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Predictive Validity of Measurements of Student Performance Obtained using the Team Objective Structured Bedside Assessment (TOSBA): evaluating the clinical competence of final year medical students.

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Running Head Title: Predictive Validity of Measurements of Student Performance Obtained using the Team Objective Structured Bedside Assessment (TOSBA)

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Abstract

Background: The importance of valid and reliable assessment of student competence and performance is gaining increased recognition. Provision of patient-based formative assessment is an increasing challenge for clinical teachers in a busy hospital setting. A formative assessment tool that reliably predicts performance in the summative setting would be of great value to both students and teachers.

Aim: This study explores the utility of the TOSBA, a novel ward-based formative assessment tool, in predicting performance in the final clinical examination.

Methods: The performance of a cohort of final year students (n=191) in the TOSBA was compared with their subsequent performance in the final examination. A comparison was also made between student performance in the existing formative assessment tool, the OSLER (Objective Structured Long Examination Record) and the final examination. The validity of the TOSBA was established using clustering around latent variables (CLV) analysis.

Results: There was a clear relationship between the TOSBA and the final and honours rate in the final examination. Student performance in the OSLER showed a poor relationship with performance in the final examination ($r^2=0.15$) compared with the TOSBA ($r^2=0.35$).

Conclusion: TOSBA performance is a strong predictor of subsequent performance in the final examination. The clustering of the TOSBA with other assessments of clinical skills underlines its validity. Further research is required to determine whether the TOSBA is predictive of subsequent performance during internship.

Introduction

The importance of valid and reliable assessment of student competence and performance is gaining increased recognition. Society and other stakeholders rightly demand that the final medical examination delivers doctors who are competent and fit to practice as an intern. Prediction of future student performance is of interest both to students and their clinical teachers and formative assessment is an important aspect of student learning and professional development. A formative assessment tool that reliably predicts future student performance, in a summative setting, would be of great value.

Prior to 2005, the OSLER (Objective Structured Long Examination Record) was the main assessment tool used at the Royal College of Surgeons in Ireland medical school in the formative assessment of final year students (Gleeson 1997) We have recently described the Team Objective Structured Bedside Assessment (TOSBA) which adapted the TOSCE format (Singleton et al 1999) as a formative ward-based teaching and assessment tool, using ward-based patients (Miller et al 2006) The TOSBA has been introduced and is now used, in addition to the OSLER, as a formative assessment tool of final year student clinical competence.

The aim of this study is to assess the utility of the TOSBA. Predictive validity is assessed by comparing the results of the TOSBA with the results of the final medical examination held later in the same academic year. In addition, we compare student performance in the TOSBA with that in the OSLER. Convergent and divergent validity is assessed by examining the relationship between student performance in the TOSBA and performance in the individual clinical components of the final examination.

Methods

The curriculum at our institution is a systems- based, five year programme. The final examination is an assessment in medicine and surgery and comprises a number of components. These can be divided into those that assess knowledge (essay, short notes, multiple choice questions and a 10 station data OSCE) and those that assess clinical, patient-centered skills (an observed long case and a 10 station clinical OSCE). The clinical OSCE consists of eight patient-based stations (each 7.5 minutes duration) and 2 communication stations (each 10 minutes duration). Students who perform well in the final examination are awarded a distinction or 'Honours'. This is designated as a 'P+' (Appendix 1)

We have previously reported a detailed description of the TOSBA (Miller et al 2006). Briefly, the TOSBA is a ward-based teaching and formative assessment during which three groups of five students rotate through three bedside stations in the same medical ward. Each station is comprised of an in-patient and an examiner. Consecutive students in each group are each given five minutes in which to perform one of five different standardised clinical tasks: (i) take a brief but focused history, (ii) perform a targeted physical examination, (iii) generate a patient-specific differential diagnosis, (iv) outline an investigation and management plan and (v) answer questions pertaining to the patient's drug prescription chart. The students are directly observed performing the tasks, are graded on their performance (Table 1) and provided with educational feedback by the examiner. On completion of the TOSBA, all three examiners confer and an agreed final grade is awarded. Students are scheduled to attend two TOSBAs during their four-week medicine rotation and therefore, ideally, see a patient with a problem in six different (organ) systems, depending on the available in-patient case-mix.

The OSLER (Objective Structured Long Examination Record) is a 10-item analytical record of the traditional long case. The 10-item scale includes 4 items on *presentation of history*, (pace/clarity, communication process, systematic presentation, correct facts established), 3 items on *physical examination* (systematic, technique, correct findings established) and one item each on *formulation of appropriate investigations in a logical sequence*, *management* and *clinical acumen* (Gleeson 1997). Unlike the TOSBA, students are not directly observed during the history-taking component of the OSLER. Educational feedback is provided and students are awarded one of four grades on their performance - the P/P- is not included (Table 1). The OSLER assessments were performed by members of the clinical team, to which a student was attached. An average of 4 (3.927) OSLERS were completed per student.

From September 2005 to March 2006, a total of 204 final year medical students were exposed to TOSBAs over the course of the academic year. One hundred and ninety one students sat the final examination in medicine and surgery and were the subject of this study (eleven students were not examined due to ineligibility and one student was absent). A core group of 8 clinical faculty who were familiar with curricular outcomes and expected level of student clinical competency carried out the TOSBA assessments. An average of 2 (1.65) TOSBAs were completed per student. Data were analyzed with Stata/SE release 10. Clustering around latent variables analysis was used to examine the patterns of association between assessment modalities.

Results

The performance of 191 students was analyzed, Complete assessment data was available for 172 (90%) students. The relationship between the OSLEER, TOSBA and final examination mark is illustrated in Figure 1. Student performance in the OSLEER showed a poor relationship with performance in the total final examination ($r^2= 0.15$). The OSLEER showed a restricted grade distribution, with 56% of students achieving the same grade (P+) and a further 26% achieving a P/P+. (Table 2) Furthermore, there was only a 2-mark mean difference in the final examination performance between students who received a P- grade and those who received a P/P+. While students who scored P- had a higher average mark than those who scored P, this difference was not statistically significant (Scheffé post-hoc test, $P = 0.444$). This pattern was repeated for the final clinical mark.

In comparison, as shown in Figure 1, a moderate correlation was found between the TOSBA and the final examination performance ($r^2= 0.35$) The TOSBA had a similar concentration of grades to the OSLEER, with 57% of students receiving the same grade (P) and only 12% receiving extreme grades (P- and P+). (Table 2) However, the relationship of TOSBA grades to final examination result showed a better discrimination, with a 12-mark difference in average performance between those who received a P- grade and those who received a P/P+ and a graded association between TOSBA grade and average final mark, though the 2-mark difference between the final results of those who achieved P/P+ and P+ grades is not statistically significant, (Scheffé post-hoc test $P=0.990$). A similar pattern was again seen for final clinical mark.

The relationship between the TOSBA and the failure and honours rate in the final examination mark is illustrated in Figure 2. There is a clear relationship in both cases. A student who performed poorly in the formative TOSBA (P-) did not achieve an honours grade in the final examination and was likely to fail (38%). The converse is true for students who performed well in the TOSBA (i.e. scored either a P/P+ or P+ grade) – they had an 80% chance of achieving honours. In addition, no student who scored a P/P+ or P+ failed

the final examination. Of those students who scored a P in the TOSBA, 44% subsequently achieved an honours grade in the final examination.

Of the eleven students who failed their final examination, nine also failed the TOSBA (sensitivity 82%, 95% CI 48% to 98%). Seven of these (77%) received a P- grade; two (23%) received a P/P- grade . There were 47 failures overall on the TOSBA giving a predictive value of failure of 19% (95% CI 9% to 33%). Of the 17 students who failed the clinical component of their final examination, 8 had failed the TOSBA, giving a sensitivity of 47%, 95% CI 23% to 72%. The predictive value was 17% (95% CI 8% to 31%).

Convergent and divergent validity

We examined the relationship between the TOSBA and the components of the final examination using clustering around latent variables analysis. Clustering around latent variables is an exploratory data analysis technique which sequentially groups variables into clusters with the aim of minimising the variation within clusters and maximising the variation between clusters. Unlike factor analysis, it is a sequential process, making it very useful for detecting complex data structures such as clusters-within-clusters. The output of the analysis is shown in Figure 3. The assessments formed two broad clusters: the cluster at the top of the figure contains all of the written assessments. It can be seen that there is a strong link between assessments of the same type – the two MCQ exams cluster together, as do the data interpretation examinations (OSCE) and the essay examinations. Taken together, this cluster is dominated by assessments which test the knowledge domain and entail recognition, recall and organisation of material.

The lower cluster is the patient-centred assessments. The TOSBA clusters with the medical *in-vivo* patient-based component of the OSCE, the clinical long case and the communication skills assessment. It correlated less well with the medical *in vitro*, data-based, component of

the OSCE and poorly with the MCQ, essay paper and short notes assessments that were fact orientated and measured knowledge and memory

Discussion

The analysis presented in this paper represents an evaluation of the utility of the TOSBA in predicting subsequent student performance and identifies aspects of the TOSBA which could improve its value as a formative assessment tool of final year student clinical competence.

Validity refers to the extent to which a measurement actually measures what it is intended to measure (van der Vleuten 2000). Validity is not so much a property of a test but rather, refers to the usefulness of the test for a particular purpose. Multiple sources of evidence are required to evaluate the appropriateness of a test for a particular purpose (Sireci 2007) Although in the present evaluation we were limited to examining the relationship between the TOSBA and other measures of student performance, we were able to use these to examine convergent, divergent and predictive validity, all characteristics of the assessment process which are often neglected because of the difficulties inherent in their determination. Convergent validity was supported by the clustering of the TOSBA scores with other measures of clinical competence, and divergent validity supported by their distinctness from knowledge-based assessments.

The TOSBA was predictive of performance in the final examination which, in itself, is unremarkable since it assesses skills which are also assessed in components of the final examination. In particular however, 82% of those who would ultimately fail their final examination failed the TOSBA. However, given the failure rate in the TOSBA, this amounted to a predictive value of just under 20% - that is, only 20% of students failing the TOSBA went on to fail the final examination. This poor correlation may be, in part, explained by the

subsequent remediation programme which was provided for those students who failed their TOSBA, accounting for the discordantly improved final examination pass rate. Timely intervention based on early identification of poor clinical performance has been shown to help weaker students to improve their performance. In addition, although poorly performing students have been shown not to seek out guidance and support (Malik 2000), we believe it is possible that students, who were identified as potential failures by the TOSBA, used this formative assessment as an incentive to improve their performance. Closer monitoring of the impact of remedial support on the subsequent performance of underperforming students will be an area of future research

The TOSBA grades showed an ordered relationship with performance in the final medical examination which was superior to that of the OSLEP, and a more impressive discriminant ability, with important differences in performance on the final examination being evident between the highest and lowest TOSBA grades. The ordered relationship with performance in the final medical examination shown by the TOSBA was not seen with the OSLEP which demonstrated poor discriminant ability, with little differences in performance on the final examination being evident between the highest and lowest OSLEP grades. The poor performance of the OSLEP may reflect the junior status and inadequate examiner training of those who carried out these assessments - predominately interns or senior house officers. In addition, observation of the history-taking process may improve the validity of this tool. However, as a result of our data showing the clear superiority of the TOSBA over the OSLEP, we no longer use the latter as a formative assessment tool.

The TOSBA was a useful predictor of an honours performance in the final examination. A student who achieved a P/P+ or P+ grade had an 80% chance of achieving honours. The converse is true for students who performed poorly in the formative TOSBA – they were very unlikely to achieve an honours grade in the final examination.

While the TOSBA is a good predictor of extremes in performance, it is less reliable for those students who received a P grade. Examination of the TOSBA grade breakdown suggests that the criteria for the P/P+ and P+ grades need to be reviewed. Forty-four per cent of

students who obtained a P grade in the TOSBA subsequently achieved honours (P+) in their final examination. Further analysis is required to evaluate this central cluster of grades.

The use of clustering around latent variables to examine the convergent and divergent validity of the TOSBA is a new and potentially useful application of this method. Rather than presenting the reader with a large table of barely interpretable correlation coefficients, clustering around latent variables shows the interrelationships between assessments as a tree diagram. This presentation allows the reader to see clustering at several levels. In the case of our final year assessments, it is clear that there are two broad categories, corresponding to knowledge-based and clinical skills assessments, and that the TOSBA fits into the latter category. However, within the assessments, a finer structure can be seen: assessments that test the same domain tend to cluster together – notably the MCQ examinations, whose close relationship indicates that there is an element of 'MCQ skill' underlying performance on these assessments.

We have not used the TOSBA in the final examination. This study is an exercise in the use of a formative assessment tool, with a high throughput, to determine whether it can predict student performance and to evaluate its potential as a summative tool. In the context of increasing student numbers, the sustainability of the Objective Structured Clinical examination (OSCE) as an assessment tool is open to question (Harden & Gleeson 1979). The challenges of running an OSCE of psychometric integrity for large student groups are well documented (Van der Vleuten & Swanson 1990). This is a circumstance where the TOSBA could be introduced with good effect.

Evaluation of test validity is not a static, one-time event {Sireci}. We are currently using the results of this evaluation to improve the conduct of the TOSBA assessment, concentrating on clearer guidelines for assessors with the aim of reducing the proportion of students clustered into the same grade.

Conclusion

The challenge of providing rigorous assessment of medical student cohorts of increasing size is one that faces all medical schools. The potential to reliably assess students in groups represents a move away from traditional approaches to undergraduate assessment. If this approach can be implemented, without jeopardising the quality of the assessment, it is to be welcomed.

We believe the TOSBA has development potential as an assessment tool. The potential is shown in the good discriminatory ability of the grades as predictors of final examination performance. The clustering of the TOSBA with other assessments of clinical skills underlines its validity. Future analyses will address the current failure of the grading scheme to identify many of the students who subsequently achieved honours in the final examination. Our findings have education and research implications. We believe the TOSBA is a valid clinical assessment tool for the formative evaluation of student clinical competence in an authentic setting, though it may benefit from further refinement. Further research is required to determine whether the TOSBA is predictive of subsequent performance during internship.

Grade	Descriptor
P+	Honours standard
P/P+	Pass but potential to achieve honours standard
P	Pass standard
P/P- (TOSBA only)	Borderline standard
P-	Fail standard

Table 1: TOSBA and OSLER Grading scheme

Table 2. Comparative performance of the OSLER and TOSBA.

OSLER = Objective Structured Long Examination Record. TOSBA =Team Objective Structured Bedside Assessment.

Assessment				
OSLER	Grade	Percentage	Average final mark (out of 100)	Average clinical mark (out of 100)
	P-	12%	54	56
	P	7%	51	49
	P/P+	26%	56	57
	P+	56%	59	60
TOSBA	P-	9%	50	50
	P/P-	17%	54	53
	P	57%	58	59
	P/P+	14%	62	62
	P+	3%	64	64

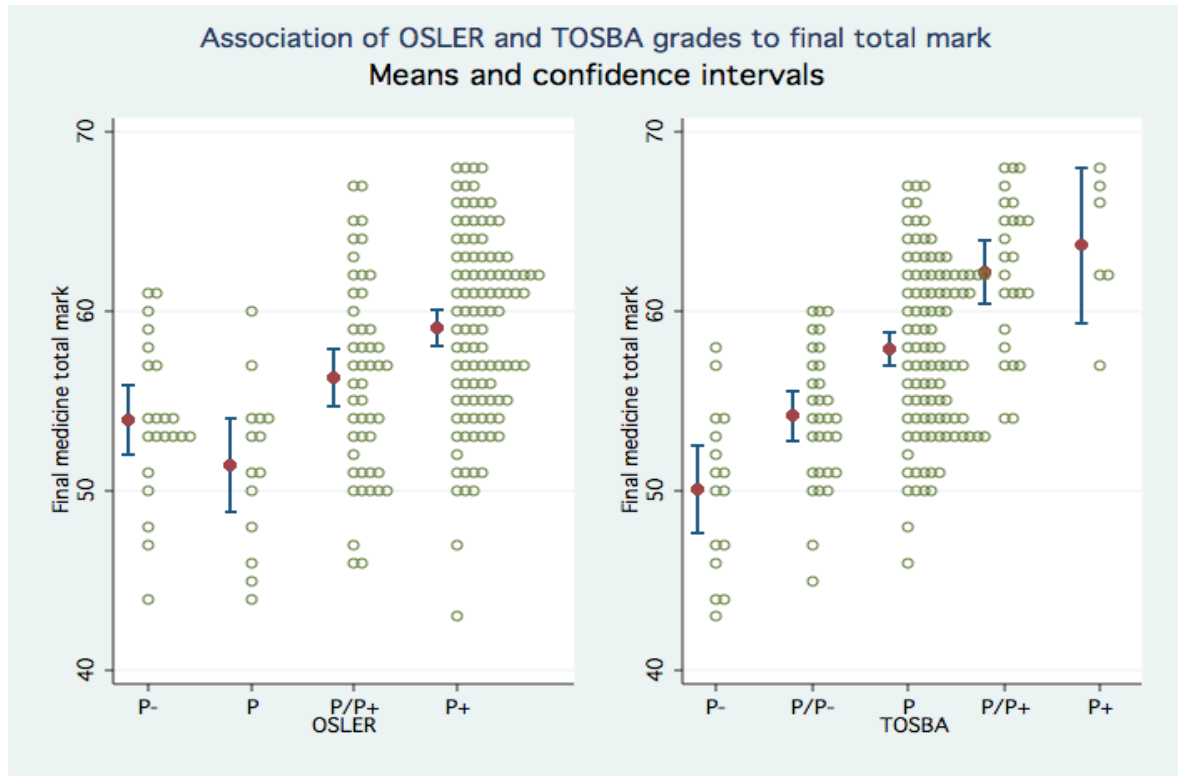
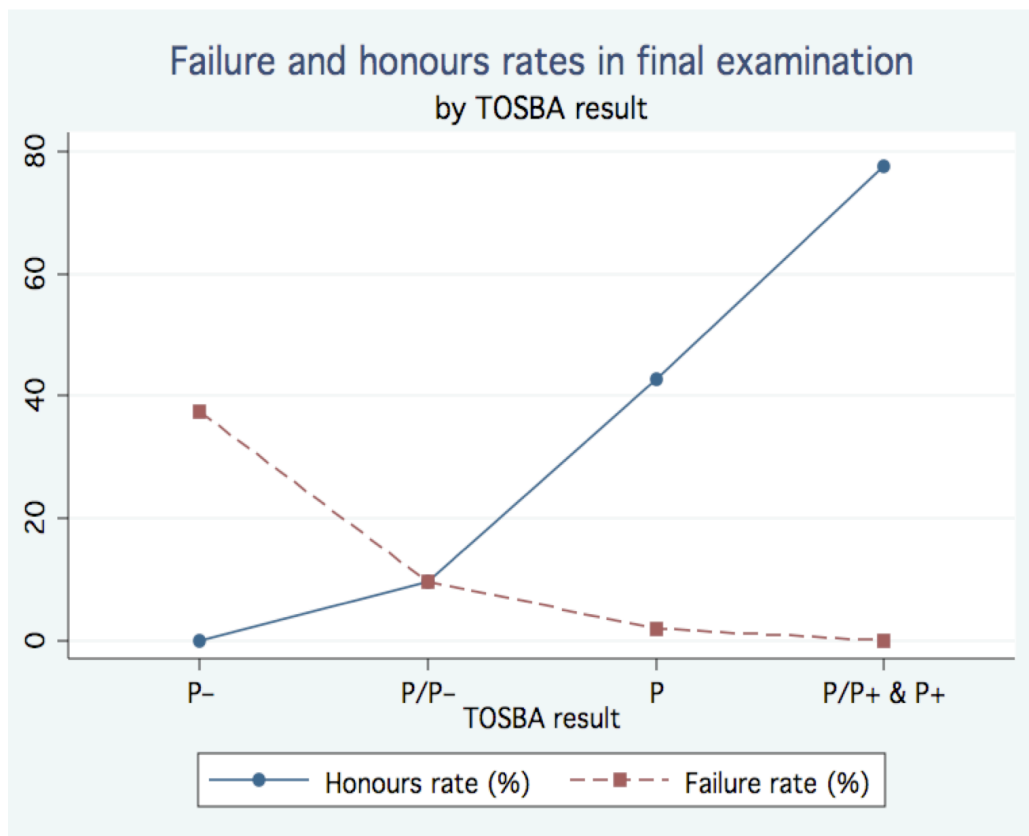


Fig 1: Association of OSLER and TOSBA grades to final total mark. OSLER $r^2=0.15$; TOSBA $r^2=0.35$.

Fig. 2. Association gradients for failure rates and honours rates



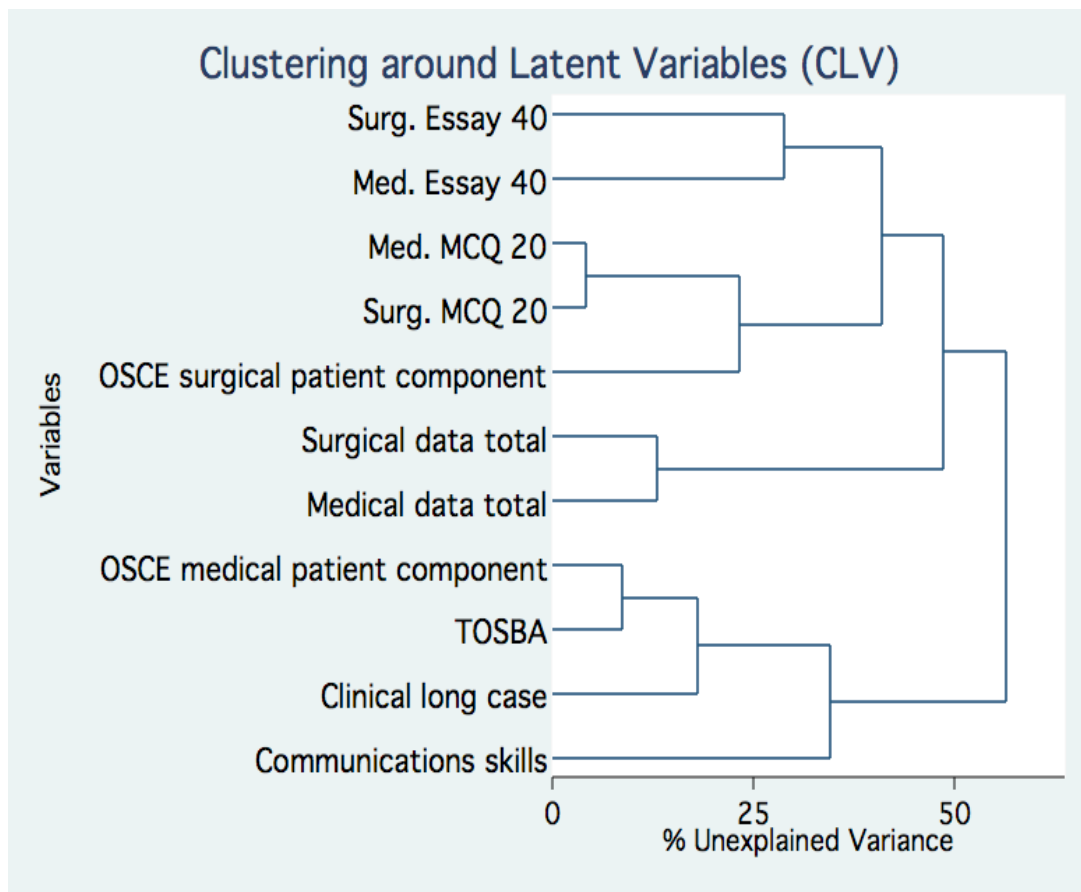


Fig. 3. Association gradients for failure rates and honours rates.

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Extended Criterion Referenced Grading Scheme	EXTENDED MARKING SCHEME	
P+	80	Outstandingly clear and factually correct presentation of the patient history, demonstration of physical signs and organisation of the case management. Clearly a candidate displaying outstanding communication skills and clinical acumen. First call honours.
	75	Excellent overall case presentation, communication skills, examination technique and demonstration of the correct facts and physical signs of the case. The candidate may even display outstanding attributes in some but not all measurable criteria. First class honours.
	70	Excellent in most aspects of overall case presentation, communication skills, examination technique and demonstration of the correct facts and physical signs of the case. Also excellent communicator and demonstrates the ability to investigate
	65	Very good overall presentation covering all major aspects; few omissions, good priorities. Very clearly an above average candidate in terms of communication and clinical acumen. Second class honours, grade 1
	60	Very good in most respects of presentation and communication but not in all aspects. However, a good solid performance in most areas assessed with a well developed clinical acumen. Second class honours, grade 2
P	55	Good sound overall presentation and communication of the case without displaying any attributes out of the ordinary. The candidate displays an overall adequate standard of examination technique. The patient's problems are identified and a reasonable management outline suggested.
	50	Adequate presentation of the case and communication ability. Nothing to suggest more than just reaching an acceptable standard in physical examination and identification of the patient's problems.
P-	45	Poor performance in most areas of case presentation, communication with the patient and demonstration of physical signs. Inadequate attempt at a clear identification of the patient's problems. The candidate may display some adequate attributes but does not reach an acceptable pass standard overall.
	40	Poor performance overall The candidate does not reach an acceptable pass standard in almost all categories. The candidate's performance in all areas is so poor that the standard required is not even remotely approached. Quite clearly this candidate requires a further period of training

Contributors

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Practice Points

The Team Objective Structured Bedside Assessment (TOSBA) is a novel and feasible approach to formative ward-based assessment

Performance in the TOSBA is predictive of subsequent student performance in the final examination

Further research is required to evaluate the TOSBA as a summative assessment tool and to establish its ability to predict clinical performance during internship