 2014); and, UNSW offers the postgraduate unit MATH5856 Introduction to Statistics and Statistical Computations as a compressed half-semester IMD unit (UNSW, 2014d).

Petroleum Engineering in Australia represents a special case, with large sections of the programme often delivered in intensive mode (Welsh, 2012). UQ offers a postgraduate coursework degree in Petroleum Engineering in partnership with Heriot-Watt University, Scotland. Heriot-Watt has a number of partner universities and their lecturers travel the world presenting the course content. To accommodate this, the teaching for each unit at UQ is delivered in a one-week block (Rufford, 2014). Students are provided with course reading at the start of semester, so they can prepare for the teaching week, and there are exams at the end of semester. There were concerns about this format when the programme first began at UQ and only part-time students were accepted. As Heriot-Watt controls the course content and assessment, they are able to compare performance across all the universities they partner with, including their home university where the course material is delivered in a more traditional format. The first cohort of students at UQ is performing well (Rufford, 2014), and in 2014 UQ decided to accept full-time students into the programme.

Finger and Penney (2001) surveyed staff and students in the School of Education and Professional Studies at Griffith University’s Gold Coast campus, focussing on their attitudes towards IMD courses and their preferred delivery models. Students were asked to rate five delivery models: traditional semester format; one-week IMD, 2-week to 3-week IMD; weekend classes; and, a combination of weekend and evening classes. Students in the first four years of their degree preferred traditional semester classes, but were also receptive to 2-week to 3-week IMD courses. Graduate students stated a preference for one-week IMD courses, followed by traditional semester classes. Interestingly, students at all levels rated both weekend and evening classes as a low preference. Almost half of the students indicated that they were unable to attend classes at those times due to a range of external factors, including work, religious, sporting, and/or family commitments.

Business schools commonly use weekend and workshop models for their postgraduate courses. The courses are aimed at adult learners who are usually working fulltime. McCarthy (2010) reported on the successful design and implementation of a workshop delivery model for the Master of Business Coaching at the University of Wollongong. The programme was designed for working professionals who want to up-skill and is delivered on a part-time basis only. Units are offered sequentially and run over 10-week trimesters. Some units are offered during the evening or on weekends and others in workshop mode (UOW, 2014). The timetable used for units delivered in workshop mode is as follows: a one-day introduction, a 2-day workshop a month later, and another 2-day workshop a month after that. The rationale given for this
schedule included research that shows student concentration can wane in longer workshops and time for learning between classes contributes to richer in-class discussions and overall learning (McCarthy, 2010). Teaching methods include required pre-reading, lectures with case studies and group discussions, video clips designed to reinforce relevant points, and opportunities for students to present their learning to each other. Class enrolment is capped at 50. Student outcomes and satisfaction with this format have been very high. McCarthy (2010) provides a comprehensive overview of the course design process and evaluation.

Burton and Nesbit (2008) surveyed graduate students at the Macquarie Graduate School of Management. Their study investigated student attitudes towards two common class schedules used for semester-length units in the school: classes delivered in weekly 4-hour blocks; or, classes delivered as a 3-day workshop (Friday, Saturday and Sunday) and a 2-day workshop (Saturday and Sunday) separated by a couple of weeks. Students enrolled in the latter format receive course material at the start of semester, and assessment tasks continue after the workshops have been delivered. Burton and Nesbit surveyed students in 45 award subjects and received 944 responses, representing an 86.7% response rate. The majority of respondents (74.7%) preferred weekly classes. Burton and Nesbit compared course delivery preference against a number of demographic measures and found no significant relationship between delivery preference and age, gender or study status (part time or full time). A weak positive relationship was found between working, full-time students and a preference for the workshop delivery model. Common reasons cited for choosing the workshop model included work and family commitments, and reduced travelling time to and from university. A small number of students cited educational benefits. There was a significant positive relationship between the number of courses completed, in either mode, and preference for the workshop model. This result ties in with the findings of Finger and Penney (2001) with students in the later years of their degree being more willing to undertake classes in intensive mode. There was also evidence that students who had undertaken a class in workshop mode were more likely to enrol in another course using the same format. However, the majority (51.4%) of this sub-group still preferred weekly classes. There was also a significant relationship between delivery preference and subject area, with over 70% of students showing a strong preference for weekly classes when the subject was considered ‘heavily quantitative’ (Burton & Nesbit, 2008, p. 15).

A small number of studies have focussed on the impact of different weekly class schedules on student performance. Four studies have evaluated the effect of lecture length and frequency. Three weekly scheduling formats were considered: 50-minute blocks over three days; 75-minute blocks over two days; or, a single 150-minute block. Gallo and Odu (2009) analysed data from 116 students who had completed college algebra in one of the three formats and found students performed significantly better with two or three shorter lectures each week. Their analysis also indicated that some learning styles respond better to more frequent, shorter lectures. Fike and Fike (2013) analysed data from 1318 students who had completed intermediate algebra in one of the three formats. They found no significant relationship between block frequency or length and student outcomes. They did identify relationships between student outcomes and age, student gender, and the time of day of classes.

Carrington (2010) investigated the effects of the three scheduling formats on student performance in two intermediate accounting courses. She also compared semester-length formats to a compressed 5-week summer session. Data from 2,012 students, representing three years of each schedule, were analysed. The same set of instructors taught the courses over this period, and “the topics covered, the general approach used and the overall level of difficulty of these classes (were) very similar” (p. 54). Carrington found no significant difference in the grade distributions (% of A’s, B’s, C’s, etc.) for all four scheduling formats. However, significantly more students dropped out of the courses with three lectures a week. The dropout rates for the other three schedules were not significantly different to each other. Carrington speculated that this behaviour could be due to students viewing shorter lectures as less important and skipping them more often. She also noted that “as topics get more complex and require more analysis and critical thinking, it may be more difficult for students to perform well in such a short period” (p. 59). She investigated this aspect in more detail by analysing the data on the basis of student age and gender. She found no significant relationship between performance in a course schedule and non-traditional students (over the age of 25) or female students. There was a significant relationship between course schedule and traditional male students. While their performance was similar across the other three schedules, this group was less likely to pass or complete a course delivered using three short lectures per week. The findings from this study suggest that
formal contact hours for a course should be concentrated into longer blocks, especially in units where the majority of students are young men.

In their study of 1,506 lecture-type courses delivered at a large US university, Loveland and Bland (2012) found students preferred meeting once a week, followed by three times per week and then two times per week. Student learning outcomes and satisfaction were also highest for classes that met once a week and in the evening. The lowest student outcomes were associated with early morning classes scheduled before 9:30am.

Lee & Horsfall (2010) reviewed student and faculty attitudes towards IMD courses at Swinburne University of Technology, and reported that academic staff with IMD experience varied in their views of the most effective class schedule. Some thought the classes should be scheduled close together, and others thought that they should be spaced several days apart. Many believed that “the scheduling of classes was sensitive but dependent on a wide range of variables relating to how the course was structured” (p. 200).

The above diversity of course lengths and delivery formats illustrates that no standardised IMD course structure has been adopted. Two studies have indicated that four to six weeks may be the optimal course length for student outcomes, but more research is required to confirm this. The IMD courses to be trialled in the FECM pilot programme are eight weeks long. Undergraduate and postgraduate ECM units have been successfully delivered at other universities in six to eight weeks. While it is unusual for ECM units to be scheduled over shorter session lengths than this, a small number of subjects such as bridging mathematics and computer science coding camps (Alaoutinen et al., 2010) are offered in highly compressed formats.

In order to reduce the risk of overloading students, a number of studies recommend a limit on the number of intensive courses that should be taken concurrently. Most recommend a maximum of two units (Hyun et al., 2006; Lee & Horsfall, 2010; Whillier & Lystad, 2013). The FECM proposal when fully implemented will require full-time students to complete two IMD units per study period. This is not the case during the pilot programme and some students may struggle as they juggle three standard units and one IMD course. The workshop model put forward in the FECM proposal is not commonly adopted, but has been used for a small number of specialist engineering units. The decision to schedule weekly one-day blocks for the FECM pilot programme is a reasonable first step. There is evidence that students prefer weekly classes for quantitative subjects (Finger and Penney, 2001; Burton & Nesbit, 2008). Current research also suggests that students perform better when classes meet for longer blocks of time than the traditional 50-minute lecture or tutorial. Weekly classes timetabled in blocks of two to four hours are common practice. A weekly timetable also helps to alleviate to some extent concerns about student and staff absences. The issue of absences and their impact on content delivery and student outcomes in IMD courses was raised by both students and academic staff in the study conducted by Lee and Horsfall (2010). Academic staff also raised this concern when the FECM proposal was tabled. It is recommended that the students in FECM be surveyed to canvass their views regarding IMD and their preferred delivery models. This will inform the choice of model to be adopted and allow effective communication strategies to be developed to manage students’ expectations.

4. Pedagogical approaches to intensive courses

“From both faculty and student responses, findings indicated that the benefits of acceleration for learning rested largely on an intensified, active learning cycle of theory, practice, and feedback and a stronger social learning experience derived from peer support, guidance and feedback.”

(Lee & Horsfall, 2010, p. 196)

Very little research to date has focused on pedagogical approaches to IMD courses (Guertler, 2010; Pritchard & MacKenzie, 2011; Omelicheva, 2012), which is unusual given their growing popularity. In the majority of studies that have compared IMD courses with matched semester-length units, the authors have stated that the teaching style, class activities and assessment were kept as close as possible between the two formats. However, surveys of academic staff tell a different story with many academics reporting that they make adjustments to their teaching methods and their approach to assessment when delivering a course in intensive mode (Kretovics et al., 2005; Lee & Horsfall, 2010; Omelicheva, 2012).
Kops (2009, 2014) and Scott (2003) have conducted the most in-depth investigations of teaching practice in IMD courses. Kops (2009, 2014) interviewed over 40 academic staff who had delivered IMD courses with high course evaluations, across a range of disciplines at two large universities in the US and Canada. Based on these interviews, he proposed a set of best practices for the design and delivery of IMD courses. He addressed course structure, assessment, teaching methods, organisation and the classroom environment. Scott (2003) focused on the student perspective. She conducted student interviews and in-class observations in two sets of matched units. Each set was taught by the same instructor, with one unit delivered intensively and the other across a semester. Scott identified attributes of high quality learning experiences in IMD courses, and related them to the effectiveness of the instructor, course structure, assessment, teaching methods and classroom environment. The findings of Kops and Scott are similar and are discussed in more detail below. Their findings also align with Chickering and Gamson’s (1987) seven evidence-based principles for good teaching practice, and Felder and Brent’s (2005) list of instructional conditions that facilitate intellectual growth. Kops (2014) concluded that the best practices for IMD courses “are important to quality teaching regardless of the format, but appear to be more critical when courses are delivered in compressed format” (p. 16).

It is prudent to comment on course length before proceeding. Kops (2009, 2014) and Scott (2003) do not explicitly state the course lengths that were used in their studies; however, Kops includes a quote that refers to a 3-week IMD course (Kops, 2014, p. 8). To compress a semester-length unit into three weeks requires more severe re-structuring of content and assessment than delivering the same unit in eight weeks. Therefore some of the recommendations below may be biased towards highly compressed courses. None the less, they provide useful guidelines.

Kops (2009, 2014) observed that high performing teachers of IMD courses re-structure and re-prioritise course content to better fit the compressed format: including shifting the focus from content delivery to learning outcomes; emphasising depth over breadth; and, often tackling complex topics earlier in the course. The last modification provides students with more time for critical thought and reflection on these topics. It also avoids adding extra pressure at the end of the course. There are conflicting views on whether the amount of course content needs to be adjusted. Some academic staff have reported that they reduce content to focus on important key concepts (Kops, 2009; Pritchard & MacKenzie, 2011), while others have reported that they cover the same or more content by using class time more efficiently and effectively (Kretovics et al., 2005; Guertler, 2010; Kops, 2014). Early assessment of students’ prior learning can assist in this process. Kuiper et al. (2014) reported on the introduction of the seven-week summer session at Macquarie University and warned that “simply delivering the same content in a shorter time will not ensure student learning will take place and may lead to high attrition rates in intensive mode courses” (p. 1).

Scheduling and re-structuring assessment to match the rhythm of a compressed course is important (Scott, 2003; Kops, 2009; Pritchard & MacKenzie, 2011; Kuiper et al., 2014). Best practice includes progressive assessment, with traditional, longer assignments being broken down into smaller linked assignments that start early in the course and build on each other. Academics have reported that this encourages early student commitment and spreads workload (Lee & Horsfall, 2010). Students have also endorsed this approach as it provides them with early feedback on their progress (Scott, 2003). Varied assessment is also recommended to cater for student diversity (Maringe & Sing, 2014). Both students and academic staff have expressed concerns that the use of objective exams at the end of IMD courses encourages surface learning and cramming (Scott, 2003; Felder & Brent, 2005; Welsh, 2012). However, adult learners have reported that examinations encourage them to "review material which they might otherwise have skimmed over (and) organise their learning in a coherent structure for future reference” (McCarthy, 2010, p. 348). Thus, student maturity needs to be taken into account when designing assessment tasks.

Kops (2009) and Pritchard and MacKenzie (2011) observed that high performing teachers did not view their adjustment of course material and assessment for intensive delivery as lowering standards. They believed that the changes led to a better learning experience for students. However, some academic staff disagree and believe IMD courses do not maintain the same level of academic rigour as semester-length units (Daniel, 2000; Welsh, 2012). In order to develop and deliver effective IMD units, and ensure academic standards and expectations of performance are not compromised, it is recommended that academic staff be guided as they re-design their courses (Swenson, 2003; Kretovics et al., 2005; Collins et al., 2013; Kuiper et al., 2014). This includes having access to successful practitioners of this...
mode of delivery (Collins et al., 2013). Three Australian studies (Finger and Penney, 2001; Hardy, n.d.; and Collins et al., 2013) recommend that academic staff not be forced to teach in intensive mode until they feel confident to do so.

Workloads associated with course preparation and marking also need to be managed (Lee & Horsfall, 2010; Kops, 2014). Self-assessment, peer assessment and online quizzes or assignments can be used to reduce the workload associated with marking. Self-assessment encourages students to reflect upon and take ownership of their learning. Peer assessment provides students with a wider range of input on their work and offers them an insight into assessment practices. When well designed, both assessment methods develop higher order thinking skills (Spiller, 2012; Maringe & Sing, 2014). Spiller (2012) presents an overview of the advantages and disadvantages of self-assessment and peer assessment, and includes examples of good and poor practice. A range of textbooks now includes access to prepared online quiz questions with built-in feedback. Some publishers allow sections from different books to be collated into custom publications (Cengage Learning, 2014). The development of high quality online resources and effective self and peer assessment protocols takes considerable time and effort (Tynan et al., 2013; NFER 2014). This time commitment needs to be included in workload models (Tynan et al., 2013). Some academic staff may also need assistance with designing and implementing these methods (Mulryan-Kyne, 2010).

Student motivation and assigned workloads can be issues for both semester-length and IMD courses. Under standard semester conditions, students in higher education are expected to dedicate 10 to 12 hours of study per week to each unit. However, surveys show that students study on average much less than this (ACER 2010, as cited in Abeyesekera & Dawson, 2014). Research on student attitudes towards IMD courses has also revealed that some students expect IMD courses to be easier than their semester-length alternatives (Lee & Horsfall, 2010; Welsh, 2012). It is therefore important to clearly articulate the expected workload and performance criteria for each unit. Lutes and Davies (2013) analysed survey data from 29,000 students to compare student workloads in IMD courses with semester-length units. They found significant variations were introduced by subject and instructor rather than delivery mode. This suggests that moderation of assessment and course load may be required across units. Coordination of assignment deadlines in IMD courses that run concurrently is also recommended to ensure multiple assessments are not due at the same time (Lee & Horsfall, 2010).

In Scott’s (2003) study, a good instructor was seen as the most essential attribute of a high quality IMD course. Students were more engaged when taught by enthusiastic, knowledgeable instructors with good communication skills. They also felt that their learning improved when their instructor was open, caring and willing to learn from and with them. Kops (2009) reported that effective instructors of IMD courses made themselves more available to students by scheduling longer and more frequent office hours. They also created a relaxed, inclusive and non-judgemental classroom environment where students felt safe and more willing to participate. Krishnan and Vrcelj (2009) surveyed 1,803 students at UNSW to determine expectations and motivations of students choosing to study at university. Both local and international students identified a friendly class atmosphere as the primary stimulus for increased learning. Extended class interaction also provides an opportunity for stronger bonds to develop between students, and between students and academic staff (Austin and Gustafson, 2006). This creates cohesion in a class and can encourage the formation of a community of learners (Lee & Horsfall, 2010; Hermida, 2014). Research has shown that strong positive classroom relationships improve learning outcomes and increase student satisfaction (White, 1999; Scott, 2003; Ho, 2007). This finding reinforces the need for academic staff to feel confident about the delivery mode.

The effectiveness of IMD courses is partly attributed to uninterrupted periods of concentrated study (Scott & Conrad, 1992; Logan & Geltner, 2000; Pritchard & MacKenzie, 2011). Students have reported that the intensity of time-compressed courses allows them to “become more focussed and immersed in the learning experience, and more motivated as a result” (Lee & Horsfall, 2010, p. 196). Research on creativity has shown that immersion in an experience can encourage optimal performance (Csikszentmihalyi, as cited in Scott & Conrod, 1992). Csikszentmihalyi calls this state of intense concentration flow. Wlodkowski and Ginsberg (2010) use the term vital engagement to characterise the ideal learning state. This requires students to be totally absorbed in the learning task and for the task to hold personal significance or meaning. The combination creates motivation as well as tapping into the students’
affective realm. Higher cognitive performance occurs when a student’s ideas, feelings and actions are engaged (McLoughlin, 1999; Felder et al., 2000; Prince & Felder, 2006; Ambrose & Lovett, 2014).

Omelicheva (2012) observed that students’ lack of interest in a subject could block their ability to gain an in-depth understanding of course content. She recommended cultivating students’ situational interest in a subject by relating course material to their personal experience and introducing active learning in the classroom. She proposed a 3R&E rule: the three Rs stand for Reason, Relevancy and Recency of the course material and examples used, and the E stands for Engagement. By applying these strategies in a 4-week IMD course on international politics, Omelicheva was able to significantly improve student learning outcomes and course satisfaction scores.

Active learning is a key aspect of high quality IMD courses (Swenson, 2003). Teaching methods that incorporate creativity, class discussions, and experiential and applied learning are highly rated by students (Scott, 2003) and embraced by successful teachers of IMD courses (Kops, 2009; Kops, 2014). Active learning requires students to interact with the course material as it is delivered rather than sit as passive recipients. This approach helps students to develop more meaningful connections between new information and their prior knowledge and experience; promoting deeper learning and better long-term retention (McLoughlin, 1999; Felder et al., 2000; Swenson, 2003; Swartz et al., 2011). It also maintains student engagement in class. Freeman et al. (2014) conducted a meta-analysis of 225 studies that investigated active learning interventions in science, technology, engineering and mathematics courses. They found that active learning significantly improved outcomes, with student performance on average increasing by 0.47 of a standard deviation. It also reduced the risk of students failing, with students one and half times more likely to fail in traditional lecture courses than in classes that incorporated active learning. Traditional lectures are also “less effective for [teaching] problem solving and higher order thinking and for developing an interest in the subject” (Mulryan-Kyne, 2010, p. 180). Active learning interventions reported in the literature vary widely and range from in-class worksheets, class discussions and the use of clickers, to delivering entire units in a studio setting. It is recommended that active learning events be introduced every 10 to 20 minutes during lectures (Felder et al., 2000; Omelicheva, 2012).

Good teaching practice aims to individualise instruction as much as possible (Swenson, 2003; Randi & Corno, 2005; Kops, 2009). This includes the design and delivery of online content (Lee et al., 2012), as well as in-class instruction. Studies have shown that student comprehension improves when instruction is inclusive of a wide range of student learning preferences (Felder & Brent, 2005; Zywno & Stewart, 2005; Thomas & MacKay, 2010). There are large bodies of literature on both learning styles and cognitive styles that provide insight into individual learning behaviours. While there is overlap between these two research areas and the terms are sometimes used interchangeably, a number of educational psychologists promote the more established cognitive learning models and question the validity of learning styles (Pashler et al., 2008). Richard Felder, a well-respected engineering education researcher, proposes “taking an engineering approach to learning styles, regarding them as useful heuristics for understanding students and designing effective instruction” (Felder, as cited in Zywno, 2007, p. 1).

Two learning models that are often used in engineering education are the Felder-Silverman model and Kolb’s experiential learning model (Felder & Brent, 2005). Felder and Silverman (1988) proposed four learning dimensions based on how we perceive (sensory/intuitive), receive (visual/verbal), process (active/reflective) and understand (sequential/global) information (Felder & Brent, 2005; Felder & Silverman, 1988). Table 1 summarises the learning styles and corresponding teaching styles of their model. Felder and Silverman define only one visual learning style. Thomas and McKay (2010) recently argued that there are two: spatial and object/pictorial. Learners of the former style see spatial relationships between objects, and the latter create detailed images of individual objects.

Engineering students have been found to be predominantly visual learners; however, their preferences on the other three learning dimensions are not as clear-cut. A number of studies have identified engineering students as mostly sensing and active learners, but note that there is a significant minority who are intuitive and reflective (Zywno, 2003; Felder & Brent, 2005; Zywno & Stewart, 2005; Kolmos & Holgaard, 2008). The division between sequential and global learners is even more closely balanced. Felder and Silverman (1988) observed that the most creative students are usually global learners. The above findings have been confirmed in studies conducted around the world (Zywno, 2003, Mazumder & Karim, 2012;
Lee & Sidhu, 2013). Kolmos & Holgaard (2008) reported similar results for students who were enrolled in Mathematics as their primary degree at Aalborg University in Denmark, although these students were borderline active/reflective. Alharbi et al. (2011) and Alaoutinen et al. (2012) studied students’ learning styles in two computer science units. The students were again predominantly visual learners with a mild preference for sensing and sequential learning. Students in one study showed a mild preference for active learning, students in the other a mild preference for reflective learning.

**Table 1:** Felder-Silverman Learning Preferences and Corresponding Teaching Styles
(Felder & Silverman, 1988)

<table>
<thead>
<tr>
<th>Preferred Learning Style</th>
<th>Corresponding Teaching Style</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perception</strong></td>
<td></td>
</tr>
<tr>
<td>sensory (concrete)</td>
<td>Content</td>
</tr>
<tr>
<td>intuitive (abstract)</td>
<td></td>
</tr>
<tr>
<td><strong>Input</strong></td>
<td></td>
</tr>
<tr>
<td>visual</td>
<td>Presentation</td>
</tr>
<tr>
<td>verbal</td>
<td></td>
</tr>
<tr>
<td><strong>Processing</strong></td>
<td></td>
</tr>
<tr>
<td>active</td>
<td>Student participation</td>
</tr>
<tr>
<td>reflective</td>
<td></td>
</tr>
<tr>
<td><strong>Understanding</strong></td>
<td></td>
</tr>
<tr>
<td>sequential</td>
<td>Perspective</td>
</tr>
<tr>
<td>global</td>
<td></td>
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</tbody>
</table>

Traditional lectures favour verbal, intuitive, reflective, and sequential learners (Felder & Silverman, 1988). This puts many ECM students at a disadvantage. A consistent mismatch between learning preference and delivery style can lead to “poor achievement, increased dropout rates and a loss of diversity among future engineers that would greatly benefit the profession” (Zywno & Stewart, 2005, p. 2). Felder and Silverman (1988) provide examples of a range of teaching techniques to suit different learning styles, including actions that can be taken during lectures. Case studies are also available in the literature. Lowery (2009) describes how teaching methods and assessment were amended in a first year electrical engineering course to better address different learning styles. Alaoutinen et al. (2012) discuss the design and implementation of an intensive one-week computer science coding camp and relate class activities to students’ learning preferences.

![Image of Kolb's learning styles and learning cycle.](Image)

**Figure 5:** Kolb’s learning styles and learning cycle.

Kolb’s experiential learning theory focuses on two learning dimensions, perception and processing, and proposes four types of learner: Type 1 are concrete/reflective, Type 2 are abstract/reflective, Type 3 are abstract/active and Type 4 are concrete/active (McLoughlin, 1999). Engineering students have been identified as being mainly Type 2 and Type 3 (Felder & Brent, 2005). Kolb argued that the four learning
types also represent a learning cycle, as shown in Figure 5. Superimposed on this cycle is a third set of learning styles that were defined by Honey and Mumford. These are the activist, the reflector, the theorist, and the pragmatist (McLoughlin, 1999). Teaching around the cycle is an instructional method that guides students from concrete experience to reflection, then to abstraction and active experimentation, before repeating the cycle. In this way, students are involved in some activities that match their learning preferences and others that develop their ability to cope with different teaching styles (Randi & Corno, 2005; Prince & Felder, 2006; Bambacas et al., 2008). A number of researchers recommend discussing learning styles with students, so that they become more aware of their preferences, and explaining techniques that may help them adjust to different delivery styles (Felder & Silverman, 1988; Kang, 1999; McLoughlin, 1999; Boyd, 2004).

Prince and Felder (2006) include a simple instructional model for engineering based on Kolb’s learning cycle. The sequence is as follows: (1) introduce a problem or challenge to students, and provide motivation for solving it by presenting it in a realistic context that students can relate to; (2) present relevant facts, experimental data, expert advice, theories and methods; (3) provide guided practice of methods and ways of thinking; and, (4) require students to apply their new knowledge and skills to novel problems or in a new context. Students are encouraged or directed to reflect on their learning during all four stages, in order to identify gaps and misconceptions, and to integrate new knowledge and skills. Prince and Felder (2006) argue that inductive instruction is best suited for Kolb’s learning cycle. Many ECM courses are taught using deductive methods, where theory is often presented first and without context. Inductive instruction provides students with the context or problem description first to establish the purpose and relevance of the knowledge and skills development to follow. Inductive methods include inquiry-based learning, problem-based learning, project-based learning, and the use of case studies. Prince and Felder (2006) reviewed the research on inductive instruction in engineering education and concluded “while the strength of the evidence varies from one method to another, inductive methods are consistently found to be at least equal to, and in general more effective than, traditional deductive methods for achieving a broad range of learning outcomes” (p. 123). They note that some inductive methods, such as project based learning, are not easy to implement and require flexible instructors with considerable subject expertise. They also include a warning that students can be resistant to this type of instruction, as it requires them to take more responsibility for their own learning. Resistance may also come when students are pushed too far out of their comfort zone (McCarthy, 2012; Wankat & Oreovicz, n.d).

Table 2: Perry Levels and learner perceptions
(Johnson, 2005)

<table>
<thead>
<tr>
<th>Perry Levels (Intellectual Maturity)</th>
<th>Description of learner</th>
<th>Perceptions of knowledge</th>
<th>Perceptions of expert/teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dualism Levels 1 &amp; 2</td>
<td>They believe things are right/wrong, good/bad</td>
<td>Knowledge is a set of truths</td>
<td>Experts explain the course material and give me the correct answers</td>
</tr>
<tr>
<td>Multiplicity Levels 3 &amp; 4</td>
<td>They recognise multiple points of view exist. Uncertainty prevails because all opinions are valid.</td>
<td>Knowledge is a matter of educated opinion</td>
<td>Experts explain the course material and express their opinions</td>
</tr>
<tr>
<td>Relativism Levels 5 &amp; 6</td>
<td>They perceive all knowledge is relative, and that they need to orient themselves based on evidence</td>
<td>Knowledge is not universal, but a matter of context and situation.</td>
<td>Experts teach procedures and analytics methods based on their experience to help me reason and compare alternatives.</td>
</tr>
<tr>
<td>Commitment to Relativism Levels 7 to 9</td>
<td>They develop the need to take positions and commit to them</td>
<td>Knowledge is constructed from experience, what is learned from others, and from reflective thinking.</td>
<td>Experts are mentors who challenge my assumptions to support my learning</td>
</tr>
</tbody>
</table>
Explicit support of students’ development as learners is necessary if students are expected to perform at a high level (Smith, 2000). A well-established framework for cognitive development is Perry’s model (Wankat & Oreovicz, n.d). William Perry studied college students at Harvard University over a period of years and defined nine levels of intellectual development as students transitioned from being dependent learners to independent learners (Ahmad et al., 2012, McCarthy, 2012). The levels can be grouped into four categories, as shown in Table 2.

Senior undergraduate engineering students are expected to perform at Perry Levels 5 and 6 (Pavelich, 1996; Wankat & Oreovicz, n.d); however, studies have shown that many of these students are operating at Levels 3 and 4 (Pavelich, 1996; McCarthy, 2012; Wankat & Oreovicz, n.d). This means that they are still struggling with procedural knowledge and disciplinary reasoning methods, and are unable to integrate and apply their learning in unfamiliar contexts. McCarthy (2012) employed the Learning Environment Preference (LEP) instrument to evaluate students’ developmental levels in a third year manufacturing systems unit at the University of Auckland in New Zealand. LEP outcomes correspond to the levels in Perry’s model. McCarthy reported a significant positive correlation between students’ ability to solve indeterminate problems and their developmental level according to Perry’s model. Bambacas et al. (2008) surveyed international students in a MBA programme that was delivered in intensive mode. The results revealed that many of these students were still dependent learners who saw the teacher as the most authoritative source of information. Therefore it cannot be assumed that all students entering a course at Master’s level are intellectually mature and able to cope with independent inquiry. It is recommended that units in the MPE be designed with this in mind, and include activities that assist students to grow as learners.

Challenge with the right level of guidance can help students transition through the different levels of Perry’s model (McCarthy, 2012; Wankat & Oreovicz, n.d). Challenge means pushing students just outside their comfort zone. Ahmad et al. (2012) recommend introducing problems that are one or two levels above students’ current intellectual development level. Higher than this and students may become overwhelmed, defensive and retreat (McCarthy, 2012; Wankat & Oreovicz, n.d). Schmidt and Bjork (1992) approached this issue from a different angle but report similar findings. They reviewed a number of experimental studies on verbal and motor skills learning and concluded that practice during acquisition should focus on long-term retention and the ability to transfer learning to new contexts. Requiring students to process and interact with new information in varied and unpredictable or challenging ways can achieve these aims, although it may lead to lower performance in the short-term (Schmidt & Bjork, 1992).

Prince and Felder (2006), Hoffman et al. (2009), and Wlodkowski and Ginsberg (2010) also recommend the use of challenging and complex problems with appropriate support to improve long-term learning outcomes. Hoffman et al. (2009, p. 19) noted that “perhaps most importantly, research on high-end learning has shown that when learners are initially exposed to simplifications of complex topics, serious misunderstandings can become entrenched and then interfere with achieving richer, accurate understandings”. This problem is often encountered in engineering foundation units, when trying to redress the simplified models and methods presented in high school physics. Student misconceptions are also evident in higher-level units. Ambrose and Lovett (2014) observed that students’ prior knowledge, skills and beliefs could help or hinder further learning. They recommend assessing students’ prior learning in order to adapt instruction to address gaps and earlier misunderstandings. Hoffman et al. (2009, p. 20) recommend that coursework, assessment and feedback be carefully designed to “help learners transcend the inclination to invoke a knowledge shield (that is, rationalize (sic) away a reductive misunderstanding) and help them unlearn notions that incorrectly simplify their understanding of the domain”.

Swartz et al. (2011) report that staggered retrieval of earlier learning can improve long-term recall. A simple example is the use of worksheets or quizzes that include revision problems as well as questions on the current topic. This requires students to retrieve and review earlier learning, thereby allowing them to identify what they have forgotten or misunderstood, and to build stronger connections between new information and prior learning. This is a form of distributed practice and encourages double-loop learning.
Helping students to develop as self-regulated learners is also important. Bjork et al. (2013) noted that “people often have a faulty mental model of how they learn and remember, making them prone to both misassessing and mismanaging their own learning” (p. 417). In their view, effective learners understand the mechanics of how human beings learn and remember, know and apply techniques that help them to remember and retrieve information, monitor and control their learning, and understand that certain biases can affect their judgment on whether they will be able to recall material at a later date. The latter two points represent forms of self-assessment. In their study of MBA students, Bambacas et al. (2008) reported that students were uncomfortable with online delivery of content because of the self-discipline required to manage their own learning. Alharbi et al. (2011) reviewed learning strategies in a second year computer science unit and found students were not aware of the importance of self-regulated learning strategies such as “goal setting, planning and self evaluation” (p. 38). Both Bambacas et al. and Alharbi et al. conclude that students might benefit from educational interventions focusing on these strategies. Kops (2009) and McLoughlin (1999) recommend coaching students on time management, especially in IMD courses. Workshops that address these issues and present a range of techniques may be of value to students.

The concentrated contact time in IMD courses requires innovation in the classroom. A variety of in-class activities are recommended to maintain student interest and concentration (Kuiper et al., 2014). This includes moving away from the standard 45-minute lecture format. For example, content might be delivered in short 15-minute sessions interspersed with individual and group activities, class discussions, case studies, demonstrations and hands-on practice (Scott, 2003; Mulryan-Kyne, 2010; Collins et al., 2013). Guertler (2010) recommends careful sequencing and pacing of activities within each class, as well as some flexibility to switch activities around when student attention wanes. She also suggests that training literature may provide useful techniques and example lesson plans, as professional training workshops are often delivered as half- or full-day sessions.

Best practice in IMD courses includes effective use of in-class time (Kops 2009, 2014). To maximise time for learning in class, a shift from information giving to interactive activities that clarify and apply course content is recommended. Strategies to achieve this include pre-reading assignments, prepared handouts of lecture notes or slides, and the delivery of some content online. Partially completed lecture notes or slides that are available before class allow students to preview content and spend less time copying notes (Kops, 2009). This provides students with more time to process and comprehend content in class. They can also be used as a trigger to encourage students to contribute to the development of the notes (Armstrong et al., 2010). A flipped classroom is a more radical approach, where lectures are watched online before students attend class. Pre-recorded lectures have been shown to improve outcomes for EFL students (Shaw & Molnar, 2011). Abeysekera and Dawson (2014) hypothesise that flipped classes may improve student motivation, but note more research is required. A recurring challenge with any of these approaches is ensuring that students do the required preparation before class. Ready assessment tests in the form of online or in-class quizzes are a commonly adopted practice to drive student behaviour.

The use of well-designed hypermedia (interactive online resources) in engineering courses has been shown to significantly improve academic achievement. Zywno (2002), and Zywno and Waalen (2002) investigated the effect of hypermedia on student outcomes in a senior undergraduate engineering control systems course. The results showed that students of all learning styles achieved higher grades when hypermedia was included. The variation in academic performance between students of different learning styles was also reduced. Over 90% of students with active, reflective, sensing, intuitive, visual, sequential and global learning preferences preferred multimedia lectures instead of conventional lectures. The sample size of verbal learners in Zywno and Waalen’s study was very small, but the results suggest that hypermedia may be less appealing to this group with 50% preferring conventional lectures. The improved grades of the verbal learners may be the result of these students discussing the course content with students who learnt more effectively using the hypermedia.

In-class breaks and time for reflection are strongly recommended when delivering a unit in compressed mode (Swenson, 2003; Boyd, 2004). Reflection is part of Kolb’s learning cycle and a learning preference of some students. Introducing a pause after presenting a new concept allows students to review their notes, gather their thoughts and ask questions. Ruhl et al. (as cited in Mulryan-Kyne, 2010, p. 181) found students learned significantly more when the instructor asked students three times during a lecture to pause for two minutes to consolidate their notes. Directed reflection can be included in class discussions and assignments.
For example, students may be asked to discuss their understanding of a new concept with the person sitting next to them in class, or reflect on working in a group at the conclusion of a team project. Short breaks in class can also be used to revitalise everyone’s attention, and allow the instructor to review progress and adjust the pace if necessary.

Tobin (1987) reviewed the literature on wait time, the pause before or after an utterance in verbal interaction. Wait time appears to be a threshold phenomenon, and research indicates that when an instructor introduces a pause of more than three seconds after asking a higher cognitive level question, students have time to reflect on their response and learning is enhanced. Tobin argues that the extended period allows sufficient time for appropriate cognitive processes to occur and this improves the quality of student-instructor interaction.

Organisational issues are mentioned in a number of studies on IMD courses. It is recommended that lesson plans and assessment tasks for the whole course be developed before the course commences (Kops, 2009; Guertler, 2010; Kops, 2014). This allows the pace of content delivery to be planned, monitored and managed, and improves the flow of a course. Students prefer courses that are presented in an easy to follow manner, and chaotic delivery can lead to some students feeling overwhelmed (Scott, 2003). Chaotic delivery can also lead to content being missed. To support students, Kops (2009, 2014) notes that high performing IMD instructors provide study guides, prepared handouts, and course readers or assigned readings. They also focus on their teaching while delivering the course and make themselves more available to students. Guertler (2010) recommends providing the syllabus a few weeks before the course commences, so students can prepare. Sufficient preparation time for course development and refinement must also be made available to academic staff (Lee & Horsfall, 2010).

Compressed delivery of courses impacts on administrative and support services, as everything needs to happen more rapidly, including resolution of enrolment issues and identifying at-risk students (Lee & Horsfall, 2010). Professional staff at the University of Canberra noted that the 7-week Winter Term required more planning and resources than originally anticipated (Collin et al., 2013). It was observed that they had to deal with more anxious students and staff. Uncertainty can be managed by having clear procedures and communication strategies in place. “Professional staff also discussed some the system barriers they experienced. These systemic issues were identified as greater ICT support, timetabling, room allocation, staffing and communication with academic educators and [students]” (Collins et al., 2013, p. 15).

Many universities are increasing the number of IMD courses they offer and, as a consequence, are including more information about this format on their websites. Some universities have developed resources to support academic staff with the design and delivery of IMD courses. When Macquarie University introduced Session 3, staff from their Teaching and Learning Centre prepared and published a range of resources to assist academics in redesigning their units for compressed delivery. Their web pages cover topics such as planning, organisation, assessment and student engagement strategies. The University of Canterbury in New Zealand has also produced a set of guidelines for developing IMD courses. There are a number of on-line resources that focus on course design in general. For example, Dee Fink (2005), the author of Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses has published a self-directed guide to designing effective courses of any length. Links to the resources at Macquarie University, the University of Canterbury, and Dee Fink’s guide are given at the end of this report.

5. Students with English as a Foreign Language (EFL)

“Intensive modes promote deep learning in all age groups and in all ethnic backgrounds: aboriginal, white, Latino, African American, and Asian, among many others. It also strongly benefits students whose first language is not English or the language of instruction, as immersion in a language has proved to help students improve their language and academic skills.” (Hermida, 2014, p. 280)

While researchers report no significant difference in outcomes between native English speakers and EFL students in IMD courses (Sankaran & Sankaran, 2000; Logan & Geltner, 2006), some academic staff have raised concerns about these students and their ability to cope in compressed courses with concentrated
contact hours (Lee & Horsfall, 2010; Welsh, 2012). There is also evidence that some EFL students may prefer semester-length courses to intensive delivery (White, 1999; Bambacas et al., 2008). A brief discussion of some of the literature and recommendations to assist EFL students are given below.

Blended learning is one approach that has been used effectively to support EFL students. Kang (1999) reported that computer assisted instruction can assist EFL students as it caters for a wide range of learning styles. This finding is supported by the work of Zywno (2002), and Zywno and Waalen (2002). Online material also allows students to review material before and after class to reinforce understanding. Shaw and Molnar (2011) found pre-recorded lectures improved learning outcomes for EFL students in a biochemistry course at Barry University in the US. The pre-recorded lectures supplemented face-to-face instruction and were captured using Articulate Presenter software, which allowed students to search for key words in a presentation. A written script of the narration was also provided to assist hearing-impaired students as well as EFL students. Although pre-recorded material was shown to assist EFL students, Shaw and Molnar conclude with a warning that “when left to their own devices, some students may utilize (sic) the online lectures in a manner that does not benefit learning” (p. 419). This included skipping classes. Concentrated contact time in IMD courses may mitigate this behaviour.

Sankaran and Sankaran (2000) investigated student attitudes about web-based instruction and face-to-face lectures in a 4-week IMD undergraduate business computer course. The sample comprised 116 students, 65 of which were EFL students. 39.7% of the total sample chose web-based only instruction. This included 41.5% of the EFL students. Sankaran and Sankaran observed that the EFL students who chose web-based instruction tended to be recent immigrants, and hypothesised that these students may have been reticent to join an interactive lecture environment. There was no statistically significant difference in average course grades between delivery modes, or between EFL and non-EFL students. There was however a significant difference in the learning strategies adopted, with more students employing a surface learning approach to the web-based format. Sankaran and Sankaran argued that this was to be expected as the web-based format included no verbal interaction to challenge students’ understanding, and course content was presented on the web in a more sequential, concise and organised manner than in the lectures.

The above studies raise a couple of important points. Verbal interaction is necessary for language development, and EFL students should be encouraged to practice their English language skills in class. Class interaction also encourages deep learning strategies to be employed. It has been shown that in many courses students can achieve similar grades using either surface or deep learning approaches (Sankaran & Sankaran, 2000; Bone & Reid, 2013); however, deep learning leads to better long-term retention. Therefore class activities need to be carefully designed to encourage and support this behaviour. Learning outcomes can also be enhanced, especially for EFL students, when online resources allow students to prepare for face-to-face classes and review course content.

Maringe and Sing (2014) considered student diversity in large classes. They recommend increasing academic staff’s intercultural understanding and also ensuring the language of instruction is accessible to all. This includes using simple English and avoiding the use of heavy accents and local idioms when communicating with students, repeating important points, and frequently checking that students understand the material. These findings apply to classes of any size.

Many language skills workshops are based on immersion. The Centre for English Language Teaching (CELT) at UWA currently offers an IMD English language course for international students who have received AusAid scholarships to study postgraduate research degrees at UWA (Barrett-Lennard et al., 2006). These students have already met the English entry level for UWA, so the aim of the course is to prepare them for study at an Australian university and to build their confidence in speaking and writing in English for academic purposes. The course is delivered in half-day sessions, Monday to Friday over four to five weeks. Topics include: an overview of tertiary study in Australia; information literacy; writing summaries; preparing critical reviews; listening and note taking; thesis conventions and structure; and, speaking in academic situations. At the end of the course, students receive detailed feedback on their English writing and speaking skills. This course could be tailored for EFL students entering the MPE, to support their transition to UWA and identify those at-risk due to poor language skills (Kettel, 2014). On-going support programmes or workshops during semester are also possible. CELT charges per student.
Many of the international students enrolling in the MPE have completed their first degree in their home country. This means that they face the same issues as other EFL students entering their first year at an Australian university. Bone and Reid (2013) assessed the impact of student age, nationality and learning style on student performance in a first year biology course at the University of Adelaide. They noted that international students who had only recently moved to Australia to study may struggle with accents and the new learning environment. They also face other challenges: “settling into accommodation, adjusting to local social norms and building support networks are likely to influence academic performance, and more profoundly in the early stages, with access to support services often critical to their level of engagement” (Bone & Reid, 2013, p. 103). Therefore these students may require assistance and support beyond the classroom.

6. Scaling to Large Classes

“Extended small-group learning strategies such as jigsaw, structured controversy, and problem-based learning have proven so effective to many faculty members that they have moved to redesign their large classes to center (sic) around small-group learning.” (Smith, 2000, p. 25)

One of the most common differences between traditional and intensive courses reported in the literature is class size, with smaller numbers of students usually enrolled in the IMD courses. Many studies report 30 students or less, and enrolment caps are common. Both academic staff and students have identified small class size as a positive attribute of IMD courses (White, 1999; Scott, 2003; Ho & Polonsky, 2007; Kops, 2009). Small class sizes in semester-length courses are also seen as more effective in terms of improving student learning outcomes and managing student diversity (Maringe & Sing, 2014). Teaching a class of 15 to 20 students is a very different experience to teaching a class of 100+ students. A good teacher uses a small class size as an opportunity to learn about the students as individuals, be more responsive to their learning styles and needs, encourage more student-teacher interaction, monitor and guide cooperative learning, and create a more relaxed and dynamic learning environment (Scott, 2003). This in turn may engender higher levels of student commitment, interest and motivation. The challenge then is to create this small class dynamic in larger classes.

Smith (2000) discusses a range of small group techniques that can be applied in large classes. These include variations on cooperative learning, jigsaw strategies, structured study groups, and problem-based learning. Smith includes examples from the literature that illustrate how these techniques have been successfully applied in science and computer science courses. The underlying principle of many of these methods is active learning.

Vreven and McFadden (2007) investigated the use of cooperative small group learning in a large 3-week IMD introductory psychology course. Students enrolled in the course were divided into two sections; one section included in-class cooperative learning activities and the other did not. There were 215 students in the cooperative learning section and 154 in the control section. Vreven and McFadden found no advantage in incorporating cooperative learning when they reviewed student grades; however, a decrease in student motivation was measured in the cooperative learning section. Vreven and McFadden hypothesised that three weeks were insufficient time for students to form a sense of community in their groups. Students may also have been more strongly focussed on their individual learning goals due to the highly compressed time frame. This result suggests that there may be a relationship between course length and the effectiveness of cooperative learning strategies in large classes (Vreven & McFadden, 2007). It also highlights an issue that was not discussed in the paper: asking students to work in groups does not guarantee cooperative learning. Students need guidance to learn effectively in groups and activities need to be carefully designed to ensure individual accountability (Stanford University, 1999). Oakley et al. (2004) have prepared a comprehensive set of guidelines on the formation and management of effective student teams.

Assessment of large classes can also be an issue, especially in compressed courses. Lee and Horsfall (2010) reported that academic staff struggled to provide early feedback in 6-week IMD courses with large enrolments. Staff may therefore require assistance with some types of marking. As with IMD courses, online quizzes, self assessment and peer assessment can be used to reduce marking loads. Also, clickers have been shown to be effective in large classes. Two examples are given below.
Clickers are a form of active learning that can be used for formative or summative assessment in class. Forster (2014) reported on his experiences with clickers in two large statistics units. He trialled both voluntary and compulsory student participation, but found using the clickers for assessment was the most effective driver of student learning. Students read ahead and listened more attentively in lectures to prepare for the in-class assessed clicker questions. Attendance at lectures increased from below 50% to over 80%. Students received immediate feedback on their understanding of course content and highly rated the use of clickers in class. Forster also received immediate feedback on how students were progressing. He reported that including clicker assessment lifted the entire mark distribution, indicating that both weak and strong students benefitted. Also, fewer students required extra assistance before the exam at the end of the course. Forster noted that the initial revision of a course to include clicker assessment took considerable time and effort, and that some academic staff may feel uncomfortable with the level of multi-tasking required in class.

Armstrong et al. (2010) used a variation on clicker technology in a large geotechnical engineering course. Students were required to bring their own internet-enabled devices and an online learning management system was used to capture student responses. Assessment was again used as a driver with students receiving a participation mark for clicker activities. Armstrong et al. argued that a participation mark, as opposed to a mark for the correct answer, promotes free and unrestricted thinking. While their student response rate was high, it was less than that reported by Forster (2014).

Armstrong et al. (2010) also provide an example of how content delivery in large classes can be designed around a learning cycle. To achieve this, they divide each lecture into five components – Awareness, Context, Maturation, Application and then Recapitulation. In the Awareness phase, examples that allow students to apply previous experience or give educated guesses are used to engage interest. For example, a crowded train carriage with people pushing in through the door is used to introduce the concept of stress distribution in soil under a building. Students might be asked use the online system to vote on which person in the carriage is squeezed the most and the lecturer moderates a discussion on different viewpoints. The Context phase then re-interprets concepts identified in the Awareness phase by introducing the technical context. During the Maturation phase, theoretical and practical frameworks are developed, beginning with estimation techniques and building to complex analyses. The online system is used to confirm students’ understanding of certain concepts or methods. The Application phase requires students to discuss and solve practical problems that highlight strengths and limitations of the developed models. Students report their answers through the online system allowing the lecturer to evaluate progress and identify areas that need further clarification. The Recapitulation phase then reviews material from previous lectures as well as the current class to highlight connections and view previous content from a new perspective. To assist students in their preparation, Armstrong et al. publish skeleton lecture notes online before class. The lecturer uses a PC tablet to annotate the notes and these are recorded for future reference. Armstrong et al. reported that most students improved academically under this scheme and preferred this mode of delivery to conventional lectures.

Mulryan-Kyne (2010) reviewed the literature on large classes in university settings. The challenges she identified included managing increased student diversity, maintaining student engagement and classroom control, overcrowding in venues, providing opportunities for student-lecturer interaction, and marking and providing feedback in a timely manner. While academic staff often have little control over the choice of venue, research shows that student diversity and engagement can be managed in large classes by the introduction of active learning techniques and effective use of online resources (Mulryan-Kyne, 2010). Thus, approaches that improve the quality of IMD courses also apply to large classes. Successful implementation of active learning interventions, access to the lecturer and a productive classroom environment depend largely on the lecturer’s commitment and expertise. “A large and growing body of research has shown that teacher expertise is a more significant determinant of student learning than class size” (Mulryan-Kyne, 2010, p. 178).

Mulryan-Kyne (2010) concludes her review of large classes with an important insight. It has been alluded to in other studies and applies equally to the introduction of IMD courses. Whether redesigning courses for large classes or intensive delivery, some academic staff will struggle due to their anxiety about change, self-perception of their roles, lack of knowledge or confidence in applying new methods, the additional workload, and the lack of incentives. Also, “time demands for designing, implementing, and testing new ...
teaching approaches can put additional pressure on faculty who are also trying to meet research and other institutional demands” (Mulryan-Kyne, 2010, p. 182). To encourage academic staff to commit to these changes, a support structure that provides incentives, resources, time and recognition is required.

7. Conclusions
The main conclusions of this report are presented in the Extended Summary.

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References


Rufford, T. (2014). Dr Tom Rufford, School of Chemical Engineering, The University of Queensland. Personal communication to D. Hesterman 1 October 2014.


Online Resources

Session 3 Staff Toolkit
The Macquarie University resource page for Session 3 covers planning the unit, organisation, assessment and student engagement strategies.

Guidelines for teaching in time-shortened, intensive, or summer school settings
These guidelines were developed by the Academic Development Group at the University of Canterbury. They include a range of approaches to teaching, course design, classroom environment, blended/online learning, and assessment in compressed courses.

A Self-Directed Guide to Designing Courses for Significant Learning
This guide offers an informative, comprehensive, step-by-step process to designing courses of any length.

Teaching Engineering
A comprehensive e-book on teaching engineering developed at Purdue University. Covers all aspects of teaching and course development.

The Centre for the Advancement of Teaching & Learning at UWA provides a range of resources including workshops on active learning, techniques for teaching large classes, assessment, etc. Teaching and Learning units at other universities also offer a wide range of resources.