Peer Assessment

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Abstract
Peer assessment is the process whereby students provide formative or summative feedback to fellow students about their work. There have been many decades of research into the potential benefits of peer assessment and numerous studies have shown that peer assessment offers real educational, and sometimes social benefits for students. In addition, self assessment is often included alongside, but the benefits are sometimes disputed. This article will provide a brief summary of the research establishing the educational benefits of peer assessment and self assessment.

There has also been a lot of work in recent years exploring the use of technology to support peer assessment. This work will be reviewed and recent examples of peer assessment in the physical sciences will be highlighted.

What is peer assessment?
Feedback from different sources, such as mentors, tutors or lecturers can greatly enhance the student learning process. Fellow students, peers, are another source of feedback and peer assessment, the formative or summative feedback provided by peers, can offer a number of educational benefits. Peer assessment involves students giving feedback to each other to grade their work or performance using relevant criteria[1]. Boud, Cohen and Sampson[2] discuss the merits of peer assessment and suggest that it can be part of an important strategy in the repertoire of approaches to teaching and learning.

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Peer assessment can be used in a more supportive way, rather than simply enabling students to grade each other. Roberts[3] refers to peer assessment as a process which allows learners to reflect critically upon the learning of their peers. Peer assessment is also a reciprocal process in that the student providing feedback also benefits from increasing their own understanding. This is achieved by students having to critique and review someone else's work and thereby reflect on their own understanding or performance.

A learning activity involving peer assessment may take a number of forms. At its simplest, peer assessment may involve peers providing formative feedback to one another. With large numbers of students, where peers are working in groups, this feedback may be formative (e.g. informal feedback) or summative, whereby each group member provides marks or grades for their fellow peers, and may be one-to-one or many-to-many.

Benefits of peer assessment
Although peer assessment can be used as a particular approach to teaching in its own right, it is often coupled with peer learning, where student peers work together to support each other's learning and then peer assess each other's progress. Johnson, Johnson and Smith[4] discuss the rationale for engaging in peer work and define the different types of engagement. They identify the 'old' paradigm in which education is competitive between students who are attempting to out perform each other. They also discuss 'cooperative' learning where students cooperate to achieve a goal – though some argue that cooperation is individualistic and students do not really learn together. Collaborative learning is more commonly used in this context, but Bruffee[5] discusses the merits of both approaches in greater detail. Cooperative learning may be considered strategically different from collaborative learning, but most people today tend to mean the social interaction of peers to promote deeper learning (for example, Gillies and Ashman[6]).

Chin[7] lists some of the main benefits of peer collaboration, including the promotion of learning through social interaction, the development of self confidence and the provision of a network of support. Kagan[8] also discusses the wide range of benefits of peer collaboration, such as supporting mixed ability students, meeting the needs of the curriculum and the positive outcomes, both personally for students and collectively. Bruffee[5] quotes Theodore Newcomb saying that the single most powerful force in undergraduate education is peer-group influence.

In addition to the benefits for students linked directly to the learning and understanding of their subject, there are a number of other benefits of peer assessment. Chin et al[9] highlight some of these including developing self reflection, developing transferable skills, such as better time management, and critical thinking skills, and the potential for saving time on task. Orsmond[10] discusses some of the benefits of peer assessment in further detail.

Issues with engaging with peer assessment

Perhaps one of the first issues with respect to peer assessment is 'does it work?' There have been a number of studies exploring the validity and reliability of peer assessment, such as by Falchikov and Goldfinch[11] who have shown that well designed peer assessment is a reliable and valid method of assessment. Topping[12] also reviews a wide range of literature and concludes similarly that peer assessment is a valid and reliable approach to teaching.

Another issue is whether peer assessment can be successfully implemented in the curriculum, given current constraints of time and classroom space. There are a wide range of methods available, some of which are highlighted by Barkley, Cross and Major[13], to enable peer collaboration and assessment to take place. Another issue is the potential for peer assessment to be too time consuming and difficult to manage for large numbers of peer groups. There are a number of potential solutions to this and technology can offer benefits. This is discussed later.

In relation to peer assessment and collaboration in groups, there is the risk that 'freeloaders' can succeed without doing any work. That is, a freeloader who does not carry out their share of the work, or engage with the rest of the group, can be carried along and be unfairly supported by the rest of the group. This issue can be addressed in a number of ways; Tu and Lu[14] discuss their method for dealing with freeloaders.

Another issue of concern is the fact that the administrative process can be difficult and time consuming to manage. This is a key issue, since it can almost negate the benefits offered if it is too time consuming. There are numerous ways to engage students successfully in peer assessment, including the use of technology to deal with administration issues. Students may resent the potential for their grades or results to be dependent on other students. These fears can be resolved in ways which are discussed later.

Self assessment

Falchikov[15] discusses some of the benefits of peer and self assessment such as the learning benefits, critical ability, confidence and independence in individuals (self confidence). This study compares some similarities and differences between self and peer assessment. Peer assessment is the process of assessing one's peers whereas self assessment is a self critique. There may be discrepancies if both are used in conjunction to award marks. One issue raised is whether self assessment is as valid as peer assessment. Some students are prone to over or under estimate their achievements when engaging in self assessment relative to their assessment of others.

Various studies demonstrate the benefits of self assessment, which can promote the ability of students to assess critically their knowledge and understanding. However, when it comes to assessing their own performance, students can have a different view from their peers. Li[16] discusses a potential problem in which self and peer assessment can skew grades. This is also discussed by Tu and Lu[14] who propose a way of resolving the issue. Dunning Heath and Suls[17] argue that the link between self assessment and actual performance is weak, claiming that peer assessment is a better measure of performance. Lejk and Wyvill[18] suggest that self assessment produces a wider range of scores and should therefore be excluded from grading.

Orsmond[10] reports on earlier research that provides conflicting evidence. Orsmond cites work by Falchikov and Boud[19] suggesting that there is no real tendency to over or underestimate performance. This suggests that including a self assessment mark with peer assessment does not have any real effect on grades. One thing these and other studies show, however, is that, as long as the assessment criteria are well designed, there tends to be a closer correspondence between student grading than between tutor grading. Therefore, despite potential differences in the way self assessment may support or detract from the overall peer assessment process, as long as it is properly designed and executed, students will benefit from it.

The social implications for peer and self assessment must also be taken into account. For example, students have to work with peers who they may not normally socialise with and many students find grading other students difficult. Topping and Ehly[20] discuss some of the social demands placed on students when engaging in self and peer assessment. Pope[21] also shows that self and peer assessment increases stress, but that it still leads to increased student performance.

Successfully embedding peer assessment in the curriculum

In order for peer assessment to be available for all students the process needs to be managed appropriately[2], which means including peer assessment explicitly as part of the formal academic programme. Bruffee[5] discusses this in further detail by highlighting how the 'traditional' academic format is designed more for information delivery in a lecture and not for promoting student interaction.

For peer assessment to be successful for both tutor and student, the process needs to be clearly defined early on, with roles and responsibilities laid out for all – including the tutor. Students need to appreciate the intended benefits of engaging with peer assessment and must be supported in developing effective collaboration. This includes support for critical and constructive peer assessment and on how to provide formative feedback. The tutor has to take responsibility for the process to ensure that it works; for example, to ensure that peers are matched appropriately, that enthusiasm for cooperation is fostered, and that social interaction is supported[8].

A wide range of methods for peer assessment are reported in the literature, which can be utilised to suit individual teaching preferences and goals. Barkley, Cross and Major[13] discuss assessment for collaborative writing. Another method cited by Topping and Ehly[20] is peer response groups where students gather together to provide feedback on each other's work. This not only promotes better understanding but helps improve social skills. Another approach is for students to comment on each others' reports. An example in organic chemistry is highlighted by Ivan et al[22]. There are numerous books giving ways of embedding peer assessment in the curriculum; for example Haines[23], Exley and Dennick[24] and Johnson, Johnson and Smith[4].

The important feature of peer assessment, however, is that it should assess the process of peer collaboration and not simply the product.

Peer assessment models

Probably most methods of peer collaboration could be used in a summative manner. However, it is this assignment of marks that makes summative peer assessment awkward, since individual tutors will have different preferences. The assessment models used have different strengths and weaknesses. The important feature of peer assessment, however, is that it should assess the process of peer collaboration and not simply the product. For example, if a group of students collaborate on a joint report, peer assessment should focus on how well the students collaborated and not simply on the report.

Lejk and Wyvill[25] review some of the main models commonly used for peer assessment. This review includes multiplication of a group mark by a weighting factor. This model was first proposed by Goldfinch and Raeside[26] and has since undergone some additional iteration, as reported by Li[16]. Another commonly used method is the distribution of marks: the tutor provides a set of marks for the group and the students divide the marks according to individual efforts and contributions to the work.

From these methods other models have evolved to meet the needs of different approaches to peer and self assessment. Johnston and Miles[27] describe a model in which students work on a group project and then submit individually. Marks are assigned and the authors acknowledge that in principle students can gain more than 100%. Another approach is taken by Margerum et al[28] whereby students are not only graded by their peers, but by their self assessment marks and, additionally, by further review in response to peer feedback on their original work.

The models predominantly focus around peer, self or a mixture of both and some take a holistic view or a structured approach using well defined weighting algorithms. In addition, the development of technological approaches to support peer assessment is also becoming more prominent.

Using technology to support peer assessment

A growing number of tools are now being reported that support peer collaboration and peer assessment. In the 1990s, when electronic communication started to become routine for undergraduate teaching, a range of 'standard' communication and other bespoke tools were utilised for peer collaboration and peer assessment. Rada[29] reports on three different approaches to foster peer collaboration and assessment using different electronic tools. Another system was developed for students to review and comment on each other's work[30]. Tsai et al[31] also report a similar tool aimed at allowing students to review each others' work online. Liu and Tsai[32] report more recently on a web based system for assessing students portfolios.

Yu et al[33] describe a web based system which was designed to meet various pedagogical underpinnings that support peer assessment. Students were able to pose questions, review and peer assess to support each other. Keppell et al[34] discuss the use of 'technology enhanced learning environments' to support peer assessment.

Peer learning and assessment facilitated through the use of Blackboard, a commercial Virtual Learning Environment, is reported by Chin[35]. Students work in groups on a project and use the VLE to communicate and share work with each other. A standard peer assessment form was used, where students grade the contribution of each group member to the project. Students submitted their marks via Blackboard. The author reports that students found the work enjoyable and beneficial and that the peer assessment scheme used was considered fair.

The Universities of Loughborough and Hull have a collaborative JISC (Joint Information Systems Committee) funded project to develop a peer assessment tool called WebPA (webpaproject.lboro.ac.uk). This web based tool currently provides support for peer assessment of large cohorts of students by automating the marking scheme. This marking scheme is similar to that developed by Goldfinch and Raeside[26] and further developed by Li[16]. Additional functionality being developed includes written peer feedback to make the tool more robust and one which can be used by any number of disciplines. WebPA is being developed as an open source tool which will be freely available.

Peer assessment in the sciences

Glaser and Poole[36] developed a web site focusing on organic chemistry which the students used to support their studies. Students were put into groups to undertake activities for which they had to produce reports. These reports were submitted and published on the course website. Students then had to review the reports of at least five other groups and submit feedback and marks to the tutor based on pre-defined assessment criteria. Student use of the supporting technology was mixed, but the authors found the overall experience was beneficial, especially for dealing with large cohorts of students.

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Hass[37] has promoted student directed learning with peer assessment in the organic chemistry laboratory. Students were placed into groups to undertake ten experiments during the semester. For each experiment different students had to act as coordinators to lead the group. At the end, peer assessment was used to assess the contributions of each group member. Students undertook experiments in a traditional fashion, in parallel . The author found that there were no statistical differences between peer collaboration and assessment and traditional laboratories, but argues that the results are more qualitative. For example, with the collaborative approach, students seem more prepared for laboratory work.

Stevens[38] discusses a simple peer assessment process to help astrophysics students engage with a difficult topic of finding extrasolar planets. Students worked together in groups for the duration of the project and gave assessed seminars once the work was completed. Students then complete peer assessment forms to assess their group members on their contributions. The author reports that the students found the support of peers in working together towards a common goal beneficial to their understanding of this difficult topic.

Peer review of work is the basis of scientific publications. Venables et al[39] therefore felt this approach to peer assessment, where students would review each others' essays would be beneficial for students as a way of introducing them to the process of scientific writing. Student essays were blind marked; some students asked for their feedback also to be anonymous as they felt uncomfortable having to point out errors in essays. The authors found that the peer assessment process was intellectually stimulating and useful to the better understanding of the course material.

The production of student posters is a fairly common tool for presenting student work. Wimpfheimer[40] reports how student posters are often assessed by tutors, but reports on a process whereby the posters are peer assessed. Students present their posters and are given a standard peer assessment form to mark each other's work, including their own, since the author feels self assessment is important and increases the students' sense of ownership. The tutors use the same assessment form and their marks account for half the assessment, the other 50% coming from the peer assessment. The author argues that the quality of posters is high and helps students to understand better how to display information concisely.

Peer assessment has been addressed in the teaching of a calculus based class to engage students in the process of evaluating scientific information[41]. Students peer assess each other's weekly homework problems. To aid this process, students are provided with evaluation rubrics that have descriptors for each criterion. Criteria cover aspects such as physics content, relevant representations and problem-solving strategy. The question of whether peer assessment in this approach aids the learning process is discussed.

Glaser and Carson[42] discuss their intent to help students connect the content of their chemistry course to that of the real world, in a process which includes peer review. The authors developed a project 'The Chemistry Is in the News' to allow students to draw explicit connections between course content and real world issues. The project involves the study, creation and peer review of news portfolios by collaborative student groups. The news portfolios created by students are peer reviewed. The authors discuss some of the barriers to be overcome to make this project successful.

One difficulty of evaluating the effectiveness of collaborative work and peer assessment is whether they have any effect on final grades. An additional problem is the correlation of any potential gains in performance to any changes in activity such as peer collaboration and assessment. Wamser[43] suggests that peer collaboration shows a discernable increase in student grades. Students on a chemistry course can opt to take weekly peer led team learning (PLTL) workshops; the results seem to suggest that final grades are higher for participating students. The benefits of PLTL and the longer term impact on workshop peer leaders are further reported by Gafney and Varma-Nelson[44]. They find that there are significant and continuing benefits to learning.

The issue of peer and self assessment is addressed by Bedford and Legg[45] for chemistry and natural science students. Students were split into four independent teaching groups (each consisting of about 35 students). Each workshop focused on different approaches, including peer and self assessment and a control group. The authors found that the students favoured self and peer comments over comments provided by tutors.

Tribe and Kostka[46] report how student peer groups developed new experiments for other students in their class, which were based around student interests but linked to required curriculum teaching. This approach came about through feedback from students that they found existing laboratory manuals difficult to understand. Peer review and feedback was provided by students undertaking the experiments, and knowing that they were 'teaching' their peers gave the groups added motivation.

Wenzel[47] provides some useful references relating to the use of self and peer assessment. The author also describes some tools to guide student peer and self assessment of group activities for laboratory work. One approach to peer evaluation is to provide open ended questions as guidance for students to respond to. It also suggests that feedback from someone in an 'instructional capacity' (laboratory demonstrator or tutor perhaps) can help students interpret the peer and self feedback. The author reports that they have used several of the tools and that students find peer and self assessment of laboratory work useful.

The literature over the years shows that there are clear educational benefits from the adoption of peer learning and assessment schemes. With increased student numbers and greater pressures on curriculum time, developments in peer assessment have kept pace to remain effective in the modern educational setting. Adoption in the physical sciences is no exception, with peer assessment schemes being used in a wide range of contexts. These include alternatives to the traditional tutor marked methods for laboratory work, scientific group projects and student poster presentations.

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