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## Introduction

Intensive mode delivery (IMD) is a contested term with no clear definitions (Harvey et al., 2017; Hesterman, 2015). Alternative descriptors for IMD include compressed, time-shortened, mixed-mode, block, accelerated learning, sandwich and sporadic modes (Czaplinski et al., 2017). Central to this mode of teaching delivery is that the learning and teaching experience is 'complete' within a shorter timeframe than is usual. In higher education a standard format for teaching is weekly classes delivered over a semester or period typically around 10-16 weeks. Importantly the subject learning outcomes should be consistent across delivery modes. However, due to the "conceptual non-uniformity in IMD" (Harvey et al., 2017, p. 232) and the range of outcomes and findings (including many inconclusive results) there is a growing need to contribute more scholarly outputs to aid the sector's understanding of IMD.

There have been a small number of meta-reviews and commissioned reports of the IMD literature which describe studies from the past few decades that attempt to evaluate how learning takes place in an intensive mode, each with varying outcomes and conclusions (Davies, 2006; Hesterman, 2015; Male et al., 2016). For example, Whillier and Lystad (2013) compared students studying neuroanatomy in both SMD (standard mode delivery, i.e. regular semester) and IMD formats and found that the SMD cohort achieved significantly higher final grades compared to the IMD cohort. Similarly, Harlow et al. (2015) compared learning gains in a first-year physics course and found similar, significant differences in favour of SMD. The researchers noted however, that additional variables such as teacher experience and enthusiasm had an influence on the findings. Some studies have found favourable student performance in IMD (Klein et al., 2019; Lutes & Davies, 2018) and other studies have found no significant differences in student achievement between IMD and SMD (Anastasi, 2007; Karaksha et al., 2013; Shaw et al., 2013).

Students' perceptions of IMD have also been investigated. One study found that most students like intensive courses once they are familiar with the format, but there is a general concern about workload and time management (Hesterman, 2015). Another study found that while surveyed students preferred SMD courses, they did acknowledge the benefits of IMD and showed a preference for courses delivered in this mode (Krug et al., 2015).

Victoria University in Melbourne, Australia recently moved their first-year curriculum exclusively into Block Mode teaching (IMD). A number of studies are beginning to emerge from this wholescale change. One of these explored student performance and satisfaction (Loton et al., 2021). Performance was shown to have substantially improved (in comparison to SMD) across the board, while satisfaction change was negligible in all categories, except in areas that had not significantly redesigned their assessment where satisfaction decreased. In another study from this institution, students who had failed a subject delivered in SMD were surveyed about their preference for the new IMD version, with the majority replying positively towards IMD (Klein et al., 2019). Institution statistics also showed significant improvement in grades and pass rates overall through IMD, including First-in-family, low socio-economic status, and non-English-speaking background students (Samarawickrema & Cleary, 2021).

In a national review of IMD teaching in Australia, Male et al., (2017) provided a set of 12 recommendations to guide the design of IMD curriculum. Their review covered studies from across all disciplines, similar to Kuiper et al. (2015) who investigated student engagement and task design in IMD subjects. The study described in this paper will concentrate specifically on the science curriculum in response to the calls to action for discipline specific examples (Czaplinski et al., 2017; Davies, 2006; Harvey et al. 2017). This paper describes a study to investigate the contextual factors of teaching IMD in the physical and life sciences and mathematics.

### *Background*

This research study took place in a faculty of science in an Australian metropolitan university and was underpinned by a number of factors. With the growing diversity of the student body, our institution has moved to a balanced session teaching timetable in order to offer more flexibility to our learners. Three sessions (Autumn, Spring and Summer[1]) of 12 weeks duration are each followed by a study break and examination period. There are a growing number of subjects offered over the summer session and in the year of this study, the science faculty introduced the IMD format in 18 of its 24 summer subject offerings. Each of these IMD subjects was delivered over 1.6-4 weeks and the majority were from the discipline of life sciences. Students choose [1]the session in which to study their selected subjects.

### *Terminology*

In this paper we use: *Subject* is a single unit of study, which combine to make a degree program. *Subject Coordinator* is the academic who has overall leadership of the subject, designs and teaches subject content, and may coordinate tutors and lab demonstrators. *Tutor* is the person who teaches small classes called tutorials which usually comprise application and worked examples. *Demonstrator* is the person who guides the students in their experimental and/or computer work in the lab. *Lab* (laboratory) is the specialised learning space where practical exercises and experiments take place. *Intensive* describes the mode of delivery (IMD), otherwise known as block mode or compressed mode. *Standard mode delivery* (SMD) is the term we use to describe the semester long, weekly delivery mode, which is 12 weeks at our institution. Our university recently moved from using the term *semester* to the term *session* and we are now on a balanced three session annual rotation. However, students and staff often still use the term semester and given the term semester is widely understood in the sector, we use that term within this paper when needed.

## Research design and methods

The aim of this research project was to investigate student and teaching staff motivations and perceptions of IMD to inform the future curriculum design of IMD sessions. Our objective was to collect a variety of evidence to support future educational development.

Our main research question was: How can an intensive mode science subject be designed to enhance engagement for both the teacher and the student? We were also interested in attainment, so our second research question was: How do students perform in a standard vs. intensive mode offering of a science subject?

We used a pragmatic paradigm to frame our research. Within this worldview, importance is placed on the questions asked rather than the methods used (Creswell & Plano-Clark, 2011) and assumes interaction with complex social phenomena involving reflective people (Healy & Perry, 2000).

We also use the transition pedagogy framework of Sally Kift (2009) to present our findings. These transition curriculum principles outline intentional and holistic curriculum design to support successful transition into university and cover: transition (allowing a smooth transition from previous learning experience), diversity (attuned and inclusive to the diverse range of students), design (learner focussed and scaffolded for student success), engagement (involve active learning and engagement), assessment (regular feedback on students' progress), evaluation and monitoring (regularly evaluated and monitoring student engagement). While originally designed to guide the design of first year curriculum, the transition pedagogy (Kift, 2009) has been extended to inform

[1]In the Southern Hemisphere, the summer session spans the Christmas and New Year closure of universities, and this may impact on timing of block mode in this study.

how best to support students through multiple transitions in, through, and out of higher education (Creagh, 2015; Kift, 2015).

### *Methodology*

A design-based research (DBR) approach was used to conduct this study. DBR is defined as:

> *A systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories* (Wang & Hannafin, 2005, p.6).

We report on the first cycle of analysis and resulting design outputs.

### *Methods*

We used mixed methods to collect and analyse the data to provide a nuanced and contextual discussion of the challenges and opportunities afforded in IMD. We collected quantitative and qualitative data from students and staff studying and teaching over a 12-week summer session, which is arranged as four blocks of teaching and learning.

### *Data collection*

All students studying in the summer session (N=760) were invited to take part in the study via an online voluntary survey instrument with a range of Likert-style and open-ended questions. We received 261 student responses to our survey (34% response rate overall). No participants asked to withdraw their data. In addition, we analysed final grades from each cohort for the summer session as well as historical grade data for the same subjects taught in SMD in the previous year.

We invited each summer subject coordinator to a face-to-face semi-structured interview (N=22). Eighteen subjects were taught using IMD and the analysis of the data from these subjects will be reported in this paper. The interviews were recorded and transcribed, and subject coordinators were sent their recordings and transcriptions to verify the accuracy prior to analysis.

### *Data analysis*

The quantitative demographic student data were analysed in chart form and provided framing for their qualitative survey responses. In addition, we used chi-squared tests ($df = 4$) to compare the distribution of student grades in both IMD and SMD for 17 of the 18 subjects (one of the subjects is not taught in SMD so no comparison is available). Grades are recorded in five categories: High Distinction (overall mark $\geq 85\%$), Distinction (75% to 84%), Credit (65% to 74%), Pass (50% to 64%), and Fail ($\leq 49\%$). The grades were compared between IMD and SMD in the previous year for each subject separately.

The qualitative survey and interview data were analysed using thematic content analysis (Krippendorf, 2004) using NVivo. Student data was coded with a simple schema for positive and negative comments across the themes of learning activities and assessment. We used two cycles of coding for the staff data, an Initial Coding for the first pass followed by Focused Coding on the second cycle to produce key themes with which to interpret the data (Saldana, 2009). Whilst the staff interview data were predominantly qualitative in nature some questions lent themselves to descriptive statistical analysis.

## Findings

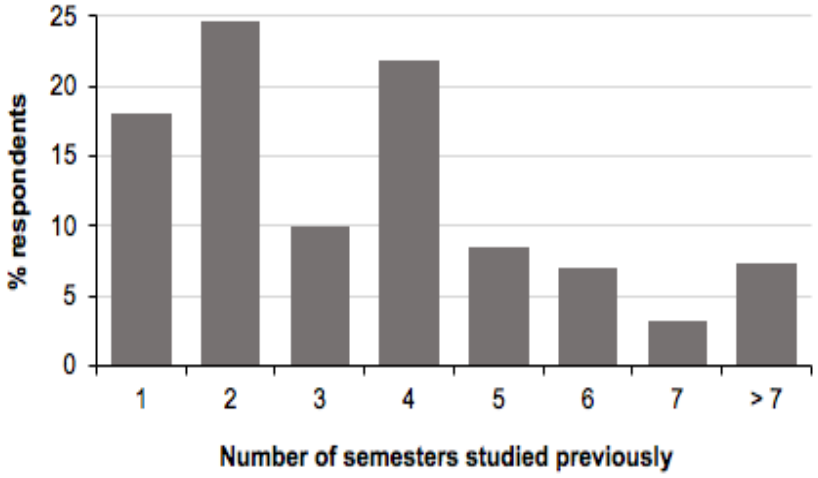
### *Student demographics*

There were 760 students enrolled in the 18 IMD subjects; 40% of these students were enrolled into first year subjects, 42% in second year subjects, 17% in third year subjects, and 2% in the postgraduate subject.

We received 261 student responses to our survey (34% response rate overall, ranging from 24% to 54% across subjects). Of these respondents, approximately 43% self-identified as being in their first year of study at our institution, having studied only 1 or 2 semesters (sessions) before the summer session under investigation (Figure 1).

**Figure 1**

*Number of Teaching Sessions (Semesters) Previously Studied by Survey Respondents (n=261)*



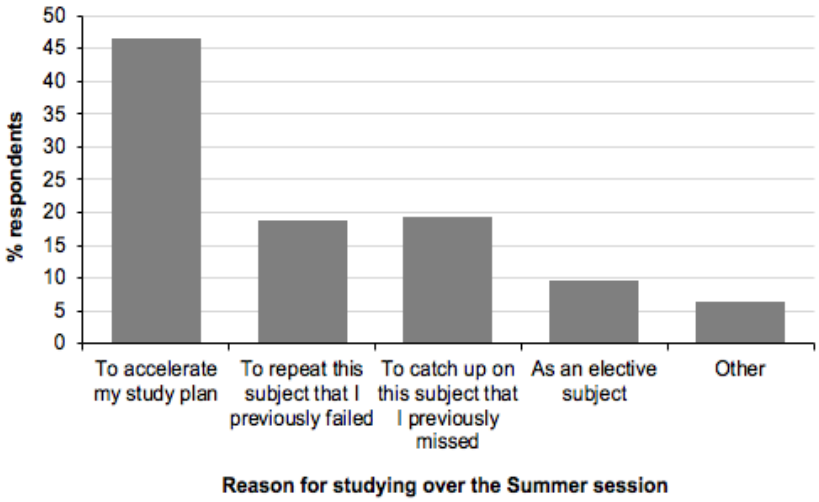

Most students surveyed (60%) were studying only one subject over the Summer (IMD) session under investigation. A further 30% of students were studying two subjects. Three percent of respondents were studying four subjects over the Summer session, which is the equivalent to a full-time session load.

### *Students' motivation for choosing IMD subjects*

Students identified that the main motivation for completing a Summer Session (IMD) subject, was to accelerate their study plan (46% of respondents, Figure 2). Other reasons included repeating the subject that they previously failed, to catch up on a subject that they previously missed, or to take elective subjects.

**Figure 2**

*Reasons Offered by Students for Studying Over the Summer Session (n=261)*




Most of the students were studying their IMD subjects for the first time (70%) and had not attempted the subject prior to the Summer session. Of the remaining respondents, 19% of students said they had previously failed the subject and 10.7% said that they had enrolled but did not complete the subject (i.e. they withdrew from the subject part way).

### *Subject coordinators' teaching experience*

All 18 IMD subject coordinators were interviewed for this study. There was a range of teaching experience across the participants. Only six subject coordinators had experience teaching in IMD format prior to the summer session in this study, and only two of these six had previously taught their subject in IMD. Three summer coordinators were new recruits and had not taught their subject before, whereas the remaining 15 coordinators had previous experience teaching their subject as either a lecturer or tutor in the standard 12-week mode.

Of the 15 subject coordinators that had taught into their subject previously, seven had planned to change their approach to teaching for IMD format. Subject coordinators also had the opportunity to change the assessment tasks (number of tasks, weightings and/or type as long as they assessed the same subject learning outcomes) in their subject, to suit the intensive delivery. Ten subject coordinators changed at least one assessment task in their IMD subject.

### *Subject coordinators' perceptions of IMD*

Nine out of 17 IMD subject coordinators liked teaching IMD more than SMD. Only one subject coordinator preferred SMD over IMD. Seven subject coordinators were undecided as to whether IMD was better than SMD. Examples of the qualitative responses behind this result are presented in Table 1. A common theme identified as underpinning these perceptions and comments is the short duration of IMD.

**Table 1**

*Responses From Subject Coordinators When Asked About Their Preference for IMD Compared to SMD*

| Response | Count | Example comments |
|---|---|---|
| IMD was ok/fine and I liked it better than SMD | 4 | I'm pretty fine with it, because I think it's good for me personally, in terms of taking leave and trying to do other things in the summer. ... it's good to have it over and done with quickly. |
| IMD was very intense but I enjoyed it more than SMD | 5 | I think it was intense in terms of planning, but once the subject came a long it was okay. |
| | | So pretty much everything had to be finished before we started, which was a good thing and also a very stressful thing at the same time. |
| IMD was ok/fine, but I'm unsure if it was better or worse than SMD | 7 | Because even though we taught everything that needed to be taught, I wasn't sure if the student got the most out of it, because it was just a lot of content … I'm not too sure if it was the best approach. |
| | | It was much easier to teach them in block mode but maybe not so much easier to coordinate in block mode. |
| I preferred SMD to IMD | 1 | You need time to prepare and recuperate because otherwise ... some days, I would sleep five hours in 48 hours. So I tried to use weekends to get prepared but still, not always happen. |

When asked how they thought the subject went overall, subject coordinators' qualitative responses tended towards perceptions of the student experience. In other words, if they thought the students had a good experience, then they tended to rate the subject 'overall' more highly. Subject coordinators' responses were across the spectrum from neutral to positive with no negative perceptions. An example of each supporting evidence is shown in Table 2.

**Table 2**

*Responses From Subject Coordinators When Asked How Their Subject Ran in IMD*

| Response | Count | Example comments |
|---|---|---|
| Excellent | 4 | It was a good group of students. I think they were genuinely interested in this topic, and I think after the first few lectures, it really got them interested. It made things easier. |
| Good | 12 | I think they were all, … slightly more motivated. They still had the full range of capability. There were still people that struggled and people that did alright, even the people that were repeating. There was a higher engagement during the lectures, though still not very high. |
| About the same as SMD | 1 | I think summer is great, but I think there are some subjects that are suitable for summer delivery and some subjects, like this one, where it's content heavy, it's probably not that suitable. |
| Poor | 0 | |
| Awful | 0 | |

### *Student perceptions of IMD*

After students had completed their IMD subject, we asked them if they would choose to study an IMD subject again. Of the 261 responses, 72% of students said they would study an IMD subject again and 21% said "maybe". Only 8% of respondents said they would not study an IMD subject again. The main reasons for answering 'no' included the IMD being "too intense", feeling an inability to "catch up" and feeling that they "don't have enough time to study and absorb the information when it is being delivered on a daily basis" (student survey responses).

We asked students to tell us what they did and did not like about studying in IMD and we present some descriptive statistics here based on their responses. We have separated their comments into two groups, those that mention learning activities (Table 3) and those that refer to assessment (Table 4). There were more positive comments for learning activities and assessments (69% and 76%) than the negative comments (24% in both cases). See additional materials for example comments for each code. We unpack these comments in the Discussion section and they feed into our guiding principles (in Table 5).

**Table 3**

*Descriptive Statistics of the Positive, Neutral and Negative Themes Discussed by Students Regarding Their Perceptions of the Learning Activities in Their IMD Course*

| Theme | Code | Number of Comments | Percentage of all Comments |
|---|---|---|---|
| **Positive** | Generally positive | 97 | 21.2 |
| | Quality | 77 | 16.8 |
| | Teaching staff | 53 | 11.6 |
| | Formative practice | 29 | 6.3 |
| | No distractions | 19 | 4.2 |
| | Online related | 16 | 3.5 |

| Theme | Code | Number of Comments | Percentage of all Comments |
|---|---|---|---|
| | Small class | 15 | 3.3 |
| | Link to future | 4 | 0.9 |
| **Total Positive** | | **310** | **67.8** |
| **Neutral** | | **32** | **7.0** |
| **Negative** | More time needed | 47 | 10.3 |
| | Generally negative | 33 | 7.2 |
| | Teaching staff | 12 | 2.6 |
| | Lack of integration | 8 | 1.8 |
| | Timing | 8 | 1.8 |
| | Lack of deep learning | 7 | 1.5 |
| **Total Negative** | | **115** | **25.2** |
| **Grand Total** | | **457** | **100** |

**Table 4**

*Descriptive Statistics of the Themes Discussed by Students Regarding Their Perceptions of the Assessment in Their IMD Course*

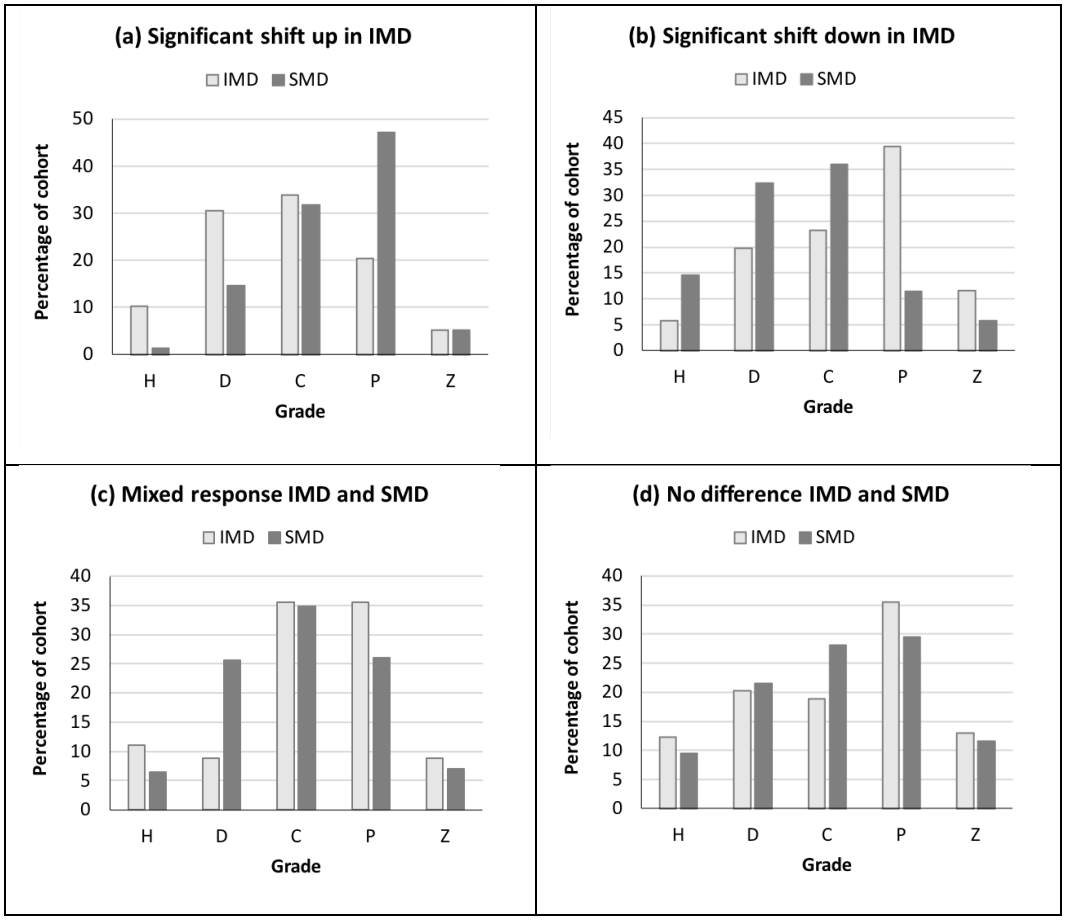
| Theme | Code | Number of Comments | Percentage of all Comments |
|---|---|---|---|
| **Positive** | Assessment was fair / not too difficult | 43 | 18.1 |
| | Generally positive | 37 | 15.5 |
| | Relevant / well aligned to content | 30 | 12.6 |
| | Good timing / enough notice / time given | 30 | 12.6 |
| | Challenging but good / enjoyable | 12 | 5.0 |
| | Similar to when I studied last time | 9 | 3.8 |
| | Well designed | 8 | 3.4 |
| | Liked the formative / review questions | 7 | 2.9 |
| | Staff related / good teacher / good communications | 5 | 2.1 |
| **Total Positive** | | **181** | **76.1** |
| **Negative** | Lack of time | 23 | 9.7 |
| | Poor sequencing | 9 | 3.8 |
| | Difficult | 9 | 3.8 |
| | Poor scaffolding / lack of clarity | 5 | 2.1 |
| | Group forming | 5 | 2.1 |
| | Interference due to the break | 2 | 0.8 |
| | Not aligned to content | 2 | 0.8 |
| | Lack of feedback | 1 | 0.4 |
| | Lack of deep learning | 1 | 0.4 |
| **Total Negative** | | **57** | **23.9** |
| **Grand Total** | | **238** | **100** |

### *Student attainment*

Comparing the 17 subjects that ran in IMD and SMD in the study year, eight subjects showed a significant shift in grade distribution to higher grades in the IMD ($P < 0.05$). This was driven by a higher proportion of students achieving high distinctions (mark ³ 85%) and lower proportion of pass and/or fail. Three subjects showed a significant shift towards lower grades in IMD compared to SMD ($P < 0.05$). The remaining six subjects showed either no difference between IMD and SMD, or a mixed response in IMD. For example, in some subjects there was an increase in high and low grades (high distinction and pass) with a decrease in mid-range grades. Examples of these outcomes in grade distribution comparing IMD and SMD are presented in Figure 3. Whilst we acknowledge the limitations of drawing conclusions from these data we include them for completeness.

**Figure 3**

*Examples of Outcomes in Grade Distributions Comparing IMD and SMD. Grades are Recorded in Five Categories: H, High Distinction; D, Distinction; C, Credit; P, Pass; Z, Fail*



## Discussion

Here we discuss the findings in light of the literature and develop recommendations for designing science subjects for IMD. We separate the discussion between our two target groups, students and staff.

### *Students*

In our work as teachers and learning designers, our primary concern is to provide a quality learning experience for our students which engages them, enables them to learn deeply and achieve their learning outcomes. In our study we investigate these aims by measuring students' attainment and analysing their perceptions. We found that 43% of students were in their first year of study which has implications for subject design. We must remember to ensure that transition pedagogy is applied and first year curriculum principles are adhered to (Kift, 2009) so that students are provided with the scaffolded guidance they need to succeed. One suggestion to help better support students would be to develop a transition unit or module that can prepare them for IMD (Dixon & O'Gorman, 2020).

The reasons that students choose to study outside of the regular semesters and in a different format are varied. Before the start of the Summer teaching session, the researchers and teaching leadership team envisaged that most students who enrolled would be those that had failed or dropped out of the subject in a previous session. There is little to no literature that discusses this even though it has implications for curriculum design. One study has investigated reasons for choosing IMD but findings only specified that students were more likely to choose IMD format if they had prior experience studying in IMD, they had a positive perception of their ability in a particular subject and their concurrent subject load was low (Burton & Nesbit, 2008).

However, we found that our assumptions were false and that in fact students chose to study in the Summer session mainly to accelerate their study and finish their degree earlier. This has implications for curriculum design, particularly assessment. Kuiper et al. (2015) reported the need to provide 'not before seen' questions and problem sets for IMD assessment. Whilst this is a good idea for assessment to reduce the risks of academic integrity breaches, perhaps less emphasis needs to be put on providing new examples and activities for students as most students were studying an IMD subject for the first time. Furthermore, use of 'getting to know your students' type of dashboards and data could help teachers in their design of IMD units if they understand motivating factors.

Students identified a number of challenges to studying over the Summer session and these align with other findings in the literature. Of the 115 comments coded to negative perceptions, 41% related to the fast pace of the IMD classes and the resulting workload required to keep up: "… too fast with not enough time to absorb everything between the classes before a next topic is brought up" and "It was difficult to keep with lecture material due to the lectures being in five consecutive days. It was really full on." (Table 5, guiding principle 2.1).

Of the negative student comments, 10% related to the teaching staff who some students felt were ill prepared for IMD and generally unhelpful. However, this was only 12 out of the overall 457 comments. The positive comments regarding teaching staff totalled many more (52 in total).

Other themes from the negative pool were related to students' perceiving the activities did not contribute to a deep sense of learning in that there was only time to scratch the surface of the content needing to be covered (6%). "It was either very simple questions, or questions just based off memory. There were only a few tasks that gauged the concept and forced you to problem solve to figure out the answer." (Table 5, guiding principles 1.1 and 1.3). This level of understanding of

the need for deep learning and application, particularly coming from first year students is welcoming. Other studies have found similar perceptions, yet it is usually staff making these exertions (Dixon & O'Gorman, 2020). Some students (7% of comments) were aware of the lack of integration between lectures, labs, tutorials and also the lack of flow of content between the different classes "…the lecture notes did not match up with the knowledge required in the labs. For example, [topic] was not taught until the day after the lab was completed and most peers struggled to understand what was happening." (Table 5, guiding principle 6.2). This may be more apparent in an intensive delivery environment because the students are not distracted by other subjects and this mismatch becomes clearer. A similarly weighted theme (7% of comments) related to the timing of the subject within the 12-week summer period - though this tended to be purely subjective regarding students' own situations. For example, one student wanted classes closer together "… the mon/wed/fri layout made the subject more difficult because I couldn't get a roll on either studying or relaxing .... I would have much preferred two 5-day weeks to three 3-day weeks" compared to another student who needed more time "…the lectures should be more spaced out to allow people to go to work for the people who have jobs that are only mon-fri". (Table 5, guiding principle 2.1).

Both students and teaching staff mentioned the timing of IMD subjects that were interrupted by the end-of-year university shut down period and the lack of support (both technical and academic) during these times. (Table 5, guiding principle 2.4). These issues can be addressed by giving more thought to the format and timing of IMD subjects offered over the holiday season. These findings may be different for IMD subjects run in regular semester time.

The main theme coded under the positive comments from students was quality (21%). Students commented on the excellent quality of the lecture content and the activities for example "I found the activities to be really good and well structured, and they definitely helped me understand the content more thoroughly…" and "The quality of the teaching and learning provided was stellar, and ironically, the difficulty of the subject resembles a bell-curve - in that, it begins and concludes being easy, but is very challenging midway." (Table 5, guiding principle 1.3).

Other positive themes included the excellence of the teaching staff (17% of positive comments) which could be related to the smaller class sizes and therefore students received more individual attention (5% of positive comments). "There wasn't much (sic) people so everyone could hear everyone else out." University class sizes are growing (Arvanitakis, 2014) and teachers and students still cling to the 'romantic' notion of small-class teaching where the teacher 'does it all' (Mantai & Huber, 2021). IMD classes may appeal to students and staff who want to experience this small class feel and could be a selling point to attract more students and staff to this mode of delivery. Most of the teaching staff self-selected to work over the Summer session and convert their subject to IMD, but the majority of staff were new to teaching their subject. Given the large number of casual and early career teaching staff it is heartening to see student praise of their teaching. One student said, "If it weren't for the fabulous teachers, I think this subject would have been impossible, but everyone was enthusiastic about [subject] and helped us get through all of the work". There were positive comments by students (9%) regarding the formative practice exercises which contributed positively to their learning and also how good the online content and activities were in this regard. Of the positive comments 6% were specifically about enjoying studying only one subject at a time so there were fewer distractions compared to SMD where their time is divided between many subjects.

Our critical reflection of the students' qualitative comments highlighted their insightful observations when it comes to understanding and appreciating the challenges in curriculum design for IMD and acts as a reminder to be more participative with students as co-designers of learning (Matthews et al., 2019). (Table 5, guiding principle 1.2).

### *Staff*

We found that science teaching staff in our study had a stronger preference for IMD over SMD (60%) which aligns with findings from other studies (e.g. Czaplinski et al. 2017). Staff reported many benefits and some challenges to teaching in IMD and these are discussed below.

It is well-documented that students perceive the ability to interact with their teachers as conducive to a quality learning experience (Meringe & Sing, 2014). Some of our IMD subjects are usually taught to large cohorts (over 400 students) in the regular semester. Staff noted that the much smaller class sizes (even 80 students in a class was deemed small in these cases) meant they could know all of their students' names and present more opportunities to give personalised feedback. "I was able to actually interact with the students continuously .... If you see them every day, it's impossible not to know most of them for the entire block." Smaller class sizes, therefore, allowed for more personal engagement with students.

Teaching staff also reported that students were more engaged and enthusiastic in the IMD subjects. With smaller class sizes comes the inability for students to hide, particularly if they come to class ill-prepared. Teachers could interact more and ensure students were following activities, discussions and not falling behind (Table 5, guiding principles 1.3 and 3.1). Other studies have reported on the misalignment of engagement and content-heavy science subjects such as anatomy (Tripodi et al., 2020) but our findings suggest that IMD may be conducive in overcoming such issues and supporting engagement. For example, one teacher said:

> *But the students really engaged with it and that took us by surprise compared to how sometimes it can be a bit draining to get them to get up and do their work but they all seemed in a really happy, positive mood and so everyone was really relaxed and it was enjoyable.*

Alternatively, one could conclude that it is the students' natural disposition (to being motivated to learn) since they choose this mode to accelerate their studies, rather than the design of IMD that promotes this.

Knowledge retention between classes was better in IMD and the time needed for recapping the previous class was reduced since concepts were fresher in the students' minds. However, this did raise the point in some teachers' minds as to whether students were conducting 'deep learning'. Was there time for concepts and theory to be deeply understood and applied to many scenarios or were surface learning techniques being deployed and would students forget things shortly after the exams? Other studies have come to similar conclusions (Dixon & O'Gorman, 2020; Lutes & Davies, 2018) but we think this is particularly relevant in science subjects which tend to be content heavy and the application to problems requires time and practise. One study in anatomy found that IMD modules did support deep learning (Tripodi et al., 2020). Focusing on threshold concepts is one way to achieve this (Table 5, guiding principle 3.2).

Our results showed that in most subjects students attained better marks in IMD compared to that attained in the same subject delivered in SMD. This is in contrast to Whillier and Lystad's (2015) study that demonstrated that there was no significant difference in science students' performance across IMD and SMD when a flipped model is used. An earlier study showed that the IMD students performed worse even though they perceived a better experience (Whillier & Lystad, 2013). However, we align with a number of other studies that have found better performance in IMD compared to SMD (Austin & Gustafson, 2006; Klein et al., 2019; Lutes & Davies, 2018) and regular checkpoints are critical to this success (Table 5, guiding principle 1.4 and 3.4).

We suggest a longitudinal survey of students along with analysis of students' subsequent performance (second year, third year etc.) would contribute to the literature in this regard as

students could be tracked through following years' study and this would align with an iterative design-based research approach (Wang & Hannafin 2005).

Academics often report the difficulties of separating their time between teaching and research. In our study, some teachers noted that with IMD it was easier to divide their time, concentrate solely on one activity which led to more enjoyment of teaching. One participant said: "You're focused on one subject for a finite number of days, so it's the focus and the continuity of concept…"

Kops (2014) created a set of guidelines for good practice based on 'top-rated' IMD instructors' feedback. They suggest teachers 'clear the decks' both logistically and mentally in order to give their full attention to teaching. However as found in one study on staff perceptions of workload in IMD (Oraison et al., 2020) we concur that there is a perceived increase in workload with faster turnarounds required for marking and feedback. We recommend that this needs to be acknowledged in reward and recognition processes. Overall, our findings showed that despite the intensity, IMD is more rewarding due to the satisfying nature of seeing students engage more (Czaplinski et al., 2017). This engagement may need to be defined for students (Table 5, guiding principle 3.1.

While there is a shift in workload priorities during IMD, it also provides opportunities to reinvigorate the curriculum. Some participants in our study reported greater freedom to rethink the content that needed to be covered. Several studies have discussed this (Harvey et al., 2015; Kops, 2014; Male et el., 2017), citing importance of ensuring the threshold concepts and learning outcomes are covered and to reconsider non-essential content (Table 5, guiding principle 1.1). We align with the findings of Kuiper et al. (2015) that students are motivated by clearly structured unit design. One teacher reported:

> *I really wanted my lectures to be the bare bone of what [subject] was, and then use that extra time that we had to try and engage the students a little bit more and get them to come up with the examples and the case studies, rather than me giving it to them, because I thought that was a much better way of them … trying to inquire a little bit more, and maybe that would facilitate their learning a little bit better.*

Conversely, we also found that some teachers didn't feel comfortable changing the structure of the subject because they felt it was not theirs to change. A similar finding by Kretoviks et al. (2005) showed that non-tenured academics felt a need to concentrate on their research and therefore not spend time making changes to the course. Similarly, Kops (2014) advised against teaching a course for the first time in IMD format.

Our findings from guided interviews and thematic analyses of science teachers' perceptions and reflective comments demonstrate the diversity and complexity of IMD curriculum design.

### *Curriculum design implications*

How do we leverage these findings and provide guidance for our academic teaching colleagues in relation to the design of IMD science curriculum? Given many of our IMD subjects were taught across first year, we have developed a set of guidelines, synthesised from the literature and supported by our findings (Table 5) that align well with the six curriculum principles of transition pedagogy (Kift, 2009). We have expanded their application by aligning to the type of teaching role, i.e. subject coordinators/lecturers (SC) and teaching assistants/tutors (TA) who play key roles in supporting successful student transition not only into university, but also through and out (Creagh, 2015; Kift 2015).

**Table 5**

*Guiding Principles for Designing Intensive Mode Science Subjects Mapped to Literature, Transition Pedagogies and Teaching Role. SC, Subject Coordinator or Lecturer; TA, Teaching Assistant, Tutor*

| Guiding Principle | Notes / Literature / Participant comments | Teaching Role | Transition Pedagogy (Kift, 2017) |
|---|---|---|---|
| **1. Unit design** | | | |
| 1.1 Ensure learning outcomes (LO) are equivalent between IMD and SMD. | There is some freedom to reconceptualise the unit design as long as the LOs are consistent. Work with learning designers / educational developers (Harvey et al., 2017) | SC | |
| 1.2 Co-Design an optimal learning space and environment. | Applies to online and face-to-face (Kuiper et al., 2015; Matthews et al., 2019). | SC<br>TA | |
| 1.3 Learning space is intentionally designed for interactive, practical, and authentic activities; development of a learning community; and continuity between learning, applying, being challenged, and practising. | Applies to the physical space, the emotional space, and the digital space. The recommendation was rated third most important by the students who reviewed the Male et al. (2017) guide. | SC | Engagement<br>Design |
| 1.4 Have checkpoints during the day ensure everyone is at a basic level of understanding. | Students take varying time to traverse the liminal space (Male et al., 2017). This could be particularly problematic for students studying quantitative subjects in IMD. A series of low (or no) stakes formative quizzes can help uncover problem areas. | SC<br>TA | Diversity<br>Evaluation and Monitoring<br>Assessment |
| **2. Preparation / welcome / set-up** | | | |
| 2.1 Provide clear instructions about expectations including workload and commitment. | IMD will be very different to SMD (Harvey et el., 2017; Kuiper et al., 2015) | SC<br>TA | Transition |
| 2.2 Add social activities on the first day | Students will be spending a lot of intense time together. | SC<br>TA | Transition<br>Engagement |
| 2.3 Build a community online to support after the IMD and to work together towards revision (for assessment) | Students take responsibility for independent learning (Male et al., 2017) | SC | Engagement |
| 2.4 Orientate students to library, food, and other student services available | Many places are closed or have limited hours/service in the summer or winter break. Orientation helps students make best use of their time (Male et al., 2017 R#9) | SC<br>TA | Transition |
| 2.5 Create terminology/ glossary guides as quick reference | To help students and allay their anxiety about understanding particular words during classes. (Teacher interview) | SC<br>TA | Diversity |
| 2.6 Create assessable pre-class activity | Assign activities relating to their existing skills and knowledge in the subject to | SC | Diversity |

| Guiding Principle | Notes / Literature / Participant comments | Teaching Role | Transition Pedagogy (Kift, 2017) |
|---|---|---|---|
| | help students orientate (Male et al., 2017 R#2) | | |
| **3. Lectures/ workshops/ tutorials** | | | |
| 3.1 Define what 'engaged' looks like | e.g., lecture vs. tutorial (Harvey et al., 2017). | SC<br>TA | |
| 3.2 Focus on threshold concepts | Move other content online for reference only. If you are new to teaching this subject, talk with colleagues about what the threshold concepts or troublesome knowledge is (Male et al., 2017). Kops (2014) suggests introducing complex and important topics early. | SC | Design |
| 3.3 Pre-class activities are carefully thought-through, particularly in respect to time available and time to complete | Willier & Lystad's (2015) study found flipped learning may not be suited to IMD.<br>"The videos we were told to watch before lectures mostly weren't relevant ..." (Student survey) | SC | |
| 3.4 Monitor students' progress in order to act quickly to address any noticed problems | A series of short formative quizzes can help uncover problem areas. Kops (2014) suggests use of a regular "goldilocks" scale: is the pace too slow, too fast, or just right.<br>"Due to the fast pace if something wasn't understood there was not enough time before the next learning activity to spend time re-learning and understanding it." (Student survey) | SC<br>TA | Evaluation and monitoring |
| 3.5 Support development of a learning community | Students can easily be isolated during interactive activities. Use strategies to ensure everyone is comfortable and has an opportunity to engage (Kops, 2014; Male et al., 2017). e.g., in SMD, students have time and opportunity to bond between classes. | SC | Transition |
| 3.6 Embed feedback into class time | Male et al., (2017) note that a lack of timely feedback between assessments is one of the three most common risks to student learning. | SC<br>TA | Evaluation and monitoring |
| **4. Lab and practical classes** | | | |
| 4.1 Develop a lab/practical manual that students fill in each day | By using workbooks and manuals, students have their own materials for revision and study towards a final exam. The manual could be assessed to encourage students' thought and effort when completing the work. (Teacher interview). | SC | Transition<br>Design |

| Guiding Principle | Notes / Literature / Participant comments | Teaching Role | Transition Pedagogy (Kift, 2017) |
|---|---|---|---|
| **5. Assessment** | | | |
| 5.1 Provide clear and detailed information regarding assessment requirements and their timing | Harvey et al. (2017); Kops (2014).<br>"The tasks were followed up by [teacher] really well, sending emails and communicating exactly when and what the task is." (Student survey) | SC<br>TA | Design<br>Assessment |
| 5.2 Develop assessments that can be marked quickly and provide timely feedback | Ensure TA's understand the importance of timing (Male et al., 2017 R#6)<br>"The online assessment tasks caused a lot of grief as it did not show immediate feedback as to whether my answers were correct or not." (Student Survey) | SC | Assessment |
| 5.3 Design assessment to increase in complexity | From weeks 1 to end, tasks can build on each other. E.g., re question design: "Simple ones to help those just wanting to pass the course, intermediate ones that weren't too obvious and made you think, and difficult ones that rewarded those who had been diligent with their studies". (Student survey) | SC | Assessment |
| **6. Support** | | | |
| 6.1 Support students to take responsibility for their own learning | This was the fourth most important recommendation as rated by student reviewers in the Male et al. (2017) study. Kops (2014) also recommends provision of scaffolds to ensure success.<br>"This subject … has helped me identify … the study habits I will need to take to perform stronger in future subjects." (Student survey) | SC<br>TA | Transition |
| 6.2 Employ strategies to motivate students and help them see the links between this subject and others in their program | Links provide a more holistic view of the curriculum (Male et al., 2017 R#7). | SC | Transition |

## Recommendations and further research

In our institution, physical science subjects did not choose to deliver in intensive mode. Future studies could investigate whether there is a connection to perception or mindset of the teacher as opposed to the content being relevant to IMD. There are some recent studies reporting on mathematics and physics being taught in IMD but these studies tend to focus on the technologies, tools and active learning approaches rather than concentrating on the compressed, time-sensitive nature of the courses (Downie et al., 2019; Huang & Jin, 2019; Sidiroglou & Fernandes, 2019).

Another area for further research would be to investigate the relationship between student motivation for choosing to study IMD, their perceived learning gains and performance i.e. did repeating students do better? Klein et al. (2019) compared the IMD and SMD options for repeating

students from health and biomedicine units. Further research could focus on these repeating students and do longitudinal comparisons. It could also differentiate undergraduate and postgraduate perceptions as the two cohorts often have different study goals.

The IMD subjects in this study were delivered to students at the end of their first year. Literature has questioned whether this mode of delivery is suitable for first year students (Dixon & O'Gorman, 2020), yet Victoria University has transitioned all of their first-year curriculum to IMD (Klein et al., 2019; Loton et al., 2020). Future research could investigate students' perceptions of how well IMD subjects prepared them for their second year of study.

### *Limitations*

We acknowledge that we can only compare existing results for subjects that have been taught previously in SMD and now in IMD and the sample sizes are small. We also do not have consistency of teachers across the SMD and IMD cohorts and we know teacher experience can influence student achievement (Harlow et al., 2015). Furthermore, student cohorts are also different and therefore statistical comparisons cannot be taken as absolute.

## Conclusion

A recent review of the IMD literature found a dearth of studies of undergraduate science students' perceptions and related achievements (Harvey et al., 2017). Furthermore, they found little evidence that science subjects in Australia are being taught in IMD at the undergraduate level. We used a survey instrument to canvas 261 undergraduate science students' perceptions of studying IMD across 18 subjects in the Faculty of Science at The University of Technology Sydney. These subjects ran for an average of three weeks and had the same learning outcomes as the 12-week semester-long subject.

We found that in 14 subjects, grade distributions were significantly different in the IMD compared to the SMD. These relationships are complex, eight had significant differences positively towards IMD, three positively towards SMD and three had an irregular pattern to the differences. However, these results are of importance as there is little to no other empirical data available in the literature on this topic of evaluating IMD in the sciences.

We also used guided interviews and thematic analysis of the teacher perceptions, reflections from the learning designers (authors), and drew on the work of a national review of intensive mode teaching in Australia (Male et al., 2017), to produce a set of guidelines for good practice specifically for the design and delivery of intensive mode subjects in the sciences. These guidelines span unit design, subject preparation and set-up, lectures/ workshops/ tutorials, lab and practical classes, assessment, and support.

Key suggestions include having subject "checkpoints" to gauge student understanding, providing clear instructions about expectations including workload, and commitment, and providing clear and detailed information regarding assessment requirements and their timing. Further suggestions include developing a transition unit or module that can prepare students for IMD, and designing in 'getting to know your students' type of dashboards and data to assist teachers to best tailor content and delivery for their student cohort.

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