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Article:

10 years of curriculum change viewed through the lens of student workload.

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Abstract

The past decade has seen significant changes to the Chemistry course at Keele including two curriculum reviews, the COVID-19 pandemic, and a more gradual evolution of how we teach, particularly including flipped classroom methods. Student workload provides a means of quantifying the impact of these changes and is also a valuable tool in ensuring that all learning and teaching activities have sufficient and equitable access to time. The longer-term impact of changes to curricula has not been studied significantly, and there are limited examples of workload models that incorporate flipped classroom methods in physical science subjects. The purpose of this study is to review 10 years of semester 1 level 6 chemistry modules through the perspective of objective workload (timetabled sessions and deadlines) and more closely through changes in one block of taught content. Workload has been selected as a metric because objective workload is within the control of teaching staff and links to attendance, engagement, and achievement. Assessment timetables and timetables were analysed and workload week maps and credit per week map visualisations devised to represent the data. A workload model was proposed. A series of recommendations are made for the use of these visualisation to both support student learning and ensure equity across modules. Further work is required to investigate this complex issue, particularly to incorporate the student voice and perceived workload.

Context and Objectives

Over the past ten academic years chemistry teaching has seen significant changes in teaching methodologies. This takes place within a context of changing institutional requirements, the rise of flipped teaching methods, and most recently the COVID-19 pandemic. Within the chemistry courses at Keele, there have been two reviews of the curriculum (changes to modules and ordering of material) and establishment of BSc single honours and Master's degree routes. This paper presents a case study based on part of a module taught at level 6 and views these changes through the lens of student workload.

What is student workload?

Workload may be broken down into two types. Firstly, subjective, or perceived workload must be represented more qualitatively. Subjective workload varies by student dependent on their individual circumstances, characteristics, and ability, mediated by whether the student believes that they have time for study related activity (Kyndt *et al.*, 2014). Our understanding of subjective workload is also complicated by a limited number of investigations asking students how much time they spend working and why it varies (Ruiz-Gallardo *et al.*, 2011). The relationship between perceived workload and hours of work was found to be weak by Kember and Leung (2006) with a greater link between the teaching and learning environment, particularly in motivating students to produce high-quality work. Workload may be a significant cause of student difficulties with Bowyer (2012) noting that "*there are many causes of student difficulties such as stress, poor time management, employment pressure while studying and life issues to name a few. However, a major cause is student workload".* Finally affective domain characteristics of students such as ability, motivation, and effort should be considered (Maslach *et al*., 2001). Mismatch between expectation and demand may lead to study burnout characterised by three stages: exhaustion due to study demands; becoming cynical and detached towards one's studies; and finally, feelings of inadequacy (Meriläinen, 2014). Nicolaou (2022) found correlations between perceived workload and students' enthusiasm towards the subject when investigating enthusiasm amongst Oxford undergraduate students.

The second is objective workload and depends how much time is appropriate for an average student to spend on a topic, defined or influenced by institutional protocols and procedures and national guidance (The Quality Assurance Agency for Higher Education, 2021a). Objective workload may be represented quantitatively through timetables and workload models.

A workload model is a method of evaluating time provided within and demanded by the curriculum for study. The most obvious feature of a workload model is objective workload and that lies within the control of the teaching team. Many courses are characterised by higher demands for self-directed study time to participate fully in contact time activities. Related factors are the quantity of work required, the type and timing of assessments, the level of difficulty of work and the requirement for independent study. Less obviously institutional resources such as access to teachers, study space, and learning resources may influence workload. Meriläinen (2014) proposed a model for a workload model that addressed many of the subjective and objective aspects of workload and this enables advice to be given to students on how to manage their studies such as a recommended maximum number of hours of paid employment per week (Curtis, 2007), or the number of hours that study requires (The Quality Assurance Agency for Higher Education, 2021b)

A workload model must also work for all students and allow for a student's personal circumstances and the impact of that on their capacity to study. Many aspects of life cannot be regulated with guidance such as health, caring responsibilities, and other individual factors including the impact of a long commute. While many of the influences proposed by Meriläinen (2014) are outside of the control of teaching staff or indeed the institution, key aspects such as the number of contact hours, the difficulty of the material, the timing and nature of assessments, and the availability of supporting resource are within scope. By charting the evolution of a course over 10 years through the lens of objective workload it is possible to see the impact of teaching innovations such as the flipped classroom, the impact of the COVID-19 pandemic and these observations can be used to propose a student workload model to ensure the expectations and reality are closer.

Within Keele, modules follow the Higher Education Credit Framework for England with one credit notionally representing 10 hours of study (The Quality Assurance Agency for Higher Education, 2021a). Third year chemistry students (FHEQ level 6) studying BSc Single Honours chemistry or specialising in chemistry (formerly major route) have six compulsory core modules (90 credits), and choice of two from four option modules (30 credits). Four taught modules (3 core and 1 option) are in semester 1, two taught modules (1 core, 1 option) are in semester 2, and two modules run through both semesters. This creates an imbalance in credit loading with 75 credits (60 + 7.5 + 7.5) being nominally completed in semester 1, and 45 (30 + 7.5 + 7.5) in semester 2. Prior to 2014/15, students studied 3 or 4 compulsory core modules in semester 1 plus half of a 30-credit project module. The organisation of semester 1 option modules in terms of workload are different, and they are discounted from this analysis. Semester 1 of third year was selected for this investigation on the basis that major route is comparable to BSc Single Honours chemistry allowing comparison from 13/14 onwards, and it has a significant contribution to the degree outcome. The option modules are discounted from this analysis which omits the impact of 15 credits (or approximately 10 hours per week of effort). Table 1 outlines the modules reviewed.

[table 1 here]

To bring context to this, the author's teaching on one third year module is considered as a case study. In 13/14 this was a set of 6 lectures assessed through exam. This was expanded to 8 contact hours during the first curriculum review (14/15) and has remained at 8 hours since. The core concepts being assessed have been retained from the original material. The content was expanded with additional learning outcomes in 17/18 during the second curriculum review. The new material is assessed by coursework only, while the original material has been assessed by exam and latterly open book assessment (OBA).

Objectives of study:

- To reflect on the impact of curriculum changes on the author's teaching as a microcosm for a more complex system
- To derive a student workload model for use in timetable design and assessment scheduling
- To highlight the impact of flipped teaching methodologies, pre- and during- pandemic on student workload

Methods

Planned timetables and assessment timetables for semester 1 level 6 from a selection of academic years were analysed. Timetables represented 12-week semesters and indicated the broad type of session and timeslot, regardless of the mode of delivery (on campus, online). Minor alterations to timetables were not included unless they were updated on the planned timetables. Since 20/21

timetables also included asynchronous content that students must do before another timetabled session such as viewing screencast content where flipped classroom methods are used. Assessment timetables represented 15-week semesters with due date and deadline but exclude formal university examinations. One 15-credit module has been discounted from analysis across all years because this represents option modules introduced in the curriculum review (14/15) where students have choice of two modules with slightly different workload and assessment patterns. The compulsory modules are the focus of this work.

Semester Workload Week Maps

Workload heat maps were generated by identifying a set of broad categories (detailed in Table 2) for the type of timetabled sessions and counting the number of each per teaching week of semester. The revision week and assessment weeks are not included in the heat maps. Scheduled sessions at Keele University are 50 minutes in length, however 1-hour slot have been used for convenience and scaled as appropriate.

[Table 2 here]

Contact time incorporates all sessions formally timetabled where a student must be present synchronously, such as lectures, laboratory classes and workshops. Support refers to induction sessions, and careers events if formally timetabled. Project time is accounted for separately and reflects the hours available to a student undertaking a 15-credit project involving experimental work which may happen in the teaching laboratories. Some flexibility is available to students regarding when to attend the laboratories due to the demands of different projects and so this represents an estimate of contact time associated with the project and may be considered an average across multiple weeks.

Asynchronous timetabled activities included screencasts created in lieu of lectures that students were required to review prior to a synchronous session designed to expand and consolidate the concepts introduced such as in a workshop. Formally these first appeared in the timetable in 20/21, where flipped classroom methodologies were widely adopted in response to Covid-19 teaching contingency measures, however they were in use in some courses prior to that. The hours for asynchronous timetabled activities have been taken from the planned timetable when known and typically allocated 1-hour blocks of time.

Formative Assessment relates to assessments taking place at scheduled times such as interviews (viva voce) and class tests. Summative assessment is calculated from assessment timetables and reflects the anticipated workload for each item of coursework. Where coursework requires contact time, this is assumed to be part of the hours listed. Exams or Open Book Assessments are detailed in Table 2 but not included in the week maps unless taking place within the 12 teaching weeks.

Assessment Timetable Analysis

Assessment timetables were reviewed, and all assessment deadlines categorised as formative or summative, by assessment type, and the percentage of the module each assessment comprised. From 20/21, each level 6 module operated on the principle that no more than 30 hours could be contact or asynchronous learning activities. The time available to complete assessment was calculated according to the following formula:

Time available for assessment = total time for module – compulsory learning activities

To enable comparison of different modules, this was used despite a degree of variation between the hours of compulsory learning activities. For a typical 15-credit module, this left 120 hours for assessment, effectively 8 hours of effort per 1 credit. This enabled a percentage weighting of each summative assessment item to be determined. For example, an item of coursework is worth 25% of a 15-credit module, and so is allocated 3.75 credits, and 30 hours of effort. The calculated hours were added into the assessment week maps according to the workload assumptions.

Workload Model

Analysis of the timetables and assessment timetables for the modules outlined in Table 1 were used to create a method of evaluating student workload per week in terms of credits gained through assessment. A series of assumptions about modules assessment were made:

1. Based on typical coverage of key content, and availability of assessment guidelines, assignments were assumed to be ‘doable’ 2-weeks before the deadline and student effort was split equally over those two weeks.

2. Where assessments varied by week within the cohort (for example presentations given in one week or the next week), the first possible week for completing the assessment was used.

3. Other than contact time and asynchronous activities, all student effort is expended on completing assessment and that there is no time within self-directed study for students to read broadly around a topic. This is reasonable for many STEM subjects but may vary depending on the module. The number of weeks where the workload module predicted effort in excess of 25, 30, 40 and 50 hours were determined. (Table 3)

[Table 3 here]

Results

Before the 14/15 academic year and changes brought in during a curriculum review that established BSc single honours and later MChem chemistry, the first semester of third year for major route BSc chemistry students comprised four 15-credit modules and half of the work, but no assessment for the 30-credit project module. From 14/15 the course comprised four 15-credit modules plus half of the 30-credit project module. A minor change in 17/18 replaced the 30-credit project module with two 15-credit modules. The requirement to undertake half the work of was unchanged and small assessments were brought into semester one for one module.

The week maps show the changing distribution of time spent on different categories of activities reflecting shifts in teaching and assessment practice from primarily exam to more extensive coursework assessment (Figures 1 – 4).

[Figure 1-4 here]

In 13/14, the week map (Figure 1) reflects three modules assessed through 70% exam, 30% class test or coursework, and taught through primarily lectures and workshops, and one project module with no assessment in semester 1. Most of the coursework in these three modules was class tests and could be viewed as formative and summative. One 15-credit module is excluded. Figure 1 shows four weeks exceeding 30 hours, with only one exceeding 40 hours. In terms of credits, 13.5 credits were gained from coursework during the 12 teaching weeks, 31.5 credits were gained from examinations during the assessment period.

From 14/15 onwards, the new 3rd year structure has four taught semester 1 modules (3 core, 1 option – discounted from analysis) as well as a project or project and dissertation and this structure was consistent through to 21/22. In 16/17, core modules were typically 65% unseen exam (29.35) and 35% coursework (15.75 credits), and modules differ in the extent to which coursework is preparatory for the exam, develop skills, or assesses intended learning outcomes (ILO) independently of the exam-style assessment. The week map shows some weeks of high predicted workload with weeks 10 and 11 exceeding 50 and 40 hours, respectively (Table 3). This pattern continues in the 19/20 academic year, however with fewer formative assessments (Figure 2). It is noted that this analysis cannot yet account for the time requirements of flipped teaching such as review of screencasts or similar activities because it was not documented on timetables before 20/21.

The impacts of the COVID-19 pandemic can clearly be seen in the week map for 20/21 (Figure 3) through a clear reduction in number of project hours, a massive increase in asynchronous hours, and a reduction in contact time. Only one week exceeds 30 hours, formative assessment is eliminated, and special arrangements are in place for any assessment that required *in situ* presence. The 21/22 academic year is very much a hybrid of the 19/20 and 20/21 academic years with high levels of asynchronous content being retained, but with project hours being reinstated (Figure 4). This caused workloads to increase, with 1 week above 50 hours, 3 above 40 and another above 30.

The curriculum review initially had a moderate impact on credits assessed through exams (31.5 credits in 13/14 to 29.25 in 16.17) versus credits assessed through coursework (increase from 13.5 to 15.75 credits). The core modules now span the range from 50% - 65% exam or OBA. The overall variation in credits gained per week reflects the redistribution of assessment from the assessment period into the 12 teaching weeks of semester and the inclusion of assessments related to the

dissertation module in semester 1 leading to 20.25 credits obtained by coursework in 21/22 (Figure 5). The number of timetabled hours per semester, excluding exam/OBA has remained relatively constant across the decade ranging from 144 – 167 hours in typical years (Table 2). Due to pandemic arrangements, 20/21 had 132 hours due to reductions in project hours and increases in asynchronous content.

[Figure 5 here]

In the context of the authors teaching, 6 hours of contact time in 13/14 was assessed through 25% of the examination. In 14/15, 10 hours of contact time was assessed through 50% of the examination and 10% of the module's coursework. In 19/20, and with the addition of content previously taught at level 5, this was increased to 12 hours of contact time assessed through coursework 25% of module, and examination (50% of exam, 25% of module). In 17/18, the coursework deadline fell in week 11 and as such contributed to extremely high workload weeks. In 18/19, this item of coursework was redesigned to enable it to be completed early in semester and submitted in week 5 (Figure 6). This increased the number of weeks above 30 hours in 18/19 but spread the higher workload weeks more evenly through semester (Figure 7).

[Figures 6 and 7]

Discussion

In 21/22, the author's teaching includes content previously taught (13/14) and additional material added to expand the topic in 17/18. This has expanded the topic from six contact hours to twelve contact hours, enabled by the restructuring of the level 6 modules. In response to the COVID-19 pandemic, flipped classroom methods were used in 20/21 and 21/22 with screencast content replacing lectures and synchronous workshops offered to consolidate learning, all other years were taught through a mixture of lecture and workshop with supporting textbook material. Flipped classroom methods did not enhance attainment, although significant confounding factors here are the impact of the pandemic restrictions on student engagement and attainment, shifting from unseen exams to OBAs, and the increased objective workload from 12 hours (19/20) to 20 hours (20/21) and 16 hours (21/22). Of this, 4, 8 and 5 hours respectively were focused on the coursework assignment and related ILO, the remainder (8, 12 and 11 hours) on the content to be assessed via exam or OBA.

The curriculum review in 14/15 changed the nature of some coursework assignments with staff starting to allocate workload to tasks that did not directly support attainment in the exam or OBA. In the case-study course the coursework was related to a new specific ILO, assessed only by coursework. This was facilitated by restructuring the order of teaching to enable an assessment deadline earlier in semester where student workloads are lighter. This approach may not be possible for all modules; however, it may be useful to schedule coursework or activities that enhances skills or does not support learning for specific exam/OBA ILOs earlier in semester, and those that more directly feed into exam/OBA assessment later in semester.

Establishing a workload model

This study is concerned with objective workload, the aspects that teaching staff have a degree of control over such as timetabled hours, nature and timing of assessment deadlines and requirements for work before or after class through flipped teaching methodologies. This discounts entirely subjective or perceived workload but must consider these in establishing reasonable expectations of a working week. The timetabling system at Keele for subjects that offer Combined Honours places some limits on the number of timetabled hours per week due to the block timetable system, however no guidelines exist on expectations for pre-session activities or on assessment regimes. In 21/22, a recommendation of 30 timetabled hours per module was agreed by the Chemistry programme team. Karjalainen *et al.* (2008) ascertained that the ratio of contact hours to independent study hours would vary depending on the nature of the activity (transmission of information, activity-based teaching, group work). Typically, this was a 1:3 ratio of contact: independent study, however group work of any sort was noted as requiring greater time (1:5 ratio). For traditional exams, 8 hours of study time for each average week of study (40 hours), calculated from total extent of the course was required, for example 80 hours of a course requires 16 hours of study (Karjalainen *et al*., 2008). Assuming that our timetabled hours in modules with exams are predominantly transmission (lecture, screencast) or

reinforcement (workshop), this agreement of 30 timetabled hours represents 120 hours of student time per module. The assessment period would require 32 additional hours per module.

On a week-by-week basis the key influences on objective workload are the presence of assessment deadlines, asynchronous learning requirements, and contact time. These have evolved over the 10-year period with changes to assessment weightings and the presence or absence of formative assessment. Assessment deadlines fall more heavily in the later weeks of semester as can be seen from the credits per week maps (Figures 5 and 6), and naturally that may draw the focus of students away from any formative assessment opportunities in those weeks. The project and dissertation components of the course are designed to be worked on continuously throughout both semesters, however anecdotally attendance at laboratory sessions and engagement with the project drops off towards the middle, then towards the end of semester when assessment demands are becoming higher. Independent study modules such as the dissertation are harder to account for in a workload model. A student working continuously and regularly would be expected to put in 5 – 8 hours per week during semester 1. The project module is similarly challenging with the total number of hours available on the timetable not necessarily reflecting the number of hours required for reasonable completion of the required research work. These may be considered systematic ambiguity across all years studied and offer a degree of reassurance that the proposed workload model may be overestimating workload in certain weeks.

Across the period studied, assessment practices shifted from 70% unseen exam, 30% summative class test to 65% unseen exam, 35% coursework, with formative assessment elements, then to 50 – 65% OBA, 35 – 50% coursework. Such changes in assessment type and nature are often documented via the Transforming the Experience of Students Through Assessment methodology, however this is limited in that it restricts itself to a count of the number of summative and formative assessment items on a programme, the proportion of written exams, and the quantity of feedback provided (by minute or by word) (Jessop & Tomas, 2017) (Jessop & Maleckar, 2016). As the credit per week maps show, the timing of summative assessments and their weighting, the workload associated with the assessment, may have significant impact on student learning and on student perceptions of workload. This might be positive with a deadline increasing the extrinsic motivation for a student to engage with concepts and content, or negative with workload related overwhelm. Exams and OBA assessments are typically end-of-module assessments, represent assessment of learning, and provide extrinsic motivation to learn. The impacts of the COVID-19 pandemic on student study habits, ability to prepare for unseen closed book exams and the impact of OBAs in earlier years of study on learning remains unclear and variable from cohort to cohort.

Flipped Teaching

The issue of workload has become more complex due to the impact of the COVID-19 pandemic. Beena and Sony (2022) measured student workload during the pandemic with the transition to online learning across six dimensions: mental, physical, and temporal demands; effort, performance, and frustration; using the National Aeronautics and Space Administration-Task Load Index to measure subjective workload (Hart, 2006; Hart & Staveland, 1988). Findings indicated that the effort required for online learning is higher than the offline equivalent, particularly related to the temporal demand and distance from the teacher (Beena & Sony, 2022).

Remote teaching methods required the production of asynchronous learning resources, a significant investment of staff workload and it is understandable that staff seek to use those resources within teaching. More recently the drive to return to in person on campus modes of delivery and targets to achieve a certain amount of contact time means there is an inherent contradiction between the desire of staff to implement flip teaching using their resources and meeting the requirements of sufficient contact time. This is highly politicised with governmental guidance parental and student expectations and the media driving certain viewpoints. Guidelines such as 30 hours per module are essential in ensuring that all modules have equitable access to student workload.

The push to move from didactic lecture dominated modes of teaching towards active learning in science subjects raises significant questions related to workload. Science subjects typically have a high level of contact time due to laboratory teaching. Flipped teaching may involve significant guided self-directed learning activity outside of formal contact hours, often in preparation for specific timetabled events which adds additional structure to student's self-study time. In level 6 chemistry, the changes from lecture intensive modules (13/14) where students have greater freedom to decide what, if any, activities they undertake to consolidate learning between classes, the shift to flipped methodologies in 20/21 and 21/22 (and before in certain courses) is a radical change in how we

spend student time. As such, these methods may better resemble assessment in the demand they impose on students to learn or complete tasks by a deadline, however they may not be explicitly assessed. It is sensible to account for these activities in timetables to ensure students are well informed of the demands of the course. In 20/21 these activities were necessary within the constraints of pandemic teaching, however there is evidence of positive impact on student learning and attainment, including addressing awarding gaps for historically minoritized groups, for example (Dewsbury *et al*., 2022). Workload becomes a useful lens in evaluating these types of changes to courses because it forces us to consider the impact of decisions made by teaching staff on student experience and student attainment, an aspect identified as vital by Ruiz-Gallardo *et al*., (2011). It is unclear how best to incorporate the flipped classroom within our module proposal and timetabling system and ensure that staff have the flexibility to innovate in this area. This is an area that requires significant further work to understand the implications for the objective workload experienced by students and whether the subjective or perceived workload is negatively or positively impacted by flipped methods.

Conclusions

This study charts the way a third-year chemistry curriculum evolves over time through a lens of objective student workload with a focus on the author's content and ILOs. Workload was selected as a metric because it is within the control of teaching staff. This shows both large shifts caused by curriculum reviews and the ongoing impact of the COVID-19 pandemic, and smaller changes related to teaching. To do this, this work presents two means of visualising the objective workload of students through both hours and credits per week maps, derived from analysis of a selection of academic years over the past decade to form a workload model. This model supports recent programme-level agreed limits on module timetabled time, a necessity to deal with the complexities of flipped teaching. This study is limited to consideration of objective workload only and further work is needed to understand the subjective and perceived workload students. The full impact of the COVID-19 pandemic shifts in teaching and assessment are not fully known at this stage and warrant further investigation. This work also considers core modules and does not account for the variation experienced by students with the 15-credit options, electives, nor does it address the complexities of Dual/Combined Honours where half of the workload is unknowable and varied. The links between student workload and attainment should be investigated, with a particular focus on students with significant personal circumstances that make high demands on time, however simply sharing the week maps would enable these students to plan accordingly.

From this study, several recommendations can be made for practice. Objective workload per week should be considered at module and programme level and include self-directed study activities required for synchronous contact time such as those for flipped classroom methodologies. The impact of changes in teaching methodologies on the objective workload for students should be evaluated and monitored. Small shifts in assessment deadlines may have larger implications for objective workload such as these noted by the author in the difference between a late and early semester deadline for one assessment. This may be more generally useful if thought of as a provocation to consider the 'when' of assessment as well as the 'why and the 'what'.

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