Teaching Chemistry in Higher Education

A *Festschrift* in Honour of Professor Tina Overton

Edited by

Michael K. Seery and Claire Mc Donnell

Published by Creathach Press

Cover image by Christopher Armstrong

Back cover image (Courtesy of Tina Overton/University of Leeds)

ISBN: 978-0-9928233-1-3

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3 Nurturing reflection in science foundation year undergraduate students

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This chapter describes how to develop skills of reflection in Science Foundation Year students that will support them in evaluating their progress and consolidating their learning as they progress through the year and onto their degree. Two case studies outlining reflective activities undertaken by students are presented alongside data providing insight into the student-perceived benefits of these approaches. The first activity focuses on practical skills development and has already been adopted by colleagues at the University of Sheffield with Chinese students in the first year of a [3+1] programme at Nanjing Tech University, generating additional data included in this chapter. The second is a self-assessment activity in organic chemistry. It was adapted from an activity used in chemistry degree programmes at Southampton that has also been used by teachers in schools and colleges locally and nationally to support A Level students. The implementation of the approaches outlined in the case studies is described in moderate detail, and all resources are available for download for those wishing to explore them in more depth. The case studies, informed by literature on reflection, metacognition and meaningful learning, are presented as novel activities with the flexibility to be adapted to other contexts in chemistry and other disciplines.

Influence of Professor Tina Overton (David Read)
When I first arrived in HE, Tina was the undisputed leader of the chemistry education community in the UK, and was an inspirational champion for evidence-based teaching innovation and effective scholarship of teaching and learning. Tina has set a very high standard for myself and my peers to aim for in developing, evaluating, and disseminating our teaching practice. Even when we fail to reach that standard, we have at least made significant progress as a result of aiming high in the first place. In terms of the work outlined in the chapter, reading Tina's seminal Study and Communication Skills for the Chemical Sciences made me realise the importance of reflection in the process of consolidation of vital skills and prompted me to devise and implement approaches which support its development.

To cite: Read, D., Barnes, S. M., Hyde, J., and Wright, J. S. (2019), "Nurturing reflection in science foundation year undergraduate students", in Seery, M. K. and Mc Donnell, C. (Eds.), *Teaching Chemistry in Higher Education: A Festschrift in Honour of Professor Tina Overton,* Creathach Press, Dublin, pp. 23-38.

Introduction

This introduction will discuss the rationale for the development of students' reflective skills during undergraduate studies with reference to their prior experiences and preparation for subsequent years of study. This work, which has primarily been carried out with Science Foundation Year students, is framed in the context of a short review of key literature in the field that has influenced the creation of a suite of reflective activities undertaken throughout an academic year.

The context of the Science Foundation Year (SFY) at the University of Southampton

The SFY is designed to provide students who do not have the prerequisite qualifications with sufficient background to progress onto a science degree at the University. Students study modules in chemistry and biology (equivalent to UK A Level) that together account for half of the academic credits for the year, along with a smaller module in mathematics (12.5% of the overall credits). Additionally, there is a Laboratories and Coursework module (25%) and a Routes to Success (12.5%) module, which focuses on skills development and incorporates assessed reflective activities. Enrolment typically ranges from 40–60 students per year.

With only 24 weeks of teaching time, it isn't possible to equip students with the same level of knowledge and skills as can be achieved within a school setting over two years. A key difference is the fact that teachers at 16–18 level spend far more time with students in smaller classes, allowing them to provide targeted feedback, support and encouragement on a frequent basis. Although staff on the SFY provide considerably more feedback than might be experienced on many degree programmes, this cannot fully compensate for the deficit in contact time with teachers compared to school.

To overcome the difficulties posed by this situation, we take the opportunity to engender skills of reflection in our students, providing them with the capability to evaluate their own progress, and essentially give themselves feedback. The approaches used are described in this chapter along with evidence of impact on students and plans for future developments to capitalise on the benefits we have identified. In addition, recommendations are provided for adaptation of these activities to other institutions.

Reflection and its potential role in the Science Foundation Year

Despite the apparent ubiquity of the term, a clear definition for reflection still remains elusive. Rogers (2001) examined a range of theoretical approaches to the concept of reflection, identifying commonalities and differences in the frameworks proposed. A common theme was that reflection, being a cognitive process, requires proactive engagement by the individual as exemplified by Dewey (1933), who described reflective thinking as the application of "*active, persistent and careful consideration*" to the task at hand. Reflection in an educational context requires the individual to "*explore their experiences in order to lead to new understandings and appreciation*" (Boud *et al*., 1985) and to critically assess the activity which is the subject of the reflective process (Mezirow, 1990). As summarised by Rogers (2001, p41):

> *the intent of reflection is to integrate the understanding gained into one's experience in order to enable better choices or actions in the future, as well as to enhance one's overall effectiveness.*

This aspect of reflection is critical for SFY students in compensating for the feedback deficit outlined in the previous section.

The process of reflection

Most models of reflection break the process into a number of stages, which typically commence with the identification of a problem and a decision on behalf of the individual to seek a solution. A commonly cited model is Gibbs' reflective cycle (Gibbs, 1988), which provides a six-stage framework for reflection (Figure 1).

The process may be triggered by some sort of new experience, which may be problematic or perplexing to the learner, providing a focus for reflection, which begins with a description of the experience. Gibbs' approach encourages iterative cycles of reflection that help a learner to move forward over time, and this presents a good overarching model for the SFY. In the case of our students, the experiences that prompt reflection include in-class tests and examinations, laboratory activities, and self-assessed exercises. The evaluation and analysis stages typically involve consideration of additional information, sometimes referred to as data collection (Rogers, 2001), which later informs planning and a decision to act. This represents an essential feature of reflection, paving the way to new experiences and skills development (Boud *et al*., 1985) and changes in thinking which lead to new understanding (Seibert and Daudelin, 1999). The use of structured reflective activities with SFY students provides a framework for their thinking to develop in this way, although students are free to draw on additional information if they so wish. The final stage then typically involves the individual taking action (and implementing their learning) based on the previous steps. Again, this is supported in SFY students through prompts which ask them to express their learning from the process.

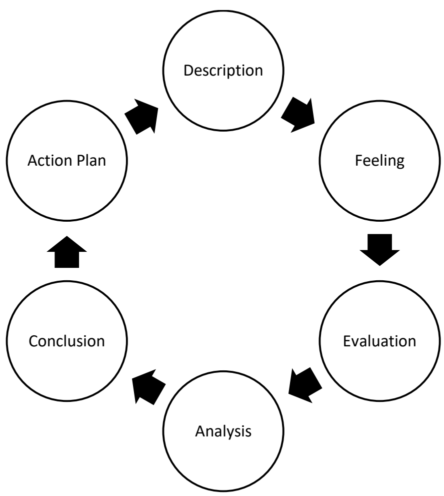


Figure 1: Schematic of Gibbs' reflective cycle

Barriers to reflection

The learner must be willing to engage, which can be difficult in cases where reflection is not perceived to be of value, presenting a barrier which inhibits the reflective process and the learning that may be derived from it. Boud and Walker (1993) classified such barriers as internal, arising from "*previous negative experiences, accepted presuppositions about what the learner can do… [and] the emotional state of the learner*" and other issues commonly identified in today's students. Roberts and Yoell (2009) classified students into three groups based on their engagement with a reflective journal activity and the benefit they derived from it:

1. *Natural students* were predisposed towards reflection and found it beneficial;
2. *Converts* were initially sceptical but became more positive as they started to engage with reflection;
3. *Disengaged students* evidently had misconceptions about the purpose of reflection and did

not find it to be beneficial.

Paterson (1995) suggested that the clarity of expectations and the quantity and quality of feedback were key factors in the development of reflective skills, as exhibited by converts in Roberts and Yoell's study. A lack of familiarity with the process can also impede reflection, which Loughran (1996) suggests may be overcome through the use of demonstrative processes, where the teacher explicitly models the process of reflection on their own practice. These points are taken into account in the design of reflective activities on the SFY, with the goal of encouraging all students to engage effectively with the tasks. In this case, the staff member delivering this strand of teaching explains the role of reflective practice in the development of his teaching, with some exemplification of the thought processes employed. The continued provision of constructive feedback on reflective assignments helps students to develop the skills required.

Reflection and metacognition

Students may also benefit from reflection in developing their subject-specific knowledge and understanding. In this case, it is important to consider the relationship between reflection and metacognition, the latter of which was described by Rickey and Stacy (2000) as involving examples where "*the object of reflection is always one's personal knowledge or thinking*". These authors noted the importance of metacognition in chemistry education, citing evidence of its value in developing the understanding of ideas and also in positively impacting on problem-solving success. With this in mind, we also endeavour to encourage students to reflect specifically on aspects of the chemistry they are studying, again with the aim of ensuring that they consolidate their learning effectively.

Reflection on general performance during the Science Foundation Year

The main focus of this chapter is on two case studies described in subsequent sections, one in which students reflect on the development of practical skills and one in which they undertake a synoptic self-assessed exercise in organic chemistry. In order to foster skills of reflection more generally, students are prompted to reflect on their progress regularly throughout the year as part of the Routes to Success module, as illustrated in Table 1. The reflective templates used in Activities 2, 3 and 5 are available for download (http://edshare.soton.ac.uk/19410/) for those interested in exploring this aspect of the work further. At different stages in the year, students are prompted to reflect on their ambitions and motivations, their academic performance and how they are adapting to university life. By providing prompts, feedback and opportunities for discussion with staff, this structured approach helps students to overcome the barriers to reflection described in the previous section. Students are required to evaluate their study approaches in the light of in-class test and exam results, identifying strengths and weaknesses and refining their approach as a result. It is intended that this should become a continuous process that students will then implement proactively in their subsequent studies and beyond into their working life.

Table 1: Schedule of general reflective activities taking place during the SFY

Activity	Week	Reflection activity	Assessment
1	4	Progress interview with staff member	Verbal feedback only
2	5	Written reflection in response to prompts	Written feedback only
3	9	Reflection on performance in in-class tests	Graded with written feedback
4	20	Progress interview (post exam)	Verbal feedback only
5	23	Reflection on performance in Sem 1 exams	Graded with written feedback
6	28	Assessed reflective interview	Graded with verbal feedback

Methods

This section will outline the context in which two reflective activities were developed within the SFY programme as well as discussing how they can be implemented and evaluated. Case Study 1 concerns a series of activities to support learning from practical work, while Case Study 2 is a one-off synoptic self-assessed task to consolidate learning of reaction mechanisms.

Case study 1: Reflection on practical skills development

The key aims of the practical component of the SFY are to:

1. provide students with experience of a range of practical techniques that they might encounter in their future studies;
2. develop students' confidence in working in a laboratory environment;
3. develop students' abilities to monitor their experimental activity and improve their performance in the light of their experiences.

Over the course of the year, there are ten three-hour chemistry practical sessions, meaning there are limited opportunities to repeat techniques to increase familiarity. During the first year of implementing the programme (2012/13), it became clear that many students were not assimilating even simple practical techniques. For example, the incorrect use of measuring cylinders led to spillages during the second practical despite teaching of the correct technique in the previous session. This prompted the development of a new approach to practical assessment the following year, namely the Practical Skills Portfolio (PSP). It should be noted that in 2012/13, students were required to write full laboratory reports for two of the ten practicals they completed, with nothing beyond answering several questions at the end of the session required for the rest. In subsequent years, students have completed nine PSP documents and one full report. The practical scripts and PSP templates used in the chemistry component of the SFY are available for download (see Supplementary Information).

The PSP was designed to minimize the effort for staff while maximising the benefit to students. An investment of time was required to create the templates, although this was straightforward once the first one had been generated. Students are familiarised with each practical through pre-laboratory activities, which include videos outlining the process of many of the techniques employed. Students are briefed about the requirements of the PSP, with positive comments from students in previous years used to exemplify the benefits. Students are made aware that the bulk of the marks are awarded for the demonstration of learning through reflection. An indicative time plan for the implementation of PSPs is shown in Table 2.

The PSP — which was subsequently adopted by colleagues at the University of Sheffield for use with students in China (see Chapter 28) — is described more fully elsewhere (Wright *et al*., 2018). Students collect photographic evidence of their completion of practical techniques, with photographs being taken in collaboration with a laboratory partner. After the session, students add the photographs to the PSP. Students are then required to reflect on the technique by writing a response to the prompt "*What was difficult about the technique? What advice would you give another student to complete it correctly?*" The PSP also includes other tasks for students to complete, which may include writing a component of a full report such as a method or evaluation. An example of a PSP entry, including a photograph and a reflective statement, rated good but not excellent, is given in Figure 2.

It is envisaged that the PSP should take 30–40 minutes to complete, representing a light-touch assessment

Table 2: Indicative timeplan for implementation of Practical Skills Portfolios

Week	Activity	Notes
Prior	Identify practical skills and techniques covered in practicals	The skills and techniques should be brought to the attention of students and prompts should be added to practical steps where they are required to obtain a photograph (see Supplementary Information).
Prior	Create PSP templates (in Word)	These are set out in a tabular format, with reflective prompts and space for students to add reflections (see Supplementary Information).
Wk 1	Outline the content and expectations of the PSP at the start of the session	Students are advised that an excellent response will identify three aspects of a practical technique on which they will reflect and provide advice to other students, with discussion of issues which should be considered when performing the skill/technique.
Wk 2	Mark students' PSPs and add feedback	The rubric and quickmark comment features of Turnitin (see Supplementary Information) are used to promote rapid marking and consistency. Demonstrators are provided with initial training by staff, and moderation continues throughout the year.
Wk 3	Students receive marks and feedback	Students alternate between biology and chemistry practicals, providing a one week window after submission for marking and feedback to support students in improving subsequent work.

focussing on skill development. PSPs are graded online, either by staff or postgraduate demonstrators, using Turnitin (see Supplementary Information), supporting the return of feedback to students in advance of the next practical so it can be utilised effectively. Ensuring that an appropriate level of reflection is displayed in all students' responses to the prompts is a focus for the feedback provided.

Case study 2: Synoptic self-assessed exercise in organic chemistry

The approach to teaching of organic reaction mechanisms on the SFY, delivered through lectures, was designed to foster an appreciation of meaningful approaches. This involved a stepwise approach, similar to that outlined by Pungente and Badger (2003):

- Step 1: Identification and labelling of lone pairs, dipoles and pi-bonds in the reactants.
- Step 2: Prediction of the first step in mechanism based on the features identified in Step 1.
- Step 3: Completion of subsequent steps leading to the reaction product(s).

Students were given opportunities to practise each mechanism in lectures, with feedback provided throughout. Students also had the opportunity to attempt mechanistic problems during weekly workshop sessions, where students were given problem sets based on the content of the week's lectures. During the sessions, they could ask questions and receive feedback from 2–3 staff and postgraduate demonstrators. Despite this framework, observations of student behaviour in 2012/13 and 2013/14 indicated that many were adopting a rote-learning approach to mechanisms, which has previously been identified as a source of misconceptions (Henderleiter *et al.*, 2001). Although it is unclear why this was the case, it is possible that the pace of teaching on the SFY programme meant that students lacked opportunities to reflect on their thinking and develop the confidence to work out a mechanism; students in such a position may be inclined to resort to rote-memorisation.

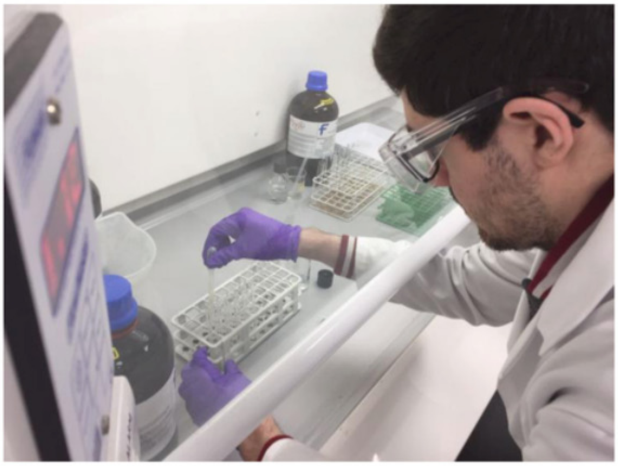
Handling a corrosive solution	Level of confidence (circle) 1 (low) 2 3 **4** 5 (high)
 Photo gd Ref gd	***What was difficult about the technique? What advice would you give another student to carry it out correctly?*** Again, the technique was not too challenging however one should always work slowly and precisely when handling corrosive solutions in a fume cupboard since movement is limited. Gloves should always be worn when corrosive solutions such as nitric acid and concentrated ammonia are used. When concentrated ammonia is being handled one should make sure that it is being handled in a fume cupboard. Test tubes should not be too full so that when corrosive solutions are added, the solution won't spill over and come into contact with skin. One should also make sure that one's line of vision is not impaired by the white bar at the bottom of the fume cupboards protective glass. Either move the test tubes or test tube rack further back or adjust so that everything can be seen.

Figure 2: An example of an entry from a PSP including feedback provided via Turnitin (used with permission)

Grove and Bretz (2012) placed students on a spectrum from rote-memorisation to meaningful learning according to the approach they adopted when studying organic chemistry. Students who adopted rote-memorisation due to a lack of awareness of more meaningful techniques were classified as unaware learners, whereas indifferent learners were those who were aware of meaningful approaches but chose not to adopt them. Those in the latter category expressed that they were unwilling to spend the time applying more meaningful techniques in the belief that it would be easier to adopt a rote-learning strategy. It was felt that a significant proportion of SFY students had the characteristics of unaware and indifferent learners because they weren't assimilating the more meaningful aspects of the taught approach, and it was desirable to induce a shift in their behaviour.

In order to move students away from rote-memorisation, it was felt that they should be prompted to analyse their approach to reaction mechanisms and to identify where more meaningful thinking could be incorporated in future. Since limited time was available in timetabled teaching sessions, it was proposed that a self-assessed exercise be set for completion over the Easter vacation break.

Description of the synoptic self-assessed exercise in organic chemistry

The use of videos of experts talking through answers to problems (talking mark schemes) to support Year 2 students in self-assessing their performance on organic chemistry problem sets at Southampton has been described previously (Brown *et al*., 2012). A key feature of a talking mark scheme — as opposed to a static written document — is the fact that the expert describes their thought process and the rationale behind it as they outline an approach to answering the problem. This allows students to compare their own thought process with that of the expert and reflect on any differences, potentially facilitating the incorporation of more meaningful strategies into their approach to mechanisms.

This approach to self-assessment involves three steps: students complete problem sets; the teacher checks the work is complete and returns it for marking; and then students carry out self-assessment and record their reflections in a survey. This approach has also been adapted as a summer vacation homework exercise encompassing inorganic, organic and physical chemistry for students transitioning between Year 1 and Year 2 in chemistry at Southampton (Read and Duckmanton, 2012), resulting in favourable feedback from students. The completion of surveys by students at the end of the process, in which they report their marks for the exercises as well as their responses to reflective prompts, has facilitated the monitoring of student engagement as well as providing insights into the benefits in terms of student confidence and their approach to learning.

The process of self-assessment with reference to talking mark schemes is aligned with Sadler's model of formative assessment (1989). Sadler referred to three conditions for effective self-monitoring, which are listed as stages in Table 3, mapped against steps in the self-assessment process outlined by Brown *et al*., (2012) and used in this case study.

Table 3: Mapping of stages in self-assessment activity onto Sadler's (1989) model of formative assessment and self-monitoring

Stage	Sadler's description	Self-assessment activity by student
1	Students should understand the goal and standard for which they are aiming.	Viewing the model answer and underpinning thought process outlined by the expert during the talking mark scheme.
2	Students should compare their performance with the standard.	Marking their answer and comparing their thought process with the expert's.
3	Students should identify steps to close the gap between their current performance and the standard for which they are aiming.	Responding to reflective prompts in the survey, asking them to explain how they will improve their future performance.

An indicative timeline for the implementation of this approach is outlined in Table 4. It should be emphasised that the creation of talking mark schemes, discussed later on, can be time consuming and it is important that perfectionism is avoided. The other steps in the creation of the activity are relatively straightforward, although an investment of time is required to create the resources in the first instance.

Since the SFY chemistry programme is based on the UK A Level specification, the problem set in this case was based on a set of activities adapted from previous A Level examination questions, and this was created and issued to students before the Easter vacation break. A set of talking mark schemes, based around PowerPoint slides and on-screen annotations, were created and uploaded as unlisted videos to YouTube (see, for example https://youtu.be/zeIMnTeCsQ4). These videos were created using Camtasia Studio on a laptop in a private office, but similar videos could also be recorded using institutional lecture capture software in a lecture theatre. A screenshot from a talking mark scheme is shown in Figure 3. In our case, the videos were then embedded in a survey which asked students to enter their own marks for each question answered (see Supplementary Information for details). When the resources were later repurposed for use with school students, the survey was replaced by a pro forma (see example in

Table 4: Example timeline for implementation of this approach

Time	Activity	Notes
Prior	Create problem set	Ideally, questions should prompt a multi-step thought process that can then be modelled in the talking mark scheme (see http://edshare.soton.ac.uk/18073 for an example).
Prior	Create talking mark schemes	Best approached with limited preparation in order to model thought process of an expert when tackling an unseen problem (see https://youtu.be/zelMnTeCsQ4 for an example).
Wk 1	Issue problem set to students	Advise students to do some preparation and then complete the problems without reference to notes.
Wk 1	Create survey OR paper pro forma for marking and reflection	It is particularly important that this prompts students to identify strengths and weaknesses, and strategies for improvement (see Supplementary Information).
Wk 2	Check completion of work, then return to students for marking.	Issue students with a link to the survey or the marking pro forma. Whichever format is used, it should include links to the talking mark scheme videos. The marking process is intuitive for students, the main guidance being to expand on their responses to reflective prompts.
Wk 3	Download survey data or collect pro formas for analysis	Generate feedback for students based on their responses to reflective prompts, and identify any common issues arising from performance on the activity itself to inform generic feedback.
Wk 3	Mark students reflections (optional)	A light touch marking process can be used to award a mark, as outlined in the supplementary information (see Supplementary Information).

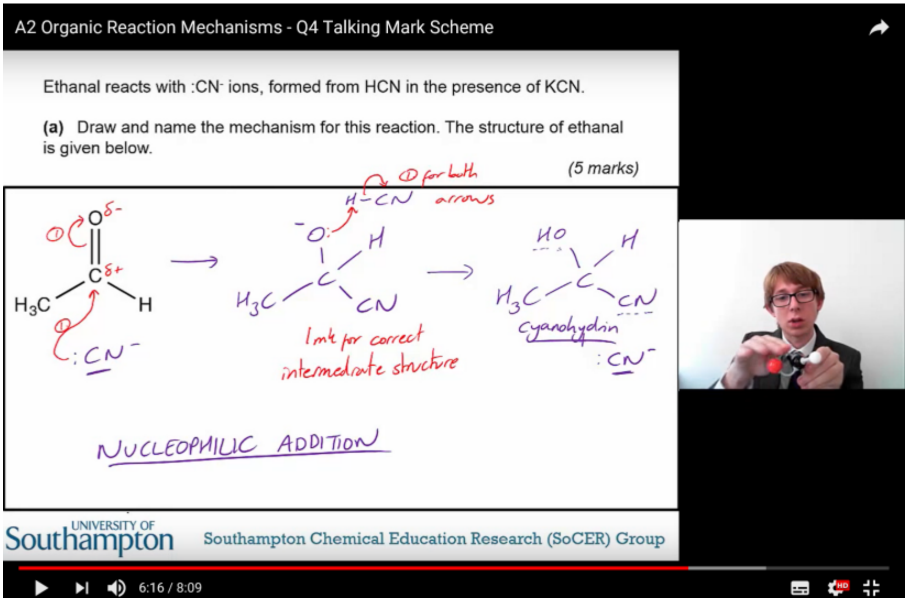


Figure 3: A screenshot from a talking mark scheme

Supplementary Information) for ease of use. This is completed on paper by students as they view the videos and can then be collected in for analysis by the teacher.

Reflective prompts were included in the survey (and the pro forma), along with some evaluative questions, to which students were required to respond. Students were instructed to complete the problem set and then self-assessment via the survey before they returned to university four weeks later. This meant that the work was not checked for completion prior to marking. Students were told in advance that the activity and the self-assessment process would each take 1–1.5 hours to complete. This exercise was credit bearing (~10% of the module mark), with students being graded on the quality of reflection in their responses. It is likely that this influenced the completion rate (typically about 75% over the three years this activity has been in operation), although it should be noted that implementations with undergraduate chemists saw completion rates > 80%, despite not being credit bearing.

Presentation and Discussion of Findings

This section will consider the evidence of impact of each case study in turn, based on students' responses to survey questions. Some qualitative data extracted from students' comments is discussed briefly in the chapter with more detailed information available in the Supplementary Information, including the themes identified through thematic analysis.

Data relating to Case Study 1 was collected as part of a process to evaluate the effectiveness of the SFY in preparing students for practical work in later years. This was achieved through a survey of students who had participated in the SFY in previous academic years before progressing to later years of study. In total, 27 complete responses were received from a population of 88 students (31%). Students voluntarily completed the survey and consented to the data being used in scholarly publications and presentations.

The data presented in relation to Case Study 2 is collected through the normal operation of the activity. Students whose comments have been used in this chapter provided consent for the data to be used for research purposes. Note that students did have the option not to respond to evaluative questions during the activity, and these were not themselves subject to assessment.

Evidence of impact on students for reflective Case Study 1

Some of the evidence collected has been reported previously (Wright *et al*., 2018), although the aspects relating to the reflective components of the PSP are discussed exclusively herein. Students responded to two reflective prompts on a Likert scale and were asked to add a comment. Likert response data is presented in Figure 4, with qualitative data extracted from comments available in the Supplementary Information. Note that the shading in the charts indicates the breakdown of responses between students who are currently studying on degree programmes in years 1–4 at Southampton (having completed the SFY) and in Years 2 and 3 on the Sheffield/Nanjing [3+1] programme. None of the students surveyed encountered PSPs in subsequent studies.

Our evaluation shows that students generally place great value on the processes of self-assessing and reflecting on their practical performance. Analysis of qualitative data (Supplementary Information) provided evidence that students perceived the reflective process to be to be valuable in developing their understanding and ability to recall different techniques and how to perform them. Bearing in mind that this is data collected from students who used PSPs one or more years previously, it is noteworthy that some of them commented on the value of this approach in preparing them for their studies that followed.

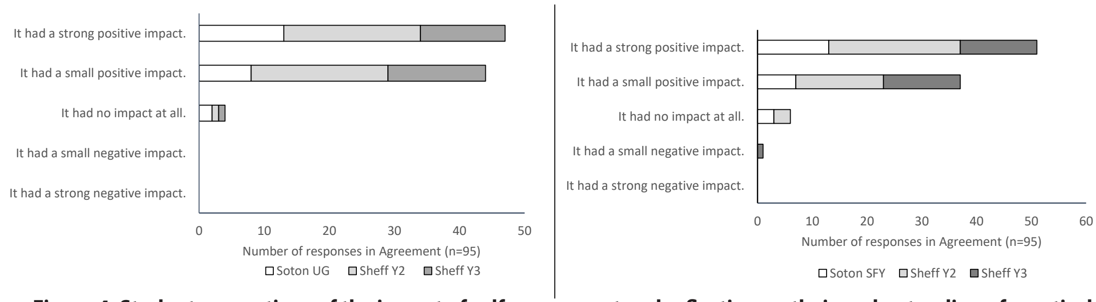


Figure 4: Student perceptions of the impact of self-assessment and reflection on their understanding of practical techniques (left) and on their ability to remember how to perform practical techniques (right)

However, it should be acknowledged that this is self-reported data based on students' perceptions of the impact of PSPs, and we have not attempted to measure students' ability to perform techniques. Thus it cannot be inferred that the self-assessment and reflection described has led to enhanced understanding and recall of practical techniques. Nonetheless, staff and demonstrators in the teaching laboratory report seeing fewer errors since the introduction of PSPs, and it was noted by the laboratory demonstrator in 2013/14 that most students were observed to be correctly viewing the meniscus in their measuring cylinder at eye-level during the second practical in contrast with the previous year.

Evidence of impact on students for reflective Case Study 2

As noted previously, students entered their marks for the exercise into a self-assessment survey, which included evaluative and reflective Likert items and open text response questions (see Supplementary Information). Completion of the survey was part of the assessment, with 117 students out of a cohort of 154 responding to questions over the three academic years. Figure 5 illustrates responses from students to Likert survey items relating specifically to their perceptions of the impact of the activity on them. This data indicates that an overwhelming majority of students felt that their understanding and confidence improved as a result of the activity. Students were asked to comment on what had caused their confidence to change, with thematic analysis of their responses presented in the Supplementary Information. Key themes identified included clarification of thought processes, changing perceptions of difficulty, and the development of a more holistic approach to mechanisms, among others.

Students were asked about the role of the activity in helping them to identify where they needed to do more work/revision, as illustrated in Figure 6. Again, quotes listed in the Supplementary Information give some indication why students were largely in agreement with the statement in the prompt. Students

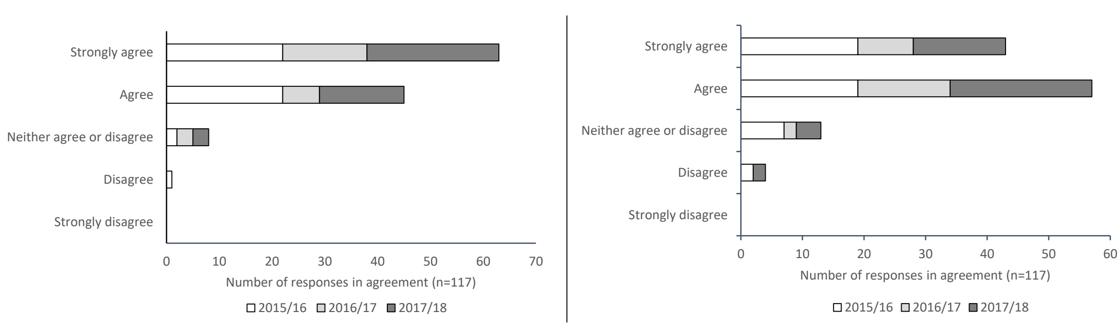


Figure 5: Student responses relating to understanding of reaction mechanisms (left) and relating to confidence in tackling exam questions (right)

were asked to suggest actions they would take to improve their performance in organic chemistry, with the most common response being that they would be practising more problems. In many cases, the students cited specific actions identified, such as the creation of flash cards to consolidate understanding of the stepwise nature of a mechanism.

It is evident that students see the value of this activity for their learning. Thematic analysis of qualitative data (Supplementary Information) identified a number of common themes, which included clarification of thought processes, changing perceptions of difficulty, and understanding the approaches to mechanisms, among others. Further analysis of this and other qualitative data collected is underway, but the themes identified illustrate the range of benefits that students have recognised through their engagement with the task. Although impact on attainment has not been measured, staff and postgraduate laboratory demonstrators have reported an improvement in many students' confidence as well as a more structured approach when drawing mechanisms after completion of the task.

Data presented is based on student perceptions, and no attempt has been made to measure impact on student attainment in organic chemistry as part of this study. However, there is strong evidence that students place great value on the process of self-assessing these exercises with reference to talking mark schemes. The qualitative data provides fascinating insight into the minds of students as they reflect on their performance and their learning in relation to reaction mechanisms. Many student comments indicate increased awareness of meaningful approaches, as defined by Grove and Bretz (2012), as a result of their reflection on the thought processes employed in successfully approaching mechanistic problems.

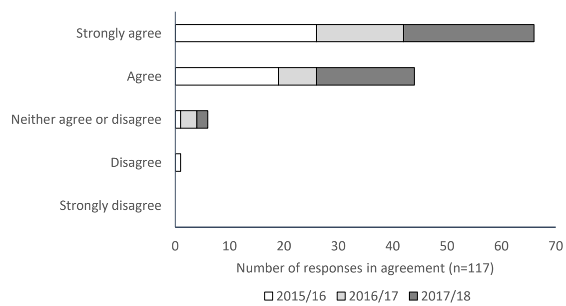


Figure 6: Student responses relating to future work and revision

Implications and Adaptability

Reflective Case Study 1 — applicability of the approach

The PSP approach has already been adopted successfully by the University of Sheffield team with students on their [3+1] programme with Nanjing University of Technology, and has been shared with teachers in schools and colleges. In the cases described, the PSP is used in the assessment of fundamental practical activity and the format is probably better suited to work of this nature, rather than the more advanced practicals encountered in later years of degree programmes. However, the reflective element could potentially be incorporated into any practical procedure either in the laboratory or as part of a post-laboratory write up.

The key points outlined below should be considered by those exploring the adoption of a similar approach:

- PSPs streamline the process of recording practical activity on the part of the student, and also the assessment process for staff, supporting rapid feedback provision.

- Feedback to students is essential, as the level of reflection can be limited in early examples.
- Students have indicated that the awarding of marks acts as an incentive, with the combined marks being worth 14% of the module mark on the SFY from 2012/13–2017/18.
- Consistency of assessment and feedback on PSPs across different markers at Southampton is supported through the use of Turnitin rubrics and Quickmark comments.
- A risk assessment should be carried out regarding the use of phones as cameras in the teaching laboratory. Note that phones can be placed in re-sealable plastic bags without losing their touchscreen functionality.

Reflective Case Study 2 — applicability of the approach
As discussed, this approach has already been used with students in Years 1 and 2 of the chemistry degree programme across all areas of the discipline, showing its versatility. Additionally, the SFY resources described herein have been adapted for use with A Level students. Over 1500 students at 23 schools and colleges took part in the initial project, and the resources are now freely available for download (http://edshare.soton.ac.uk/18073). At the time of writing, there have been > 2600 file downloads from this page since January 2017.

The points below outline key considerations for those exploring the adoption of a similar approach:

- Explore the downloadable examples at http://edshare.soton.ac.uk/18073 for ideas about how to create appropriate exercises and talking mark schemes and run this type of self-assessment activity.
- If setting up a survey for the self-assessment is problematic, students can still be prompted to record their marks and reflections using a paper pro forma instead.
- Shorter reflective exercises based on this approach can be embedded in any teaching activity, including a lecture. For example, students could attempt an exercise and then mark it with guidance from the lecturer, before reflecting either through peer discussion or via a classroom response system.
- Awarding credit for the activity is likely to incentivise students to engage, although a non-credit bearing version employed with Southampton undergraduates achieves high completion rates.

Conclusions and Future Work

Activities which prompt students to engage in reflection on their learning have been implemented on the SFY programme, two of which are the focus of this chapter — reflection on development of practical skills (PSPs) and reflection on self assessment of organic mechanisms using talking mark schemes. The resulting data provides evidence of the impact of the activities on students' learning and their confidence in their capabilities. Such activities help to prepare students for their future studies and for life beyond in the workplace. This sentiment is captured in the quote below from a student now in the 3rd year of their pharmacology degree:

> *[The SFY] helped with my organisation skills and really understanding what's expected of me at university level. It taught me the importance of independent work and also becoming a reflecting student who understands what works and doesn't work in terms of learning content.*

We are currently exploring methods to facilitate and monitor continuous reflection on progress more generally during the SFY, potentially using an online system to capture students thoughts each week regarding their grasp of content and what they need to concentrate on going forwards. Data collected via such an approach would support staff in pastoral activity, helping to identify students who are at risk of underachieving due to ineffective study approaches or lack of engagement.

There is great scope for future work in this area, which could progress towards more rigorous pedagogical research. The impact of the reflective component of PSPs on students' abilities to replicate techniques correctly could be investigated. Photographs in PSPs could be also replaced by videos, supporting peer review as outlined by Seery *et al*. (2017), with the reflective component being incorporated in the commentary added to the video.

A long-term goal of the work with talking mark schemes is to investigate their impact on students' abilities to successfully tackle mechanistic problems in organic chemistry. This could be done by using a think aloud protocol, where students verbalise their thought process while working through a problem, as previously reported in organic chemistry by Ferguson and Bodner (2008) and Kraft *et al*. (2010). By working with students pre- and post-activity, it would be possible to probe the effect of the self-assessment task on students' assimilation of the meaningful learning approaches conveyed in the talking mark schemes into their own problem-solving toolkit.

Supplementary Information
Supplementary information referred to in this chapter is available at: overtonfestschrift.wordpress.com.

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