How to measure the quality of the OSCE: A review of metrics

Godfrey Pell
Richard Fuller
Matthew Homer
Trudie Roberts
Welcome to AMEE Guides Series 2

The AMEE Guides cover important topics in medical and healthcare professions education and provide information, practical advice and support. We hope that they will also stimulate your thinking and reflection on the topic. The Guides have been logically structured for ease of reading and contain useful take-home messages. Text boxes highlight key points and examples in practice. Each page in the guide provides a column for your own personal annotations, stimulated either by the text itself or the quotations. Sources of further information on the topic are provided in the reference list and bibliography. Guides are classified according to subject:

- Teaching and Learning
- Curriculum Planning
- Research in Medical Education
- Assessment
- Education Management
- Theories of Medical Education

The Guides are designed for use by individual teachers to inform their practice and can be used to support staff development programmes.

'Living Guides': An important feature of this new Guide series is the concept of supplements, which will provide a continuing source of information on the topic. Published supplements will be available for download.

If you would like to contribute a supplement based on your own experience, please contact the Guides Series Editor, Professor Trevor Gibbs (tig.gibbs@gmail.com).

Supplements may comprise either a ‘Viewpoint’, when you communicate your views and comments on the Guide or the topic more generally, or a ‘Practical Application’, where you report on implementation of some aspect of the subject of the Guide in your own situation. Submissions for consideration for inclusion as a Guide supplement should be maximum 1,000 words.

Other Guides in the new series: A list of topics in this exciting new series are listed below and continued on the back inside cover.

30 Peer Assisted Learning: a planning and implementation framework
Michael Ross, Helen Cameron (2007)
ISBN: 978-1-903934-38-8
Primarily designed to assist curriculum developers, course organisers and educational researchers develop and implement their own PAL initiatives.

31 Workplace-based Assessment as an Educational Tool
John Norcini, Vanessa Burch (2008)
Several methods for assessing work-based activities are described, with preliminary evidence of their application, practicability, reliability and validity.

32 e-Learning in Medical Education
Rachel Elaway, Ken Masters (2008)
ISBN: 978-1-903934-41-8
An increasingly important topic in medical education – a ‘must read’ introduction for the novice and a useful resource and update for the more experienced practitioner.

33 Faculty Development: Yesterday, Today and Tomorrow
Michelle McLean, Francois Cilliers, Jacqueline M van Wyk (2010)
Useful frameworks for designing, implementing and evaluating faculty development programmes.

34 Teaching in the clinical environment
Subha Ramani, Sam Leinster (2008)
An examination of the many challenges for teachers in the clinical environment, application of relevant educational theories to the clinical context and practical teaching tips for clinical teachers.

35 Continuing Medical Education
Nancy Davis, David Davis, Ralph Bloch (2010)
ISBN: 978-1-903934-44-9
Designed to provide a foundation for developing effective continuing medical education (CME) for practicing physicians.

36 Problem-Based Learning: where are we now?
David Taylor, Barbara Mlinin (2010)
ISBN: 978-1-903934-45-6
A look at the various interpretations and practices that claim the label PBL, and a critique of these against the original concept and practice.

37 Setting and maintaining standards in multiple choice examinations
Raja C Bandaranayake (2010)
ISBN: 978-1-903934-51-7
An examination of the more commonly used methods of standard setting together with their advantages and disadvantages and illustrations of the procedures used in each, with the help of an example.

38 Learning in Interprofessional Teams
Marilyn Hammick, Lorna Olckers, Charles Campion-Smith (2010)
ISBN: 978-1-903934-52-4
Clarification of what is meant by inter-professional learning and an exploration of the concept of teams and team working.

39 Online eAssessment
Reg Dennick, Simon Wilkinson, Nigel Purcell (2010)
ISBN: 978-1-903934-53-1
An outline of the advantages of online eAssessment and an examination of the intellectual, technical, learning and cost issues that arise from its use.

40 Creating effective poster presentations
George Hess, Kathryn Tosney, Leon Liegel (2009)
Practical tips on preparing a poster – an important, but often badly executed communication tool.

41 The Place of Anatomy in Medical Education
ISBN: 978-1-903934-54-8
The teaching of anatomy in a traditional and in a problem-based curriculum from a practical and a theoretical perspective.
Institution/Corresponding address:
Godfrey Pell, Principal Statistician, Medical Education Unit, Leeds Institute of Medical Education,
Worsley Building, University of Leeds, Leeds LS2 9JT, UK
Tel: +44 (0)113 23434378
Fax: +44 (0)113 23432597
Email: G.Pell@leeds.ac.uk

The authors:
Godfrey Pell is a Senior Statistician who has a strong background in management. Before joining the University of Leeds he was with the Centre for Higher Education Practice at the Open University. Current research includes standard setting for practical assessment in higher education, and the value of short term interventionist programmes in literacy.

Richard Fuller is a Consultant Physician, and Director of the Leeds MB ChB undergraduate degree programme within the Institute of Medical Education. His research interests include clinical assessment, in particular monitoring and improving the quality of the OSCE.

Matthew Homer is a Research Fellow at the University of Leeds, working in both the Schools of Medicine and Education. He works on a range of research projects and provides general statistical support to colleagues. His research interests include the statistical side of assessment, particularly related to OSCEs.

Trudie Roberts is a Consultant Physician, a Professor of Medical Education and is the Director of the Leeds Institute of Medical Education. Her research interests include clinical assessment.

This AMEE Guide was first published in Medical Teacher:
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>2</td>
</tr>
<tr>
<td><strong>Understanding quality in OSCE assessments – General Principles</strong></td>
<td>3</td>
</tr>
<tr>
<td>Which method of standard setting?</td>
<td>4</td>
</tr>
<tr>
<td>How to generate station level quality metrics</td>
<td>5</td>
</tr>
<tr>
<td><strong>Metric 1 – Cronbach’s Alpha</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Metric 2 – Coefficient of Determination R^2</strong></td>
<td>7</td>
</tr>
<tr>
<td><strong>Metric 3 – Inter-grade discrimination</strong></td>
<td>9</td>
</tr>
<tr>
<td><strong>Metric 4 – Number of failures</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>Metric 5 – Between-group variations (including assessor effects)</strong></td>
<td>11</td>
</tr>
<tr>
<td><strong>Metric 6 – Between-group variations (other effects)</strong></td>
<td>12</td>
</tr>
<tr>
<td><strong>Metric 7 – Standardised Patients ratings</strong></td>
<td>13</td>
</tr>
<tr>
<td><strong>The 360 degree picture of OSCE quality</strong></td>
<td>13</td>
</tr>
<tr>
<td>Quality control through observation – detecting problems</td>
<td>15</td>
</tr>
<tr>
<td>Post hoc remediation</td>
<td>15</td>
</tr>
<tr>
<td>Conclusions</td>
<td>16</td>
</tr>
<tr>
<td>References</td>
<td>18</td>
</tr>
<tr>
<td>Suggested Further Reading</td>
<td>18</td>
</tr>
</tbody>
</table>
Abstract

With an increasing use of criterion based assessment techniques in both undergraduate and postgraduate healthcare programmes, there is a consequent need to ensure the quality and rigour of these assessments. The obvious question for those responsible for delivering assessment is how is this ‘quality’ measured, and what mechanisms might there be that allow improvements in assessment quality over time to be demonstrated? Whilst a small base of literature exists, few papers give more than one or two metrics as measures of quality in Objective Structured Clinical Examinations (OSCEs).

In this Guide, aimed at assessment practitioners, the authors aim to review the metrics that are available for measuring quality and indicate how a rounded picture of OSCE assessment quality may be constructed by using a variety of such measures, and also to consider which characteristics of the OSCE are appropriately judged by which measure(s). The authors will discuss the quality issues both at the individual station level and across the complete clinical assessment as a whole, using a series of ‘worked examples’ drawn from OSCE data sets from the authors’ institution.

TAKE HOME MESSAGES

- It is important always to evaluate the quality of a high stakes assessment, such as an OSCE, through the use of a range of appropriate metrics.

- When judging the quality of an OSCE, it is very important to employ more than one metric to gain an all round view of the assessment quality.

- Assessment practitioners need to develop a ‘toolkit’ for identifying and avoiding common pitfalls.

- The key to widespread quality improvement is to focus on station level performance and improvements, and apply these within the wider context of the entire OSCE assessment process.

- The routine use of metrics within OSCE quality improvement allows a clear method of measuring the effects of change.
Introduction

With increasing scrutiny of the techniques used to support high level decision making in academic disciplines, Criterion Based Assessment (CBA) delivers a reliable and structured methodological approach. As a competency-based methodology, CBA allows the delivery of ‘high stakes’ summative assessment (e.g. qualifying level or degree level examinations), and the demonstration of high levels of both reliability and validity. This assessment methodology is attractive, with a number of key benefits over more ‘traditional’ unstructured forms of assessment (e.g. viva voce) in that it is absolutist, carefully standardised for all candidates, and assessments are clearly designed and closely linked with performance objectives. These objectives can be clearly mapped against curricular outcomes, and where appropriate, standards laid down by regulatory and licensing bodies, that are available to students and teachers alike. As such, CBA methodology has seen a wide application beyond summative assessments, extending into the delivery of a variety of work-based assessment tools across a range of academic disciplines (Norcini, 2007; Postgraduate Medical Education and Training Board, 2009). CBA is also now being used in the UK in the recruitment of junior doctors, using a structured interview similar to that used for selecting admissions to higher education programmes (Eva et al., 2004).

The Objective Structured Clinical Examination (OSCE) uses CBA principles within a complex process that begins with ‘blueprinting’ course content against pre-defined objectives (Newble, 2004). The aim here is to ensure both that the ‘correct’ standard is assessed, and that the content of the OSCE is objectively mapped to curricular outcomes. Performance is scored, at the station level, using an item checklist, detailing individual (sequences of) behaviours, and by a global grade, reliant on a less deterministic overall assessment by examiners (Cohen, 1997; Regehr, 1998).

Central to the delivery of any successful CBA is the assurance of sufficient quality and robust standard setting, supported by a range of metrics that allow thoughtful consideration of the performance of the assessment as a whole, rather than just a narrow focus on candidate outcomes (Roberts, 2006). ‘Assessing the assessment’ is vital, as the delivery of OSCEs is complex and resource intensive, usually involving large numbers of examiners, candidates, simulators and patients, and often taking place across parallel sites. This complexity means CBA may be subject to difficulties with standardisation, and is heavily reliant on assessor behaviour, even given the controlling mechanism of item checklists. No single metric is sufficient in itself to meaningfully judge the quality of the assessment process, just as no single assessment is sufficient in judging, for example, the clinical competence of an undergraduate student. Understanding and utilising metrics effectively are therefore central to CBA, both in measuring quality and in directing resources to appropriate further research and development of the assessment (Wass, 2001).
Understanding quality in OSCE assessments – General Principles

This Guide will examine the metrics available, using final year OSCE results from recent years as exemplars of how exactly these metrics can be employed to measure the quality of the assessment. It is important to recognise that a review of the OSCE metrics is only part of the overall process of reviewing OSCE quality – which needs to embrace all relationships in the wider assessment process (Figure 1).

Where OSCEs are used as part of a national examination structure, stations are designed centrally to a common standard, and typically delivered from a central administration. However, at the local level with the assessment designed within specific medical schools, some variation, for example, in station maxima will result dependent upon the importance and complexity of the station to those setting the exam. These absolute differences between stations will adversely affect the reliability metric making the 0.9 value, often quoted, unobtainable. It is possible to standardise the OSCE data and thereby obtain a higher reliability metric but this would not be a true representation of the assessment as set with respect to the objectives of the assessing body. This Guide is aimed primarily at those involved with clinical assessment at the local level within individual medical schools where, although the assessment may take place across multiple sites, it is a single administration. Those involved with national clinical assessments are likely to have a different perspective.

![Diagram](attachment:figure1.png)
Which method of standard setting?
The method of standard setting will determine the metrics available for use in assessing quality. Standards can be relative (e.g. norm referenced) or absolute, based either on the test item (Ebel & Angoff), or the performance of the candidate (borderline methods). With the requirement for standards to be defensible, evidenced and acceptable (Norcini, 2003), absolute standards are generally used. Whilst all methods of standard setting will generate a number of post-hoc metrics (e.g. station pass rates, fixed effects (time of assessment, comparison across sites) or frequency of mark distribution), it is important to choose a method of standard setting that generates additional quality measures. At present, a large number of institutions favour borderline methods, but only the regression method will give some indication of the relationship between global grade and checklist score and also the level of discrimination between weaker and stronger students. Table 1 highlights the key differences between different borderline methods, and what they contribute to assessment metrics.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Comparison of the borderline methods of standard setting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Borderline Groups (BLG) &amp; Contrasting Groups</strong></td>
<td><strong>Borderline Regression (BLR)</strong></td>
</tr>
<tr>
<td>- Easy to compute</td>
<td>- More expertise required for computation</td>
</tr>
<tr>
<td>- Only 3 global ratings required (fail, borderline, pass)</td>
<td>- Usually 5 global ratings (e.g. fail, borderline, pass, credit, distinction)</td>
</tr>
<tr>
<td>- Uses only borderline data and only a proportion of assessor/candidate interactions</td>
<td>- Uses all assessor/candidate interactions in analysis</td>
</tr>
<tr>
<td>- Needs sufficient candidates in borderline group (20+)</td>
<td>- Requires no borderline grade students</td>
</tr>
<tr>
<td>- Produces limited quality assurance metrics</td>
<td>- Wider variety of quality assurance metrics</td>
</tr>
</tbody>
</table>

The authors favour the borderline regression method because it uses all the assessment interactions between assessors and candidates, and these interactions are ‘real’. It is objectively based on pre-determined criteria, using a large number of assessors and generates a wide range of metrics.

One of the criticisms sometimes levelled at the borderline regression method is its possible sensitivity to outliers. These outliers occur in three main groups:

- Students who perform very badly and obtain a near zero checklist score.
- Students who achieve a creditable checklist score but who fail to impress the assessor overall.
- The assessor who gives the wrong overall grade.

These issues will be discussed in more detail at the appropriate points throughout the Guide.
How to generate station level quality metrics

Table 2 details a ‘standard’ report of metrics from a typical OSCE (20 stations over two days, total testing time ~ three hours, spread over four examination centres). This typically involves ~250 candidates, 500 assessors and 150 simulated patients, and healthy patient volunteers with stable clinical signs (used for physical examination). Candidates are required to meet a passing profile comprising of an overall pass score, minimum number of stations passed (preventing excessive compensation, and adding the fidelity to the requirement for a competent ‘all round’ doctor) and a minimum number of acceptable patient ratings. Assessors complete an item checklist, and then an overall global grade (the global grades in our OSCEs are recorded numerically as 0=Clear fail, 1=Borderline, 2=Clear pass, 3=Very good pass, 4=Excellent pass).

The borderline regression method was used for standard setting (Pell & Roberts, 2006). Typically such an OSCE will generate roughly 60,000 data items (i.e. individual student-level checklist marks), which form a valuable resource for allowing quality measurement and improvement. As a result of utilising such data, we have seen our own OSCEs deliver progressively more innovation, whilst simultaneously maintaining or improving the levels of reliability.

Under any of the borderline methods of standard setting, where a global grade is awarded in addition to the checklist score, accompanying metrics are useful in measuring the quality of the assessments. For other types of standard setting, where such a global grade does not form part of the standard setting procedure e.g. Ebel & Angoff, inter-grade discrimination and coefficient of determination ($R^2$) will not apply (Cusimano, 1996).

<table>
<thead>
<tr>
<th>Station</th>
<th>Cronbach’s alpha if item deleted</th>
<th>$R^2$</th>
<th>Inter-grade discrimination</th>
<th>Number of failures</th>
<th>Between-group variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.745</td>
<td>0.465</td>
<td>4.21</td>
<td>53</td>
<td>31.1</td>
</tr>
<tr>
<td>2</td>
<td>0.742</td>
<td>0.590</td>
<td>5.23</td>
<td>24</td>
<td>30.1</td>
</tr>
<tr>
<td>3</td>
<td>0.738</td>
<td>0.555</td>
<td>5.14</td>
<td>39</td>
<td>33.0</td>
</tr>
<tr>
<td>4</td>
<td>0.742</td>
<td>0.598</td>
<td>4.38</td>
<td>39</td>
<td>26.0</td>
</tr>
<tr>
<td>5</td>
<td>0.732</td>
<td>0.511</td>
<td>4.14</td>
<td>29</td>
<td>20.5</td>
</tr>
<tr>
<td>6</td>
<td>0.750</td>
<td>0.452</td>
<td>4.74</td>
<td>43</td>
<td>40.3</td>
</tr>
<tr>
<td>7</td>
<td>0.739</td>
<td>0.579</td>
<td>4.51</td>
<td>36</td>
<td>19.5</td>
</tr>
<tr>
<td>8</td>
<td>0.749</td>
<td>0.487</td>
<td>3.45</td>
<td>39</td>
<td>33.8</td>
</tr>
<tr>
<td>9</td>
<td>0.744</td>
<td>0.540</td>
<td>4.06</td>
<td>30</td>
<td>36.0</td>
</tr>
<tr>
<td>10</td>
<td>0.747</td>
<td>0.582</td>
<td>3.91</td>
<td>26</td>
<td>29.9</td>
</tr>
<tr>
<td>11</td>
<td>0.744</td>
<td>0.512</td>
<td>4.68</td>
<td>37</td>
<td>37.6</td>
</tr>
<tr>
<td>12</td>
<td>0.744</td>
<td>0.556</td>
<td>2.80</td>
<td>23</td>
<td>32.3</td>
</tr>
<tr>
<td>13</td>
<td>0.746</td>
<td>0.678</td>
<td>3.99</td>
<td>30</td>
<td>22.0</td>
</tr>
<tr>
<td>14</td>
<td>0.746</td>
<td>0.697</td>
<td>5.27</td>
<td>54</td>
<td>27.3</td>
</tr>
<tr>
<td>15</td>
<td>0.739</td>
<td>0.594</td>
<td>3.49</td>
<td>44</td>
<td>25.9</td>
</tr>
<tr>
<td>16</td>
<td>0.737</td>
<td>0.596</td>
<td>3.46</td>
<td>41</td>
<td>34.3</td>
</tr>
<tr>
<td>17</td>
<td>0.753</td>
<td>0.573</td>
<td>3.58</td>
<td>49</td>
<td>46.5</td>
</tr>
<tr>
<td>18</td>
<td>0.745</td>
<td>0.592</td>
<td>2.42</td>
<td>15</td>
<td>25.4</td>
</tr>
<tr>
<td>19</td>
<td>0.749</td>
<td>0.404</td>
<td>3.22</td>
<td>52</td>
<td>39.5</td>
</tr>
<tr>
<td>20</td>
<td>0.754</td>
<td>0.565</td>
<td>4.50</td>
<td>37</td>
<td>34.1</td>
</tr>
</tbody>
</table>

Number of candidates=241
**Metric 1 – Cronbach’s Alpha**

A selection of these overall summary metrics will be used in this Guide to illustrate the use of psychometric data ‘in action’, and to outline approaches to identifying and managing unsatisfactory station-level assessment performance. We have chosen older OSCE data to illustrate this Guide, to highlight quality issues, and subsequent actions and improvements.

This is a measure of internal consistency (commonly, though not entirely accurately, thought of as ‘reliability’), whereby in a good assessment the better students should do relatively well across the board (i.e. on the checklist scores at each station). Two forms of alpha can be calculated – non standardised or standardised – and in this Guide we refer to the non standardised form (this is the default setting for SPSS). This is a measure of the mean intercorrelation weighted by variances, and yields the same value as the G-coefficient for a simple model of items crossed with candidates. The (overall) value for alpha that is usually regarded as acceptable in this type of high stakes assessment, where standardised and real patients are used, and the individual station metrics are not standardised, is 0.7 or above.

Where station metrics are standardised a higher alpha would be expected. Alpha for this set of stations was 0.754, and it can be seen (from the second column of Table 2) that no station detracted from the overall ‘reliability’, although stations 17 and 20 contributed little in this regard.

Since alpha tends to increase with the number of items in the assessment, the resulting ‘alpha if item deleted’ scores should all be lower than the overall alpha score if the item/station has performed well. Where this is not the case this may be caused by any of the following reasons:

- The item is measuring a different construct from the rest of the set of items.
- The item is poorly designed.
- There are teaching issues – either the topic being tested has not been well taught, or has been taught to a different standard across different groups of candidates.
- The assessors are not assessing to a common standard.

In such circumstances, quality improvement should be undertaken by revisiting the performance of the station, and reviewing checklist and station design, or examining quality of teaching in the curriculum.

However, one cannot rely on alpha alone as a measure of the quality of an assessment. As we have indicated, if the number of items increases, so will alpha, and therefore a scale can be made to look more homogenous than it really is merely by being of sufficient length in terms of the number of items it contains. This means that if two scales measuring distinct constructs are combined, to form a single long scale, this can result in a misleadingly high alpha. Furthermore, a set of items can have a high alpha and still be multidimensional. This happens when there are separate clusters of items (i.e. measuring separate dimensions) which intercorrelate highly, even though the clusters themselves do not correlate with each other particularly highly.
It is also possible for alpha to be too high (e.g. >0.9), possibly indicating redundancy in the assessment, whilst low alpha scores can sometimes be attributed to large differences in station mean scores rather than being the result of poorly designed stations.

We should point out that in the authors’ medical school, and in many similar institutions throughout the UK, over 1,000 assessors are required for the OSCE assessment season (usually comprising 2-3 large scale examinations as previously described). Consequently, recruiting sufficient assessors of acceptable quality is a perennial issue, so it is not possible to implement double-marking arrangements that would then make the employment of G-theory worthwhile in terms of more accurately quantifying differences in assessors. Such types of analysis are more complex than those covered in this Guide, and often require the use of additional, less user-friendly, software.

An individual, institution-based decision to use G-theory or Cronbach’s alpha should be made in context with delivery requirements and any constraints.

The hawks and doves effect, either within an individual station, or aggregated to significant site effects, may have the effect of inflating the alpha value. However, it is highly likely that this effect will lead to unsatisfactory metrics in the areas of coefficient of determination, between-group within-station error variance, and, possibly, in fixed effect site differences as we will explore later in this Guide. Our philosophy is that one metric alone, including alpha, is always insufficient in judging quality, and that in the case of an OSCE with a high alpha but other poor metrics, this would not indicate a high quality assessment.

As an alternative measure to ‘alpha if item is deleted’, it is possible to use the correlation between station score and ‘total score less station score’. This will give a more extended scale, but the datum value (i.e. correlation) between contributing to reliability and detracting from it is to some extent dependent on the assessment design and is therefore more difficult to interpret.

**Metric 2 – Coefficient of Determination $R^2$**

The $R^2$ coefficient is the proportional change in the dependent variable (checklist score) due to change in the independent variable (global grade). This allows us to determine the degree of (linear) correlation between the checklist score and the overall global rating at each station, with the expectation that higher overall global ratings should generally correspond with higher checklist scores. The square root of the coefficient of determination is the simple Pearsonian correlation coefficient. SPSS and other statistical software packages also give the adjusted value of $R^2$ which takes into account the sample size and the number of predictors in the model (one in this case); ideally this value should be close to the unadjusted value.

A good correlation ($R^2 > 0.5$) will indicate a reasonable relationship between checklist scores and global grades, but care is needed to ensure that overly detailed global descriptors are not simply translated automatically by assessors into a corresponding checklist score, thereby artificially inflating $R^2$. In Table 2, station 14 (a practical and medico-legal skills station) has a good $R^2$ value of 0.697, implying that 69.7% of variation in the students’...
global ratings are accounted for by variation in their checklist scores. In contrast, station 19 is less satisfactory with an $R^2$ value of 0.404. This was a new station focusing on patient safety and the management of a needlestick injury. To understand why $R^2$ was low, it is helpful to examine the relationship graphically (for example, using SPSS Curve estimation) to investigate the precise nature of the association between checklist and global grade – see Figure 2. In this figure, assessor global grades are shown on the x-axis and the total item checklist score is plotted on the y-axis. Clustered checklist scores are indicated by the size of the black circle, as shown in the key. SPSS can calculate the $R^2$ coefficient for polynomials of different degree, and thereby provide additional information on the degree of linearity in the relationship. We would recommend always plotting a scatter graph of checklist marks against global ratings as routine good practice, regardless of station metrics.

In station 19 we can see that there are two main problems – a wide spread of marks for each global grade, and a very wide spread of marks for which the fail grade (0 on the x-axis) has been awarded. This indicates that some students have acquired many of the marks from the item checklist, but their overall performance has raised concerns in the assessor leading to a global fail grade.

In our introduction, we raised the impact of outliers on the regression method. Examples of poor checklist scores but with reasonable grades can be observed in Figure 3. In other stations, we sometimes see candidates scoring very few marks on the checklist score. This has the effect of reducing the value of the regression intercept with the y-axis, and increasing the slope of the regression line. For the data indicated in Table 2, the removal of outliers and re-computation of the passing score and individual station pass marks makes very little difference, increasing the passing score by less than 0.2%.
This unsatisfactory relationship between checklist marks and global ratings causes some degree of non-linearity, as demonstrated in the accompanying Table 3 (produced by SPSS), where it is clear graphically that the best fit is clearly cubic. Note that mathematically speaking, a cubic will always produce a better fit, but parsimony dictates that the difference between the two fits has to be statistically significant for a higher order model to be preferred. In this example the fit of the cubic polynomial is significantly better than that of the linear. The key point to note is whether the cubic expression is the result of an underlying relationship or as a result of outliers, resulting from inappropriate checklist design or unacceptable assessor behaviour in marking. In making this judgement, readers should review the distribution of marks seen on the scattergraph. Our own experience suggests that where stations metrics are generally of good quality, a departure from strict linearity is not a cause for concern.

<table>
<thead>
<tr>
<th>Polynomial fitted</th>
<th>R Square</th>
<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>.401</td>
<td>159.889</td>
<td>1</td>
<td>239</td>
<td>.000</td>
</tr>
<tr>
<td>Quadratic</td>
<td>.435</td>
<td>91.779</td>
<td>2</td>
<td>238</td>
<td>.000</td>
</tr>
<tr>
<td>Cubic</td>
<td>.470</td>
<td>70.083</td>
<td>3</td>
<td>237</td>
<td>.000</td>
</tr>
</tbody>
</table>

The existence of low $R^2$ values at certain stations and/or a wide spread of marks for a given grade should prompt a review of the item checklist and station design. In this particular case, although there was intended to be a key emphasis on safe, effective management in the station, re-assessment of the checklist in light of these metrics showed this emphasis was not well represented. It is clear that weaker candidates were able to acquire many marks for ‘process’ but did not fulfil the higher level expectations of the station (the focus on decision making). This has been resolved through a re-write of the station and the checklist, with plans for re-use of this station and subsequent analysis of performance within a future OSCE.

**Metric 3 – Inter-grade discrimination**

This statistic gives the slope of the regression line and indicates the average increase in checklist mark corresponding to an increase of one grade on the global rating scale. Although there is no clear guidance on ‘ideal’ values, we would recommend that this discrimination index should be of the order of a tenth of the maximum available checklist mark (which is typically 30-35 in our data).

A low value of inter-grade discrimination is often accompanied by other poor metrics for the station such as low values of $R^2$ (indicating a poor overall relationship between grade and checklist score), or high levels of assessor error variance (see metric 5 below) where assessors have failed to use a common standard. Too high levels of inter-grade discrimination may indicate either a very low pass mark, or a lack of linearity caused by a small number of badly failing students who tend to steepen the regression line.
Where very poor student performance in terms of the checklist score occurs, consideration needs to be given to whether these very low scores should be excluded from standard setting to avoid excessive impact on overall passing scores in a downward direction.

Returning to Table 2, it is clear that the inter-grade discrimination values are generally acceptable across the stations (station maxima being in the region of 30-35 marks), although there are three stations with discrimination values in excess of 5 (e.g. station 14 – a skills station involving completion of a cremation form).

Where there is doubt about a station in terms of its performance based on the discrimination metric, returning to the $R^2$ measure of variance and curve estimation is often instructive. In Table 2, station 14 has the highest inter-grade discrimination, and it can be seen in Figure 3 that most global grades again encompass a wide range of marks, especially the ‘clear pass’ grade – value 2 on the x-axis, ranging from 4 to 27, but that the lower of these values are clearly outliers. As the rest of the station metrics are acceptable, this station can remain unchanged but should be monitored carefully when used in subsequent assessments.

![Figure 3](image)

**Metric 4 – Number of failures**

It would be a mistake to automatically assume that an unusually high number of failures indicates a station that is somehow too difficult. The ‘reality check’, which is an essential part of borderline methods, will to a large extent compensate for station difficulty. This represents the expert judgement made by trained assessors in determining the global rating against the expected performance of the minimally competent student.
As previously described, other psychometric data can be used to investigate station design and performance in order to identify problems. Failure rates may be used to review the impact of a change in teaching on a particular topic – with higher such rates indicating where a review of content and methods of teaching can help course design. There are no major outliers for this metric in Table 2, but the difficulties with station 19 have allowed us to identify and deliver additional teaching around elements of patient safety within the final year curriculum, and introduce this specific safety focus into checklists.

**Metric 5 – Between-group variation (including assessor effects)**

When performing analysis on data resulting from complex assessment arrangements such as OSCEs where, by necessity, the students are subdivided into groups for practical purposes, it is vital that the design is fully randomised. Sometimes, however, this is not always possible, with logistical issues including dealing with special needs students who may require more time and have to be managed exclusively within a separate cycle. Any non-random subgroups must be excluded from statistically-based types of analysis that rely on randomness in the data as a key assumption.

In the ideal assessment process, all the variation in marks will be due to differences in student performance, and not due to differences in environment (e.g. local variations in layout or equipment), location (e.g. hospital based sites having different local policies for management of clinical conditions), or differences of assessor attitude (i.e. hawks & doves). There are two ways of measuring such effects, either by performing a one-way ANOVA on the station (e.g. with the assessor as a fixed effect), or by computing the proportion of total variance which is group specific. The latter allows an estimation of the proportion of variation in checklist scores that is due to student performance as distinct from other possible factors mentioned above, although this is usually given as the proportion of variance which is circuit specific.

If the variance components are computed, using group (i.e. circuit) as a random effect, then the percentage of variance specific to group can be computed. This is a very powerful metric as it gives a very good indication of the uniformity of the assessment process between groups. It is also relatively straightforward to calculate. Ideally between-group variance should be under 30%, and values over 40% should give cause for concern, indicating potential problems at the station level due to inconsistent assessor behaviour and/or other circuit specific characteristics, rather than student performance.

From Table 2, stations 6, 17 and 19 give cause for concern with regard to this metric, with the highest levels of between-group variance. In addition, station 6 has a poor $R^2$, and the overall combination of poor metrics at this station tells us that the poor $R^2$ was probably due to poor checklist design. These observations prompted a review of the design of station 6, and the checklist was found to consist of a large number of low level criteria where weaker candidates could attain high scores through ‘process’ only. In other words,
there was a likely mismatch between the nature of the checklist, and the aims and objectives of the station as understood by the assessors. Hence, in redesigning the station, a number of the low-level criteria were chunked (that is, grouped together to form a higher level criterion) in order to facilitate the assessment of higher level processes as originally intended.

Station 17 tells a different story, as the good $R^2$ coupled with the high between-group variation indicates that assessors are marking consistently within groups, but that there is a distinct hawks and doves effect between groups. In such a case, this ought to be further investigated by undertaking a one-way ANOVA analysis to determine whether this is an individual assessor or a site phenomenon. The amount of variance attributable to different sites is subsumed in the simple computation of within-station between-group variance as describe above. However, its significance may be determined using a one-way ANOVA analysis with sites as fixed effects.

However, care needs to be exercised in making judgements based on a single metric, since, with quite large populations, applying ANOVA to individual stations is likely to reveal at least one significant result, as a result of a type I error due to multiple significance tests across a large number of groups (e.g. within our own OSCE assessments, a population of 250 students and approximately 15 parallel circuits across different sites). Careful post-hoc analysis will indicate any significant hawks and doves effects, and specific groups should be tracked across other stations to determine general levels of performance. If a completely random assessment model of both students and assessors has been used (mindful of the caveats about local variations in equipment and exam set up), then many of these effects should be largely self-cancelling; it is in the aggregate totals that group-specific fixed effects are important and may require remedial action.

**Metric 6 – Between-group variance (other effects)**

ANOVA analysis can also be of use when there are non-random allocations of either assessors or students, as is the case in some medical schools with large cohorts and associated teaching hospitals where multi-site assessment may occur. Such complex arrangements can result in the non-random assignment of assessors to circuits since it is often difficult for clinical staff to leave their place of work. This may then lead to significant differences due to ‘site effects’ which can be identified with appropriate action taken in the analysis of results.

Other important fixed effects can also be identified through the use of ANOVA. For example, assessor training effects, staff/student gender effects, and associated interactions, which have all been previously described (Pell, 2008), and which underline the need for complete and enhanced assessor training as previously highlighted (Holmboe, 2004).
Metric 7 – Standardised Patients ratings

Most centres that use simulated/standardised patients (SPs) require them to rate candidates, and this typically follows an intensive training programme. Within our own institution, SPs would be asked a question such as “Would you like to consult again with this doctor?” with a range of responses (strongly agree, agree, neither agree nor disagree, disagree, strongly disagree), the two latter responses being regarded as adverse. Akin to Metric 4 (Number of station failures), a higher than normal proportion of candidates (e.g. >10%) receiving adverse SP ratings may indicate problems. There is no available literature on what constitutes an ‘acceptable’ range of SP ratings at station level, so we have chosen an arbitrary cut off figure of 10%. The critical issue here is that other station metrics should be reviewed, and the impact on SP ratings monitored in response to training or other interventions.

If this is coupled with a higher than normal failure rate it could be the result of inadequate teaching of the topic. Adverse values of this metric are often accompanied by high rates of between-group variance; assessors viewing candidates exhibiting a lower than expected level of competence often have difficulty in achieving consistency.

The overall reliability of the assessment may be increased by adding the SP rating to the checklist score; typically the SP rating should contribute 10-20% of the total station score (Homer & Pell, 2009). An alternative approach, taken within our own institution at graduating level OSCEs, is to set a ‘minimum’ requirement for SP comments as a proxy for patient satisfaction (using rigorously trained SPs).

The 360 degree picture of OSCE quality

As outlined, it is critical to review station quality in light of all available station-level metrics before making assumptions about quality, and planning improvements.

Review of the metrics of station 8 (focusing on consultation, diagnosis and decision making) show a positive contribution to overall assessment reliability (alpha if item deleted 0.749). As can be seen below in the curve estimation in figure 4, the $R^2$ coefficient is poor at 0.4 with a wide spread of item checklist scores within grades, and significant overlap across the higher grades (pass, credit and distinction).

Coupled with high levels of between-group variance of 33.8%, this suggests a mismatch between assessor expectations and grading, and the construct of the item checklist in the provision of higher level performance actions. This leads to inconsistency within and between stations.

Actions to resolve this would typically include a review of the station content and translation to the item checklist. Reviewing grade descriptors and support material for assessors at station level should help overcome the mismatch revealed by the poor $R^2$ and higher error variance.
Station 9 is represented by the curve estimation seen below in Figure 5.

Here we see a more strongly positive contribution to reliability (alpha if item deleted 0.74) and better station-level metrics. The $R^2$ coefficient is acceptable at 0.5, but between-group variance is still high at 36%.

The curve shows wide performance variance at each grade level. The good $R^2$ suggests the variation in assessor global rating rather than assessor checklist scoring, with a hawks and doves effect.
Action to investigate and improve this would focus on assessor support material in relation to global ratings.

Quality control by observation: detecting problems in the run up to OSCEs and on the day

It is essential for those concerned with minimising error variance between groups to observe the OSCE assessment systematically. When considering some of the causes of between-group error, all those involved in the wider OSCE process (Figure 1) must be part of the quality control process.

In advance of the OSCE, many of the contributing factors to error variance can be anticipated and corrected by applying some of the points below:

- Checking across stations to ensure congruence in design.
- Ensuring that new (and older, established) stations follow up-to-date requirements in terms of checklist design, weighting and anchor points.
- Reviewing the set up of parallel OSCE circuits – for example, differences in the placing of disinfectant gel outside a station may mean the assessor may not be able to score hand hygiene approaches.
- Ensuring that stations carry the same provision of equipment (or permit flexibility if students are taught different approaches with different equipment).

Other sources of error variance can occur during the delivery of the OSCE:

- Assessors who arrive late and miss the pre-assessment briefing and who therefore fail to adhere adequately to the prescribed methodology.
- Unauthorised prompting by assessors (despite training and pre-exam briefings).
- Inappropriate behaviour by assessors (e.g. changing the ‘tone’ of a station through excessive interaction).
- Excessively proactive simulated patients whose questions act as prompts to the students.
- Biased real patients (e.g. gender or race bias). Simulated patients receive training on how to interact with the candidates, but this may not be possible with the majority of real patients to the same level undertaken with simulators.
- Assessors (or assistants) not returning equipment to the start or neutral position as candidates change over.

Post hoc remediation

When faced with unsatisfactory metrics, a number of pragmatic, post hoc remediation methods can be employed.

1. Adjustment of total marks for site effects: The easiest method is to adjust to a common mean across all sites. After any such adjustment, the site profile of failing students should be checked to ensure that, for example, all failures are not confined to a single site. The effect of any special needs group (e.g. candidates receiving extra time as a result of health
needs) located within a single specific site needs to be discounted when computing the adjustment level.

2. **Adjustment at the station level**: This is seldom necessary because any adverse effects will tend to cancel each other out. In the rare cases where this does not happen, a station level procedure as above can be carried out.

3. **Removal of a station**: Again, this is a rare event and the criteria for this are usually multiple adverse metrics, the result of which would disadvantage students to such an extent that the assessment decisions are indefensible against appeal.

**Conclusions**

Using a series of worked examples and ‘live data’, this Guide focuses on commonly used OSCE metrics and how they can be used to identify and manage problems, and how such an approach helps to anticipate future issues at the school/single institution level. This methodology therefore naturally feeds into the wider assessment processes as described in Figure 1.

In the authors’ institution there is a close relationship between those who analyse the data and those who design and administer the clinical assessments and develop/deliver teaching. Routine and detailed review of station level metrics has revealed mismatches between checklists and global ratings. This has led to the redesign of certain OSCE stations with a subsequent improvement of metrics. Some of these redesigns include:

- Chunking of a number of simple criteria into fewer criteria of higher level.
- Chunking to allow for higher level criteria commensurate with the stage of student progression, allowing assessment of higher level, less process driven performance
- The inclusion of intermediate grade descriptors on the assessor checklists.
- Ensuring that checklist criteria have three instead of two anchors where appropriate, thereby allowing greater discrimination by assessors.
- A greater degree of uniformity between the physical arrangements of the different circuits.

The presence of high failure rates at particular stations has led to a revisiting of the teaching of specific parts of the curriculum, and was followed by changes in the way things were taught, resulting in improved student performance as measured in subsequent OSCEs.

Indications of poor agreement between assessors has, on occasion, led to a number of changes all of which have been beneficial to the quality of assessment:

- Upgrading of assessor training methods.
- Updating (‘refreshing’) assessors who were trained some time ago.
- The provision of more detailed support material for assessors.
• Improved assessor briefings prior to the assessment.
• Improved SP briefings prior to the assessment.
• Dummy runs before the formal assessment for both assessors and SPs (this is only really practicable where student numbers are relatively small e.g. resits, and in dental OSCEs with smaller cohorts of students).

The need for all the above improvements would be unlikely to have been apparent from using a single reliability metric, such as Cronbach’s alpha or the G Coefficient. It is only when a family of metrics is used that a true picture of quality can be obtained and the deficient areas identified. Adopting this approach will be rewarded with a steady improvement in the delivery and standard of clinical assessment.
References


Suggested Further Reading


42 The use of simulated patients in medical education
A detailed overview on how to recruit, train and use Standardized Patients from a teaching and assessment perspective.

43 Scholarship, Publication and Career Advancement in Health Professions Education
William C McGaghie (2010)
ISBN: 978-1-903934-50-0
Advice for the teacher on the preparation and publication of manuscripts and twenty-one practical suggestions about how to advance a successful and satisfying career in the academic health professions.

44 The Use of Reflection in Medical Education
John Sandars (2010)
A variety of educational approaches in undergraduate, postgraduate and continuing medical education that can be used for reflection, from text-based reflective journals and critical incident reports to the creative use of digital media and storytelling.

45 Portfolios for Assessment and Learning
J van Tartwijk, Erik W Driessen (2010)
An overview of the content and structure of various types of portfolios, including e-portfolios, and the factors that influence their success.

46 Student Selected Components
Simon C Riley (2010)
An insight into the structure of an SSC programme and its various important component parts.

47 Using Rural and Remote Settings in the Undergraduate Medical Curriculum
A description of an RRME programme in action with a discussion of the potential benefits and issues relating to implementation.

48 Effective Small Group Learning
Sarah Edmunds, George Brown (2010)
ISBN: 978-1-903934-60-9
An overview of the use of small group methods in medicine and what makes them effective.

49 How to Measure the Quality of the OSCE: A Review of Metrics
Godfrey Peil, Richard Fuller, Matthew Homer, Trude Roberts (2011)
A review of the metrics that are available for measuring quality in assessment and indicating how a rounded picture of OSCE assessment quality may be constructed by using a variety of measures.

50 Simulation in Healthcare Education. Building a Simulation Programme: A Practical Guide
Kamran Khan, Serena Tolhurst-Cleaver, Sara White, William Simpson (2011)
ISBN: 978-1-903934-63-0
A very practical approach to designing, developing and organising a simulation programme.

Anita Laidlaw, Jo Hart (2011)
An overview of the essential steps to take in the development of assessing the competency of students' communication skills.

52 Situativity Theory: A perspective on how participants and the environment can interact
Steven J Durning, Anthony R Artino (2011)
ISBN: 978-1-903934-87-6
Clarification of the theory that our environment affects what we and our students learn.

53 Ethics and Law in the Medical Curriculum
Al Dowie, Anthea Martin (2011)
ISBN: 978-1-903934-89-0
An explanation of why and a practical description of how this important topic can be introduced into the undergraduate medical curriculum.

54 Post Examination Analysis of Objective Tests
Mohsen Tavakol, Reg Dennick (2011)
ISBN: 978-1-903934-91-3
A clear overview of the practical importance of analysing questions to ensure quality and fairness of the test.

55 Developing a Medical School: Expansion of Medical Student Capacity in New Locations
David Snaudgen, Joaanna Bates, Philip Bums, Oscar Casino, Richard B Hays, Dan Hunt, Angela Towle (2011)
ISBN: 978-1-903934-93-7
As many new medical schools are developed around the world, this guide draws upon the experience of seven experts to provide a very practical and logical approach to this often difficult subject.

56 Research in Medical Education. “The research compass”: An introduction to research in medical education
Charlotte Ringsted, Brian Hodges, Albert Scherpbier (2011)
ISBN: 978-1-903934-95-1
An introductory guide giving a broad overview of the importance attached to research in medical education.

57 General overview of the theories used in assessment
Lambert Wt Schuwirth, Cees PM van der Vleuten (2012)
As assessment is modified to suit student learning, it is important that we understand the theories that underpin which method of assessment are chosen. This guide provides an insight into the essential theories used.

58 Self-Regulation Theory: Applications to medical education
John Sandars, Timothy J Cleany (2012)
Self-regulation theory, as applied to medical education, describes the cyclical control of academic and clinical performance through several key processes that include goal-directed behaviour, use of specific strategies to attain goals, and the adaptation and modification to behaviours or strategies to optimise learning and performance.

59 How can Self-Determination Theory assist our understanding of the teaching and learning processes in medical education?
O’Be Th ten Cate, Rashmi A Kasurkar, Geoffrey C Williams (2012)
ISBN: 978-1-908438-01-0
Self-Determination Theory (SDT) serves among the current major motivational theories in psychology but its applications in medical education are rare. This guide uncovers the potential of SDT to help understand many common processes in medical education.

60 Building bridges between theory and practice in medical education by using a design-based research approach
Diana Hj M Dolmans, Dineke Tigelaar (2012)
ISBN: 978-1-908438-03-4
This guide describes how Design-Based Research (DBR) can help to bridge the gap between research and practice by contributing towards theory testing and refinement on the one hand and improvement of educational practice on the other.

61 Integrating Professionalism into the Curriculum
Helen O’ Sullivan, Walthers van der Mook, Ray Frewell, Val Was (2012)
ISBN: 978-1-908438-05-8
Professionalism is now established as an important component of medical curricula. This guide clearly explains the why and how of integrating professionalism into the curriculum and ways to overcome many of the obstacles encountered.
About AMEE

What is AMEE?
AMEE is an association for all with an interest in medical and healthcare professions education, with members throughout the world. AMEE's interests span the continuum of education from undergraduate/basic training, through postgraduate/specialist training, to continuing professional development/continuing medical education.

- **Conferences**: Since 1973 AMEE has been organising an annual conference, held in a European city. The conference now attracts over 2300 participants from 80 countries.

- **Courses**: AMEE offers a series of courses at AMEE and other major medical education conferences relating to teaching, assessment, research and technology in medical education.

- **MedEdWorld**: AMEE's exciting new initiative has been established to help all concerned with medical education to keep up to date with developments in the field, to promote networking and sharing of ideas and resources between members and to promote collaborative learning between students and teachers internationally.

- **Medical Teacher**: AMEE produces a leading international journal, Medical Teacher, published 12 times a year, included in the membership fee for individual and student members.

- **Education Guides**: AMEE also produces a series of education guides on a range of topics, including Best Evidence Medical Education Guides reporting results of BEME Systematic Reviews in medical education.

- **Best Evidence Medical Education (BEME)**: AMEE is a leading player in the BEME initiative which aims to create a culture of the use of best evidence in making decisions about teaching in medical and healthcare professions education.

Membership categories

- **Individual and student members (£85/£39 a year)**: Receive Medical Teacher (12 issues a year, hard copy and online access), free membership of MedEdWorld, discount on conference attendance and discount on publications.

- **Institutional membership (£200 a year)**: Receive free membership of MedEdWorld for the institution, discount on conference attendance for members of the institution and discount on publications.

See the website (www.amee.org) for more information.