Developing a procedure for learning and assessing peer review in a forensic science programme

Hilary J. Hamnett*[†] and Amanda E. McKie[‡]

Forensic Medicine & Science, School of Medicine, Dentistry & Nursing, University of Glasgow, Glasgow, G12 8QQ, UK

Dr Hilary Hamnett, Forensic Medicine & Science, University of Glasgow, University Place, Glasgow, G12 8QQ, UK

h.hamnett@imperial.ac.uk

[†] Present address: Toxicology Unit, Imperial College London, Charing Cross Campus, St Dunstan's Road, London, W6 8RP, UK. ORCiD: 0000-0002-0640-0422

[‡] ORCiD: 0000-0003-2431-7849

Developing a procedure for learning and assessing peer review in a forensic science programme

Peer review of forensic casework is essential for ensuring quality and reducing error rates. However, it is not a common component of forensic science degree courses, and there are no published studies, guidelines or methods for teaching and learning forensic peer review. This study describes a method of learning, teaching and assessing forensic peer review through the use of group work to prepare checklists for reviewing casefiles and expert witness reports, followed by individual peer feedback. Example checklists and assessment criteria are provided. The peer feedback comments on expert reports were categorised revealing that suggestions are the most frequent type of feedback provided, followed by questions. Through a questionnaire, participants strongly agreed that the learning and teaching process described here was relevant to their future professional practice, and that through the use of checklists they understood the criteria for effective forensic peer review. It emerged from a semi-structured interview that limited time led some students to surface review expert reports, that peers were seen as legitimate sources of knowledge, and additional feedback from lecturers was required. This study may be relevant to other areas where professional peer review is used, such as open source software development, nursing and community pharmacy.

Keywords: peer review; forensic science; postgraduate students; checklist

1. Introduction

Scholarly or *editorial peer review* is responsible for improving the quality of manuscripts to be published in academic journals, and weeding out serious methodological errors (Schroter et al. 2008). It has long been held up as the premier approach to ensuring the validity of methods and conclusions and detecting fraud (Ballantyne, Edmond, and Found 2017), and is firmly embedded in academic practice (Mulder, Pearce, and Baik 2014).

The peer review encountered between professionals in forensic science differs from editorial peer review in that it is not used to check the validity of new methodologies

or theories, but the application of existing methods to forensic casework (Ballantyne, Edmond, and Found 2017). It also differs somewhat from the *student peer review* described in the education literature (Dochy, Segers, and Sluijsmans 1999; Topping 1998; Mulder, Pearce, and Baik 2014; Gatfield 1999) and is more akin to the *peer feedback* defined by Liu and Carless (2006), where detailed comments on a peer's work are provided. In *forensic peer review*, experts check each other's case notes, charts, data, calculations and photographs to ensure that (Ballantyne, Edmond, and Found 2017; Jeanguenat, Budowle, and Dror 2017):

- appropriate investigations have been conducted;
- standard operating procedures and policies were followed;
- results are scientifically accurate and complete; and
- any scientific opinions tendered are sound, backed up by appropriate literature or databases, consistent with the data in the casefile and fit within the constraints of validated scientific knowledge.

It is also an open process, *i.e.*, the reviewer and author are known to each other, and the review is documented. This type of professional peer review is also used in other areas, including open source software development (Rigby et al. 2012), nursing (Gopee 2001) and community pharmacy (Milchak, Shanahan, and Kerzee 2012).

Existing studies on student peer review have demonstrated that it helps them develop skills such as reflection, analysis and providing constructive feedback (Falchikov and Goldfinch 2000; Liu and Carless 2006; Heylings and Stefani 1997). Student peer review also seems to promote deeper learning (Morris 2001) and higher order cognitive skills, as students judge, analyse, clarify and correct each other's work, and justify their

reasons for working in particular ways (Mulder, Pearce, and Baik 2014; Falchikov and Goldfinch 2000). It also offers students a view of themselves that is not often available, and peer review is sometimes more informative than traditional marking (Falchikov 1995). There is an argument that students often pay more attention to feedback from peers than from lecturers (Pearce, Mulder, and Baik 2009), with some students reporting that whilst they took lecturer feedback at face value, they considered their peers' suggestions more carefully (Walkington et al. 2011). Further practical reasons for using peer review are that students receive more feedback from peers and more quickly than from lecturers (Liu and Carless 2006; Topping 1998).

Students themselves report enjoying the process and finding it beneficial – making them work in more structured ways and increasing their confidence, self-awareness and self-regulation (Dochy, Segers, and Sluijsmans 1999; Mulder, Pearce, and Baik 2014; Orsmond, Merry, and Reiling 1996; Liu and Carless 2006).

Despite all of these advantages, student peer review has a number of issues. For example, it can produce results based on uniformity, race and friendship if training is not provided (Dochy, Segers, and Sluijsmans 1999). This can include over- or under-marking and collusion (Dochy, Segers, and Sluijsmans 1999; Ballantyne, Hughes, and Mylonas 2002). Students may also feel socially uncomfortable about finding errors and criticising their friends (Dochy, Segers, and Sluijsmans 1999; Falchikov 1995; Topping 1998), or may be anxious about how their comments will be received (Pearce, Mulder, and Baik 2009); some students find it easier emotionally to accept feedback from peers than others (Liu and Carless 2006). Students can also report feeling reluctant to engage in peer review because of concerns relating to validity and reliability, *i.e.*, their fellow students' ability to peer review (Mulder, Pearce, and Baik 2014; Liu and Carless 2006). Others feel 'unqualified' to give feedback (Orsmond, Merry, and Reiling 1996) or find it difficult to

think of comments to write (Falchikov 1995). In previous studies, students have described student peer review as ‘unfair’ or ‘risky’ (Liu and Carless 2006) as well as ‘time consuming’ (Orsmond, Merry, and Reiling 1996).

These concerns may be well founded, as the studies investigating the accuracy of student peer review show inconsistent results (Dochy, Segers, and Sluijsmans 1999), and in some studies, students have reported reviews varying dramatically in quality in terms of their accuracy and helpfulness (Mulder, Pearce, and Baik 2014), with a minority of students treating the process in a rather cavalier manner (Orsmond, Merry, and Reiling 1996). It is worth noting that it is not only the reviewers who are required to take the process seriously, some recipients have not taken feedback seriously either (Pearce, Mulder, and Baik 2009). In addition, some lecturers have resisted the introduction of student peer review on the grounds that it disrupts power relations in the classroom (Liu and Carless 2006). The related problem has also been reported, where some students resent being required to review and comment on other students’ work, because they hold the belief that assessment is the lecturer’s responsibility (Pearce, Mulder, and Baik 2009; Knutson et al. 2014).

Although student peer review is potentially applicable to virtually all areas and levels of higher education (Topping 1998), the number of studies reported in the literature involving postgraduate taught students is small (Ballantyne, Hughes, and Mylonas 2002; Topping et al. 2000). In addition, few studies have been concerned with evaluating the experience from the viewpoint of the students themselves (Ballantyne, Hughes, and Mylonas 2002).

In the UK throughout the last 10 years there has been an increase in the number of university programmes related to forensic science and the number of students applying

(Mennell 2006; Evison 2018). At August 2018 there were 31 UK higher education institutions offering undergraduate (BSc) or postgraduate taught (MSc) programmes including the phrase ‘forensic science’ in the title for 2019–20 entry (UCAS 2018). However, ‘peer review’ was not mentioned in any of the online course information available, including detailed programme specification documents for 13 institutions. It is important for such programmes to feature content specifically focused on professional practice (Mennell 2006) to enable closure of the gap between what we require of students in assessment tasks and what will be required of them in the workplace (Boud 1990). The inclusion of forensic peer review in the curriculum is challenging, as despite being universally accepted as necessary in forensic science, there are few standards or guidelines regulating forensic peer review, and no standards of training on how to conduct reviews, or what should be checked (Ballantyne, Edmond, and Found 2017).

This study was conceived in order to address the above issues by answering a recent call for checklists to be designed to ensure forensic peer reviewer attention is directed to appropriate areas (Ballantyne, Edmond, and Found 2017; Witt 2010). We also aimed to develop a method for learning and assessing forensic peer review in higher education using these checklists, and to explore the postgraduate taught science student perspective on peer review.

2. Methods

This study was conducted over a two-year period (2015 to 2017), and involved students and staff on the MSc in Forensic Toxicology programme offered by Forensic Medicine & Science at the University of Glasgow, UK. Forensic toxicology is the study of alcohol, drugs and poisons and the role they play in deaths and crimes. The course is a 12-month full-time postgraduate taught programme designed to prepare students for employment in

a forensic toxicology laboratory (Hamnett and Korb 2017). The programme is closely associated with a routine toxicology casework laboratory and is taught by practising forensic toxicologists.

In the spring semester, students are enrolled on a mandatory 20-credit module known as *Case Review & Interpretation*. In the main summative assessment for this module each student is given a real, different, forensic toxicology casefile that has been anonymised. The casefile consists of raw data, and over the course of the semester, the students analyse the data in order to draw conclusions and write an expert report on the case. The casefile and report are submitted and summatively assessed, and the students are questioned on their report in a moot court exercise at the end of the semester. This is a mock jury trial that takes place in the University of Glasgow's Sir Alexander Stone court room, and involves the students acting as expert witnesses and lecturers acting as lawyers. The casefile is submitted as part of a portfolio of written work worth 80% of the module's grade and the moot court is worth the remaining 20%. Students sign a confidentiality agreement, and permission to use anonymised case data for teaching purposes has been obtained from the owners of the data. The analysis of data from the students' casefiles takes place in structured lab sessions during the semester, but the expert report writing is self-directed.

Prior to the 2015–16 academic year, peer review was not part of the MSc programme curriculum. However, mandatory forensic peer review was introduced to the associated casework laboratory as a result of new regulations (ILAC 2014) in 2016, therefore in the spring semester of that year a preliminary trial was carried out with 16 students enrolled on the module in the 2015–16 academic year. Peer reviews of students' casefiles and expert reports were formatively assessed and informal feedback was obtained by lecturers from students on the process. Following this, in the 2016–17

academic year, peer review was formally introduced into the curriculum and peer reviews were summatively assessed. Ethical approval to evaluate the intervention in the 2016–17 academic year (with nine students) was granted by the University of Glasgow Medical, Veterinary & Life Sciences Ethics Committee (project no. 200160065).

2.1 Phases

The study consisted of four phases over 16 weeks (Figure 1).

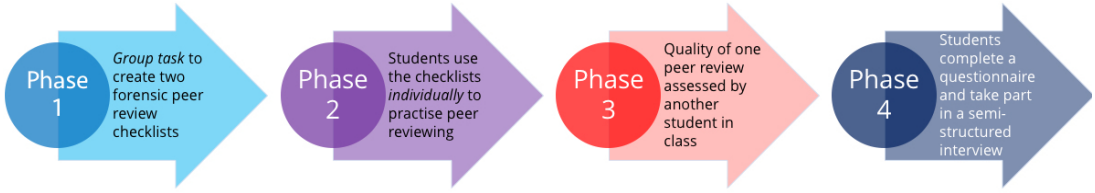

Figure 1. The four phases of the peer-review study.

There was an initial lecture in week 3 of the semester, aimed at familiarising the students with the notion and procedure of forensic peer review (Cheng and Warren 1999) and to explain the four phases of the intervention. In **Phase 1** (week 6), students worked in groups of three (assigned by staff) to review a recent real casefile and expert report (compiled and written by one of the authors) and prepare two simple forensic peer review checklists – one for reviewing casefiles and one for reviewing expert reports. The checklists were written by hand in pre-prepared printed templates (see the supplementary information for a template example) and consisted of the key points to check in a case as well as prompts for common errors and omissions, based on the casework experience of the authors. The lists prepared by the students were checked by staff and discussed as a class. During this session, help was provided if students did not understand the forensic peer review process (Gielen et al. 2010). Examples of checklists produced by the students for both casefiles and expert reports are given in the supplementary information. Checks differ among casework laboratories and some of those given in the examples may not

apply, depending on the type of work undertaken and the accreditation (if any) held by the laboratory, as well as on local regulations.

In **Phase 2** students used their checklists to review their fellow students' work over several weeks. In weeks 6, 8 and 10 the students produced three formative expert reports, based on three real cases (all students interpreting the same set of results each week), and were required to have each report peer reviewed by a student in the class before submission. The writing process was self-directed and students chose their own reviewers. The students incorporated feedback from the review into their report and submitted a final version to the lecturer. These were then reviewed by the lecturer and returned to the students with additional comments (if required) before the next report was assigned.

In week 10, a two-hour teaching session was set aside for peer review of the casefiles and draft expert reports to be submitted in end-of-semester portfolios, which meant the class had to have completed their casefiles for week 10. On this occasion, each student interpreted a different set of results, and peer reviewers were chosen by a lecturer. The deadline for the final hand-in of their summative assessments was in week 14. Students were informed of the timeline in week 1. Feedback on casefiles consisted of post-it notes to draw the student author's attention to errors (post-its were removed before final submission), whereas handwritten comments were added to draft expert reports. Any changes indicated by this review could be incorporated into the casefile and report by the students before final submission. The marked-up copy of their peer reviewed draft expert report was included with the casefile and final expert report, as is standard practice in casework laboratories. A marked-up copy of *any* draft expert report they had reviewed was also required for each student's summative assessment. Handwritten comments on

the expert reports were collated anonymously by one of the authors and categorised to identify the underlying themes and dimensions (Hanrahan and Isaacs 2001).

In **Phase 3** (immediately after Phase 2, in class) each student's peer review was assessed by a third student (chosen by the lecturer) using the criteria given in the supplementary information, and completed criteria sheets were returned to the peer reviewer. The criteria were produced in collaboration with the students and were based on constructive feedback characteristics, namely the presence of positive and negative comments, of suggestions, and of thought-provoking questions (Gielen et al. 2010). There were also marks available for the tone of the review to reflect the fact that peer review is not simply a case of 'criticising' someone else's work, but requires a professional attitude.

All peer review was carried out openly so students knew the identity of their reviewers and authors. This was partly due to the time-consuming nature of maintaining an anonymous environment (Li and Steckelberg 2006) but also in preparation for open peer review in the workplace. It has been suggested that a reasonable number of marks (10–15% of the total) be allocated to student performance in the peer review process, as it may boost student engagement and commitment to the task (Ballantyne, Hughes, and Mylonas 2002). In this study, 10% of the marks for the portfolio were assigned to peer review performance.

In **Phase 4** (immediately after Phase 3, in class) students were asked to complete a questionnaire (see the supplementary information), which consisted of questions dealing with students' prior experience with any type of peer review, five structured items rated on a 5-point Likert scale, and open-ended questions designed to gather their perceptions of the process. In previous studies, the method of evaluation has been limited to questionnaires, therefore themes from the questionnaire were substantiated by more in-depth information from a semi-structured interview with three students (Gillham 2005).

The semi-structured interview lasted 22 mins, took place in week 16 and was facilitated by one of the authors.

3. Results

3.1 Peer review comments

One hundred and eighty handwritten peer comments were collated from draft expert reports and classified into categories under the *affective* and *cognitive* dimensions from Cheng and Hou (2015). The affective dimension included students' praise or emotional responses toward peers' work. Cognitive comments consisted of corrections, the expression of personal opinion (without giving more information) and the provision of guidance (Tsai and Liang 2009). The overall distribution of the comments is given in Table 1. In five cases, a comment was consistent with two categories, *e.g.*, contained elements of both A1 and C2.

[Table 1 near here]

Table 1 shows that C4 (Suggestion) was the most frequent feedback provided by the students to their peers. This was followed by C2 (Question). This differs from a previous study, which investigated the development of science activities by education students, where supportive comments were the most frequently observed, followed by personal opinion (Tsai and Liang 2009).

3.2 Questionnaires

Six of the participants (67%) answered Yes to Q1 (Do you have experience of peer review prior to this course?). Their experience with peer review ranged from reading other people's assignments for spelling and grammar but not content (at undergraduate and secondary school level) to previous experience in the workplace (n = 3) in a pharmacy or

forensic casework laboratory (mature students). This question was included, as in previous studies it was unclear from the details provided whether or not the students had prior experience of peer review (Morris 2001). For those participants who had no prior experience of peer review this series of assignments introduced them to an important professional concept: their learning ceased to be a private and individual matter, and moved to a more public domain (Liu & Carless, 2006). This is important because in forensic science laboratories and other workplaces, experts' work and learning is measured constantly, open to the scrutiny of many others, and potentially available to the media and hence the general public in high-profile cases. The public nature of the forensic peer review described above, although possibly intimidating for students can also improve performance. Student comments from previous studies have indicated that public display causes them to strive to submit higher quality work (Walkington et al. 2011).

For Q2 (Which assignment did you find most useful?), the results were mixed with 22% (n = 2) of the participants finding working in a group to produce the checklists, 33% (n = 3) using the checklist individually on a casefile, and 44% (n = 4) having another student check their peer review the most useful.

The responses to the statements given in Q3 are shown as a bar chart in Figure 2.

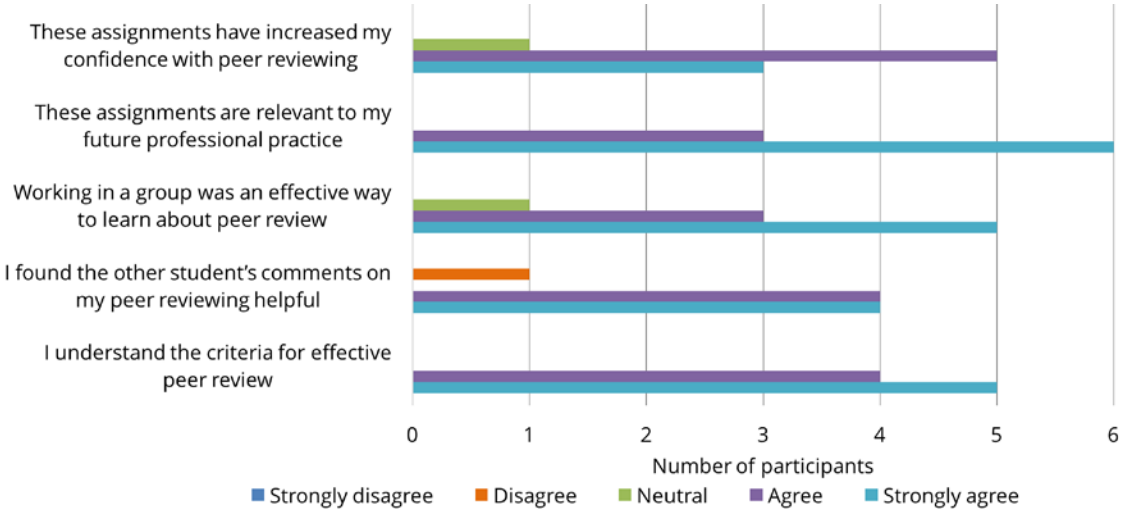

Figure 2. A bar chart showing the results of Q3 of the questionnaire (n = 9).

It can be seen that the majority of participants agreed or strongly agreed with all five statements. This is consistent with a previous study where most students who completed similar questionnaires perceived that peer review had clear benefits in facilitating their learning (Ballantyne, Hughes, and Mylonas 2002). All participants agreed or strongly agreed with the usefulness of the assignments for their future professional practice. This is likely due to the use of real cases, providing a clear link to professional activities. The responses to the question on the use of group work showed a similar pattern to a previous study on group work for students enrolled on this programme, where students expressed mixed preferences for group *vs.* individual assignments (Hamnett, McKie, and Morrison 2018). Participants gave the least positive response to the question on the helpfulness of the peer reviewer's comments. A detailed analysis of the comments on the expert reports is given in section 3.1. All participants agreed or strongly agreed that they understood the assessment criteria for effective peer review. The criteria were produced in collaboration with the students in academic year 2015–16 (Pearce, Mulder, and Baik 2009) and were designed specifically for this assessment (Falchikov 1995). The use of explicit assessment criteria has the benefit of

making all students aware of what the lecturer expects to see in an assignment (Nordberg 2008). In addition, engaging learners in thinking about achieving outcomes to certain agreed standards is a learning process in itself (Liu and Carless 2006). It has also been shown that familiarity with and ownership of criteria tend to enhance peer review validity (Falchikov and Goldfinch 2000).

Very few comments were given in the free text area for Q4 (comments in relation to the group exercise to write the checklists), however one participant commented:

> Found it very helpful as you know what is expected & what is needed. Made very clear.

In the free text area for Q5 (comments in relation to using the checklists), the participants were more forthcoming:

> Gave guidance on how to check the casefile and provided structure
>
> Makes me feel more confident in my review
>
> Helpful for aims of peer review
>
> Will help for future work

The final area, for Q6 (comments in relation to the peer review check by another student), was the most commented on:

> Helped pick up on things I had missed and things I hadn't thought of
>
> Good to see how effective your peer reviewing actually was
>
> Constructive criticism helpful for the final assessment
>
> Comments improve our self-judgement

The participants also appreciated the additional peer reviewing practice in weeks 6, 8 and 10, with one commenting at the bottom of the questionnaire:

> The weekly peer review helped me to think of the types of things to look for. Helped me be more picky on details.

It is important to note that students can easily form the impression that 'being picky' is the key to good peer review; whilst an eye for detail is undoubtedly useful, once errors have been spotted, it is necessary to exercise professional judgement to determine what is sufficiently important to require changing.

3.3 Semi-structured interview

Raw data themes in the form of direct quotations were gathered from the semi-structured interview, and higher order themes identified via content analyses (see Table 2) (Hanrahan and Isaacs 2001).

[Table 2 near here]

One of the themes that emerged from the semi-structured interview was that the participants felt they needed more time to complete the casefile peer review, preferably several days, to avoid surface reviewing. It is important that students take a deep approach to reviewing as focussing on the 'easy pickings' of language errors or typos and giving simple correctional feedback (which only identifies an error and/or supplies the correct answer) challenges both students minimally (Topping 1998). Students should be encouraged to delve into the more demanding areas, such as interpretation of results. A longer time period (*e.g.*, a few days) for the peer reviews could be incorporated as a future development, however in a casework laboratory there may be security implications to taking work off-site, and senior forensic toxicologists (Cosbey, Elliott, and Paterson 2017) would be expected to peer review multiple cases under time pressure in the

workplace.

Although the aim of this intervention was the learning and assessment of peer review, it was evident from the semi-structured interview that students were also improving their own work by peer reviewing. This has been demonstrated previously, in that peer review can help students achieve better learning outcomes (Tsai and Liang 2009). As each student had a different summative casefile, this was also an opportunity to enhance their knowledge and understanding of forensic toxicology through a range of case studies (Heylings and Stefani 1997; Zhou et al. 2017).

3.4 Implications for practice

In forensic science, peer review is an essential part of quality management and error-mitigation systems (Ballantyne, Edmond, and Found 2017; ILAC 2014; Elliott, Stephen, and Paterson 2018); it is both a quality check on findings and interpretation (Dinis-Oliveira and Magalhães 2016), and a training and development activity. In forensic toxicology specifically, peer review of expert reports by another toxicologist may help guard against over-interpretation of results (Flanagan 2018). By learning and practising forensic peer review using this method, students can gain an appreciation for what counts as good quality work in this field (Mulder, Pearce, and Baik 2014), and follow this up with actions to improve their own practice (Liu and Carless 2006). We believe that the conclusions and design of the assessments in this study may also be relevant to preparing students for other professions where peer review is used, such as open source software development, nursing and community pharmacy.

A key factor to the success of peer review seems to be the use of explicit and clearly defined assessment criteria (Orsmond, Merry, and Reiling 1996; Pearce, Mulder, and Baik 2009). A scoring rubric (as used in this study) is particularly valuable because

it presents the assessment criteria in a structured format (Gielen and De Wever 2015). There are ethical considerations around recruiting students onto an already validated programme and then allowing them to re-write the assessment criteria (Dann 2001), however in this case the assessment was new to the module, and the student-created criteria were approved before being used for summative assessment.

3.5 Limitations

Some limitations should be taken into account when considering the extent to which these results can be generalised. This research involved postgraduate taught science students undertaking an MSc in Forensic Toxicology at one specific institution. However, the learning and assessment method described would be broadly applicable to other programmes. Some of the checks in the example checklists provided correspond specifically to a post-mortem forensic toxicology case, but many of the general prompts would apply to other forensic disciplines.

It is not possible to comment on any gender differences in the answers to the questionnaires, due to the small sample size. For the same reason, no attempt was made to pair reviewers and authors by ability, although pairing by ability is not common practice in forensic casework laboratories.

3.6 Future work

In future iterations of this learning and teaching method an opportunity for the student author to reflect on and reply to their peer feedback could be provided (Harland, Wald, and Randhawa 2017; Gielen et al. 2010). This would enable students to practise assessing suggestions (Liu and Carless 2006; Topping et al. 2000), responding constructively to views expressed by others (Katzenbach and Smith 1993), and rejecting suggested changes tactfully (Topping 1998). This further step is an important reflection of professional

practice where peer review can be a messy and ambiguous process with professionals disagreeing on when changes are necessary (Biggs and Tang 2007).

Another consideration for the future is the 'lens' that students use to view each other's work. In response to Q6 in the questionnaire, one student said:

> I would not ask the students to give marks as it is very subjective and personal

In future the need to assign marks could be removed from the assessment criteria. Then, rather than focus on what grade a piece of work might receive (a *student lens*) the emphasis would be on whether the work is fit-for-purpose (a *professional lens*).

The process described above was paper-based, but as more forensic casework laboratories move towards e-reporting, electronic review using track changes could be introduced. A piece of reflective writing on peer review could also be incorporated into the process to demonstrate that it is through ongoing critical self-reflection that practitioners continuously improve their understanding, knowledge and practice (Kardos et al. 2009).

Finally, in the semi-structured interview one participant suggested multi-stage peer review:

> For the portfolio have a first stage review of your expert report then have a second review just before you hand it in – maybe get a different person to review it the second time

This additional check could also be incorporated into the process, and indeed is in place in some forensic casework laboratories.

4. Conclusions

This is the first study, of which we are aware, to describe a method of learning, teaching and assessing forensic peer review and to explore the views of postgraduate taught

science students on peer review. Example checklists for reviewing both casefiles and expert reports, and assessment criteria have been provided. From analysis of the comments students gave to their peers, suggestions were the most frequent type of feedback provided, followed by questions. From a questionnaire given to the students on their experiences with peer review there was strong agreement that the process described here was relevant to their future professional practice and that they understood the criteria for effective peer review. The higher order themes on peer review that emerged from a semi-structured interview included that limited time led to surface reviewing and peers were seen as legitimate sources of knowledge, but the students would value additional input from lecturers in terms of organisation and feedback.

Acknowledgements

We would like to thank all the students for participating in this study and Dr Sarah Russell of Environmental Science & Research Ltd for advice on forensic peer review. Steven Baginski and Katherine Smith from Imperial College London are acknowledged for helpful comments on the manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Ballantyne, K., N., G. Edmond, and B. Found. 2017. "Peer Review in Forensic Science." *Forensic Science International* 277: 66–76.

Ballantyne, R., K. Hughes, and A. Mylonas. 2002. "Developing Procedures for Implementing Peer Assessment in Large Classes Using an Action Research Process." *Assessment & Evaluation in Higher Education* 27 (5): 427–441.

Biggs, J., and C. Tang. 2007. *Teaching for Quality Learning at University*. Maidenhead: McGraw-Hill Education.

Boud, D. 1990. "Assessment and the Promotion of Academic Values." *Studies in Higher Education* 15 (1): 101–111.

Cheng, K.-H., and H.-T. Hou. 2015. "Exploring Students' Behavioural Patterns During Online Peer Assessment from the Affective, Cognitive, and Metacognitive Perspectives: A Progressive Sequential Analysis." *Technology, Pedagogy and Education* 24 (2): 171–188.

Cheng, W., and M. Warren. 1999. "Peer and Teacher Assessment of the Oral and Written Tasks of a Group Project." *Assessment & Evaluation in Higher Education* 24 (3): 301–314.

Cosbey, S., S. Elliott, and S. Paterson. 2017. "The United Kingdom and Ireland Association of Forensic Toxicologists; Establishing Best Practice for Professional Training & Development in Forensic Toxicology." *Science & Justice* 57 (1): 63–71.

Dann, K. 2001. "Commentary on Peer Assessment: A Missing Link between Teaching and Learning? A Review of the Literature." *Nurse Education Today* 21 (7): 513–515.

Dinis-Oliveira, R.J., and T. Magalhães. 2016. "Teaching and Learning Based on Peer Review: A Realistic Approach in Forensic Sciences." *F1000Research* 5: 1048.

Dochy, F., M. Segers, and D. Sluijsmans. 1999. "The Use of Self-, Peer and Co-Assessment in Higher Education: A Review." *Studies in Higher Education* 24 (3): 331–350.

Elliott, S.P., D.W.S. Stephen, and S. Paterson. 2018. "The United Kingdom and Ireland Association of Forensic Toxicologists Forensic Toxicology Laboratory Guidelines (2018)." *Science & Justice* 58 (5): 335–345.

Evison, M.P. 2018. "Forensic Science Policy and the Question of Governmental University Research Quality Assessment." *Forensic Science International* 290: 279–296.

Falchikov, N. 1995. "Peer Feedback Marking: Developing Peer Assessment." *Innovations in Education and Training International* 32 (2): 175–187.

Falchikov, N., and J. Goldfinch. 2000. "Student Peer Assessment in Higher Education: A Meta-Analysis Comparing Peer and Teacher Marks." *Review of Educational Research* 70 (3): 287–322.

Flanagan, R.J. 2018. "Cut Costs at All Costs!" *Forensic Science International* 290: e26–e28.

Gatfield, T. 1999. "Examining Student Satisfaction with Group Projects and Peer Assessment." *Assessment & Evaluation in Higher Education* 24 (4): 365–377.

Gielen, M., and B. De Wever. 2015. "Structuring the Peer Assessment Process: A Multilevel Approach for the Impact on Product Improvement and Peer Feedback Quality." *Journal of Computer Assisted Learning* 31 (5): 435–449.

Gielen, S., E. Peeters, F. Dochy, P. Onghena, and K. Struyven. 2010. "Improving the Effectiveness of Peer Feedback for Learning." *Learning and Instruction* 20 (4): 304–315.

Gillham, B. 2005. *Research Interviewing: The Range of Techniques*. Maidenhead: Open University Press.

Gopee, N. 2001. "The Role of Peer Assessment and Peer Review in Nursing." *British Journal of Nursing* 10 (2): 115–121.

Hamnett, H.J., and A.-S. Korb. 2017. "The Coffee Project Revisited: Teaching Research Skills to Forensic Chemists." *Journal of Chemical Education* 94 (4): 445–450.

Hamnett, H.J., A.E. McKie, and C.M. Morrison. 2018. "Postgraduate Students' Attitudes Towards Group Work: Experiences within a Forensic Chemistry Programme." *Chemistry Education Research and Practice* 19 (4): 1240–1252.

Hanrahan, S.J., and G. Isaacs. 2001. "Assessing Self- and Peer-Assessment: The Students' Views." *Higher Education Research & Development* 20 (1): 53–70.

Harland, T., N. Wald, and H. Randhawa. 2017. "Student Peer Review: Enhancing Formative Feedback with a Rebuttal." *Assessment & Evaluation in Higher Education* 42 (5): 801–811.

Heylings, D.J., and L.A.J. Stefani. 1997. "Peer Assessment Feedback Marking in a Large Medical Anatomy Class." *Medical Education* 31 (4): 281–286.

ILAC. 2014. *ILAC-G19: 08/2014. Modules in a Forensic Science Process*. Silverwater: International Laboratory Accreditation Cooperation.

Jeanguenat, A.M., B. Budowle, and I.E. Dror. 2017. "Strengthening Forensic DNA Decision Making through a Better Understanding of the Influence of Cognitive Bias." *Science & Justice* 57 (6): 415–420.

Kardos, R.L., J.M. Cook, R.J. Butson, and T.B. Kardos. 2009. "The Development of an Eportfolio for Life-Long Reflective Learning and Auditable Professional Certification." *European Journal of Dental Education* 13 (3): 135–141.

Katzenbach, J., R., and D. Smith, K. 1993. "The Discipline of Teams." *Harvard Business Review* 71 (2): 111–120.

Knutson, C.C., M.N. Jackson, M. Beekman, M.E. Carnes, D.W. Johnson, D.C. Johnson, and D.A. Keszler. 2014. "Mentoring Graduate Students in Research and

Teaching by Utilizing Research as a Template." *Journal of Chemical Education* 91 (2): 200–205.

Li, L., and A.L. Steckelberg. 2006. "Perceptions of Web-Mediated Peer Assessment." *Academic Exchange Quarterly* 10 (2): 1–15.

Liu, N.-F., and D. Carless. 2006. "Peer Feedback: The Learning Element of Peer Assessment." *Teaching in Higher Education* 11 (3): 279–290.

Mennell, J. 2006. "The Future of Forensic and Crime Scene Science: Part II. A UK Perspective on Forensic Science Education." *Forensic Science International* 157 (Supplement): S13–S20.

Milchak, J.L., R.L. Shanahan, and J.A. Kerzee. 2012. "Implementation of a Peer Review Process to Improve Documentation Consistency of Care Process Indicators in the EMR in a Primary Care Setting." *Journal of Managed Care Pharmacy* 18 (1): 46–53.

Morris, J. 2001. "Peer Assessment: A Missing Link between Teaching and Learning? A Review of the Literature." *Nurse Education Today* 21 (7): 507–513.

Mulder, R.A., J.M. Pearce, and C. Baik. 2014. "Peer Review in Higher Education: Student Perceptions before and after Participation." *Active Learning in Higher Education* 15 (2): 157–171.

Nordberg, D. 2008. "Group Projects: More Learning? Less Fair? A Conundrum in Assessing Postgraduate Business Education." *Assessment & Evaluation in Higher Education* 33 (5): 481–492.

Orsmond, P., S. Merry, and K. Reiling. 1996. "The Importance of Marking Criteria in the Use of Peer Assessment." *Assessment & Evaluation in Higher Education* 21 (3): 239–250.

Pearce, J., R. Mulder, and C. Baik. 2009. *Involving Students in Peer Review: Case Studies and Practical Strategies for University Teaching*. Melbourne: Centre for the Study of Higher Education.

Rigby, P., B. Cleary, F. Painchaud, M. Storey, and D. German. 2012. "Contemporary Peer Review in Action: Lessons from Open Source Development." *IEEE Software* 29 (6): 56–61.

Schroter, S., N. Black, S. Evans, F. Godlee, L. Osorio, and R. Smith. 2008. "What Errors Do Peer Reviewers Detect, and Does Training Improve Their Ability to Detect Them?" *Journal of the Royal Society of Medicine* 101 (10): 507–514.

Topping, K.J. 1998. "Peer Assessment between Students in Colleges and Universities." *Review of Educational Research* 68 (3): 249–276.

Topping, K.J., E.F. Smith, I. Swanson, and A. Elliot. 2000. "Formative Peer Assessment of Academic Writing between Postgraduate Students." *Assessment & Evaluation in Higher Education* 25 (2): 149–169.

Tsai, C.-C., and J.-C. Liang. 2009. "The Development of Science Activities Via on-Line Peer Assessment: The Role of Scientific Epistemological Views." *Instructional Science* 37 (3): 293–310.

UCAS. 2018. "The Universities and Colleges Admissions Service." Accessed 01 August. https://www.ucas.com/.

Walkington, H., A.L. Griffin, L. Keys-Mathews, S.K. Metoyer, W.E. Miller, R. Baker, and D. France. 2011. "Embedding Research-Based Learning Early in the Undergraduate Geography Curriculum." *Journal of Geography in Higher Education* 35 (3): 315–330.

Witt, P.H. 2010. "Forensic Report Checklist." *Open Access Journal of Forensic Psychology* 2: 233–240.

Zhou, N., Y. Wu, T. Su, L. Zhang, K. Yin, D. Zheng, J. Zheng, L. Huang, Q. Wu, and J. Cheng. 2017. "Course Constructions: A Case-Base of Forensic Toxicology." *Journal of Forensic and Legal Medicine* 50: 36–38.

Dimension and category	Definition	Example	Number (%)
Affective			
A1 (Supporting)	Containing clear support and praise (*i.e.*, showing praise and supporting the reviewee's ideas)	*Good.*	9 (5)
A2 (Opposing)	Simply expressing one's negative feelings about the work	—	—
Cognitive			
C1 (Personal Opinion)	Offering general advice or personal perspectives without providing solid evidence or concrete directions	*Too technical.*	15 (8)
C2 (Question)	Questioning direction or introducing concepts, content, or frameworks	*Benzos may contribute to death from methadone toxicity by increasing upper airways obstruction.*	46 (26)
C3 (Analysis and Evaluation)	Assessing, appraising, or verifying the reviewee's knowledge and skills	*Interpretation is very thorough and looks very professional.*	10 (6)
C4 (Suggestion)	Providing concrete directions, corrections, or strategies for the improvement of work	*[Add a] small amount of information on alcohol, even just a sentence.*	100 (56)

Table 1. Distribution of the quantitative content analysis of codes within the cognitive dimensions of Cheng and Hou (2015).

Selected raw data themes	Higher order themes
There was not enough time for the [other] student to read your report with focus	Limited time led to surface learning
If we have [more] time we will give more improvements, not just picking up mistakes	
People pick up different things – things that you've missed over other people pick up	Peers are legitimate sources of knowledge Productive self-critique
It increased my confidence. You compare your report with another student's report and you can check how to improve your own report especially for us non-native English speakers	Students locate themselves in relation to the performance of their peers
In my case they found a big mistake – when I had tried to interpret my result I misread it	Improved own assignment prior to submission Diagnosed misconceived and missing knowledge
When I reviewed my friend's report I found some mistakes that I had made [in my own report] and I had to go back and change it	
You can make the changes before you hand it in	
The checklist gave you some guidance so you won't miss anything	Checklist reinforced the criteria for effective peer review
The checklist meant you spent more time going through each point as you knew what to look for	
When you peer reviewed someone's report and they handed it in then you could see the feedback that they got [from the lecturer] and if it was good feedback you knew you'd done your job	Lecturer input still required
Schedule [lecturer] feedback for both the author and the peer reviewer	
Have a schedule for organising which student does the weekly peer reviews	

Table 2. Themes discussed in the semi-structured interview. Higher order themes taken from Hanrahan and Isaacs (2001); Topping (1998); Pearce, Mulder, and Baik (2009); Biggs and Tang (2007).

1. Checklist template

Error	Corresponding check
Page numbering in casefile jumps from p. 10 to p. 12	Page numbering consecutive

2. Examples of checks

Expert report	Casefile
Case and customer details transcribed correctly from original request form	Laboratory case reference number on every page of the casefile
Scientific data transcription from casefile accurate	Table of contents completed
Interpretation reasonable given the analysis results and circumstances of the case, the following considered (if applicable): Tolerance, post-mortem redistribution, post-mortem interval/time delay, post-mortem production/loss, hospital/emergency medical treatment received, drug–drug interactions All results interpreted where appropriate/possible	Any deviations from standard operating procedures noted Use of an expired drug standard, concentrations above or below the calibration curve reported, different sample volume used Most recent versions of forms and procedures used Analysts conducting the tests authorised at the appropriate level or supervised
All tests completed in the casefile are mentioned in the expert report	Blank pages stamped 'BLANK' or scored through, initialled and dated
References and citations in the correct style	Cross-outs initialled and dated No 'scrubbing' out or correction fluid used, original error still visible
Citations and references match	All analyses checked, initialled and dated by the analyst and checker
Units correct	Data from all tests on the case present in the casefile Any data missing from casefile or tests not yet completed
Spelling, typos, punctuation and grammar OK	All forms completed, including 'N/A' in blank boxes
Any further tests or repeat analyses required? Poor precision between replicates, results above calibration curve	Page numbering consecutive and matches table of contents
Analyses completed align with customer request	Manual calculations checked
Scientist writing the report authorised at the appropriate level	Any quality incidents or non-conformities associated with the case recorded
Sample types transcribed correctly	Communication with the customer recorded, initialled and dated Emails printed including laboratory case reference number
Case reported within the required turnaround time	Analyses consistent with the laboratory information management system
Sample type/condition considered Ante-mortem vs. post-mortem blood, plasms vs. whole blood Preserved vs. unpreserved blood, hospital tube additives e.g. serum gel tubes Site of sampling e.g. femoral vs. cardiac blood Clotted or decomposed samples unsuitable for accurate quantification Limited sample volume	Chain of custody intact Samples sent by the customer all received Samples labelled correctly Disposal/retention instructions recorded correctly
Any likely questions from customer anticipated and answered	Any decisions on the case recorded in the casefile, initialled and dated
Language appropriate to audience Minimal jargon, abbreviations/acronyms/units defined, emotive terms not used	Previous copies of reports marked 'DRAFT'

3. Assessment criteria

Check	Comments	Mark (max)
Casefile Contents page completed Case number on every page Analyses checked, initialled and dated Blank pages stamped or scored through Page numbering correct All data present Cross-outs Initialled as peer-reviewed		(4)
Expert Report Interpretation Transcription Spelling, punctuation, grammar All analyses recorded All results interpreted Signed as peer-reviewed References correct		(3.5)
Style of peer review Professional tone Both positive and negative points made Thorough Comments legible Up-to-date knowledge		(2.5)

4. Questionnaire

Your answers are for research purposes only and will remain anonymous. Please TICK (✓) the boxes below.

Q1 Do you have experience of peer review prior to this course?

Yes ☐ *please give details below*

_____

_____

No ☐

Q2 Which assignment did you find most useful? Please tick (✓) ONE box only.

Working in a group to produce a checklist ☐

Using the checklist individually on a casefile ☐

Having another student check your peer reviewing ☐

Q3 Please rate your agreement with the following by TICKING (✓) the appropriate box.

Statement	**1** ***Strongly disagree***	**2**	**3** ***Neutral***	**4**	**5** ***Strongly agree***
These assignments have increased my confidence with peer reviewing					
These assignments are relevant to my future professional practice					
Working in a group was an effective way to learn about peer review					
I found the other student's comments on my peer reviewing helpful					
I understand the criteria for effective peer review					

Q4 Any comments in relation to the group exercise

_____

_____

Q5 Any comments in relation to using your checklist on a casefile individually

_____

_____

Q6 Any comments in relation to another student checking your peer review

_____

_____