

Use of Progress Testing in a UK Dental Therapy and Hygiene Educational Program

Kamran Ali, PhD; Daniel Zahra, PhD; Christopher Tredwin, PhD; Claire Mcilwaine, DHDT; Gill Jones, BDS

Abstract: Progress testing provides a longitudinal assessment of the development and sustainability of students' knowledge at regular intervals over the duration of an educational program. Comparisons of performance on successive tests are used to monitor growth in knowledge. The aim of this study was to evaluate the effects of progress testing in an undergraduate program for dental therapy and hygiene (DTH) students in the United Kingdom as the main tool for academic assessment. Data were collected for progress tests of all 38 DTH students from 2015 to 2017. Each test consisted of 100 single best answer multiple-choice items with accompanying vignette. The students chose their answer from five options. A score of 1 was awarded for a correct answer, -0.25 for an incorrect answer, and 0 for don't know (DK). Three cohorts of DTH students were included in the study, and seven progress tests were conducted over a period of three years. Analysis of performance showed growth in knowledge across successive years, with the largest increase in knowledge in the transition from Year 1 to Year 2 and concomitant reduction in incorrect and DK responses. This was a pioneering study to report the establishment and use of progress testing among undergraduate DTH students. Notwithstanding the challenges involved, the study found merit in further exploring the use of progress testing for students in the DTH program.

Dr. Ali is Associate Professor, Peninsula Dental School, Plymouth University, Plymouth, Devon, United Kingdom; Dr. Zahra is Senior Psychometrician, Peninsula Schools of Medicine and Dentistry, Plymouth University, Plymouth, Devon, United Kingdom; Dr. Tredwin is Professor of Restorative Dentistry and Head of Peninsula Dental School, Plymouth University, Plymouth, Devon, United Kingdom; Ms. Mcilwaine is Lecturer in Oral Health Sciences, Peninsula Dental School, Plymouth University, Plymouth, Devon, United Kingdom; and Dr. Jones is Director of Undergraduate Dental Studies, Peninsula Dental School, Plymouth University, Plymouth, Devon, United Kingdom. Direct correspondence to Dr. Kamran Ali, Peninsula Dental School, Room C523 Portland Square, Drake Circus, Plymouth University, Plymouth, Devon, PL4 8AA, United Kingdom; (+44) (0) 1752 586768; kamran.ali@plymouth.ac.uk.

Keywords: dental hygiene, dental hygiene education, dental therapy, dental therapy education, allied dental education, assessment

Submitted for publication 6/27/17; accepted 9/22/17
doi: 10.21815/JDE.018.015

Progress testing is aimed at a longitudinal assessment of the development and sustainability of knowledge at regular intervals over the duration of an educational program, predicated on a frequent-look rapid-remediation philosophy. The key objectives of progress testing are to provide repeated and comparable integrated assessments across the range of topic areas covered across a program.¹ Comparisons of performance on successive tests are used to monitor growth in knowledge. The results of the tests are combined to determine the growth of knowledge for each student, enabling more reliable and valid decision making about progression to later phases of study.² The regularity and frequency of testing support early recognition of students' learning needs and provide structured feedback that can be discussed with academic tutors or faculty members.

Progress testing was first used to assess the knowledge of medical students.^{3,4} It is now firmly established as a recognized form of assessment in predoctoral medical curricula.⁵⁻⁹ Our dental school was the first to use progress testing in its Bachelor

of Dental Surgery (BDS) program.^{10,11} Subsequently, we implemented progress testing in a joint undergraduate three-year program for dental therapy and hygiene (DTH). The aim of this study was to evaluate the effects of progress testing in this undergraduate program for DTH students as the main tool for academic assessment.

Dental Therapy and Hygiene Program

Peninsula Dental School in Plymouth, Devon, United Kingdom introduced its first cohort of DTH students in September 2014. Changes to regulations regarding direct access to dental care professionals had been announced by the General Dental Council (GDC) in 2013.¹² These changes, based on a consensus for shared care, drove the school to develop a new innovative program to address the changing demands of dentistry and tackle related issues in the profession today.

Design of DTH Program

The DTH and BDS programs are fully integrated in the first year of the course and have been designed to encourage interprofessional learning and effective teamwork from the very start. This approach has been adopted to overcome barriers to interprofessional working that traditional programs experience. These barriers not only inhibit teamwork and communication but also create a hierarchical working culture. Embedding teamwork into each day of the program creates understanding and respect for each other's roles, leading to greater utilization of team members' skills and aiming to improve patient care. As the two programs share learning outcomes and overlap in their scopes of clinical practice, teaching sessions and assessments are designed to support and enhance interprofessional education. This simulates the way in which dentists and dental hygienists and therapists interact in clinical practice.

Academic sessions consist of enquiry-based learning supported by interactive small group sessions, plenaries, workshops, and self-directed learning. These activities provide students with ample opportunities to discuss shared care, scope of practice, and their roles on the dental team. Students learn and share their clinical skills in the simulated dental learning environment and progress to the clinical environment together, where they are encouraged to work in a team. Where their teaching differs or elements of clinical practice extend beyond the DTH scope of practice, the focus changes from shared content learning to team-based teaching and learning. This focus allows students to explore profession-specific issues and gain a sense of professional identity and a place within the team.

As DTH students progress through their program, their clinical experience increases from one day per week in Year 1 to four days per week in Year 3. Senior cohorts of DTH and BDS students work alongside each other, gaining experience in planning and managing patient cases together, which prepares them for general practice and the future dental profession.

Progress Testing in DTH Program

The progress tests are aimed at assessing applied dental and therapy knowledge and are administered on three occasions annually (once per term). Each progress test is standard-set to the level expected of newly qualified dental hygienists and therapists as outlined by the GDC,¹³ and progress is

indexed by a steady increase in scores achieved. DTH students in Years 2 and 3 are required to sit all three tests, and their performance on these tests contributes to their progression in the program. DTH students in Year 1 sit only one formative test during the last term. Therefore, each class sits seven progress tests during the DTH program.

Each test is based on 100 single best answer multiple-choice items. Each question is based on a dental vignette that places the test item within a clinical context. The questions are aimed at testing the application, analysis, and synthesis of knowledge rather than simple factual recall. Each question has five possible responses plus a don't know (DK) option, but only one correct answer. A score of 1 is awarded for each correct answer, -0.25 for an incorrect answer, and 0 for DK.

Test production. A question bank was developed in-house for the DTH program, and all questions undergo a multistage quality assurance process before final inclusion in the bank. New questions are initially reviewed by senior academics and clinicians. Questions deemed to be appropriate are then submitted to a dental question writing group, which considers all details of each question before acceptance. Questions remain subject to further scrutiny during pretest and posttest meetings, which serve the purposes of reviewing items before assessments are produced and evaluating item performance after students have completed the assessment, respectively.

The entire question bank and individual progress tests are mapped against learning outcomes for dental hygienists and therapists in four key domains: clinical, communication skills, professionalism, and management and leadership skills. A blueprint for each test is produced to ensure the items measure a representative sample of the curriculum content and match specific learning outcomes for the DTH program. Approximately 50% (N=50) of the test items are allocated to the clinical domain; 10% (N=10) to communication skills; 15% (N=15) to professionalism; and 15% (N=15) to the management and leadership domain. The allocation of test items broadly mirrors the weighting of the four domains in the learning outcomes for the DTH program. Moreover, the test blueprint serves to identify any duplicate items. The aim is to assess applied knowledge related to all learning outcomes amenable to assessment in a multiple-choice examination format over the course of the program.

Standard setting. The standard of the questions is benchmarked against the knowledge expected from newly qualified dental hygienists and therapists.

The standard expected of a new graduate is set by a combination of criterion- and norm-referencing using a combination of the Angoff and Hofstee methods.^{14,15} A panel of experienced faculty members determines the difficulty level for each question in a test by indicating if a borderline (minimally capable) student is expected to answer the question correctly (Angoff method). The faculty members also indicate the minimum and maximum passing marks, along with minimum and maximum failure rates acceptable for a given test (Hofstee method).

The ratings are averaged across panel members for each item and then summed to obtain a panel-recommended cut-off score that represents the score expected from a minimally competent candidate (Year 3, newly qualified DTH graduate). The standard setting is then discussed further in a group setting during a moderation meeting to finalize the cut-off score for Year 3. The cut-off score for Year 2 is lower than Year 3 to account for differences in difficulty and variance between the two classes. The Year 3 cut-off score can be converted to a z-score, which expresses the number of standard deviations the pass mark is away from the Year 3 mean. The Year 2 standard is placed relative to the Year 2 mean at the same number of standard deviations.

Grade boundaries for unsatisfactory, borderline, satisfactory, and excellent are then constructed for individual tests. These grade boundaries are based on a combination of cut-scores, mean cohort performance, and standard errors of measurement (Table 1).

Progression of students. The three-year DTH curriculum has a modular structure, and students are required to pass all the modules in each year before progressing to the next stage. Individual test grades are combined to produce an end-of-year aggregate grade of satisfactory, borderline, or unsatisfactory at the end of Year 2. These aggregate grades are used for decisions on passing the module. Because of the progressive nature of the testing, Year 2 students who progress to Year 3 carry forward their end-of-year

aggregate grades. After each subsequent test in Year 3, the aggregate grade is combined with the test grade to provide a new aggregate grade. Students who retake a year commence the repeat year with the aggregate grade from the end of their most recent successful year. An overall module grade of excellent, pass, or fail is awarded based on the final aggregate grade in Year 3.

A key element of progress testing is to provide immediate and comprehensive feedback on performance to students. Feedback to the students includes grade boundaries, individual test scores, and grade. Moreover, students receive their ranking in the class, progress in relation to previous sittings, and details of correct, incorrect, and DK responses. As part of the feedback, a short statement outlining the main learning outcome being addressed by each test item is also provided along with the student's response to that item.

Methods

Ethical approval for this study was obtained from the Peninsula Dental School Institutional Review Board (Number 16/17-695). Examination data related to seven progress test sittings conducted over a period of three years (2014-17) for all undergraduate DTH students were collated. The study population consisted of three cohorts of DTH students.

Analyses of data were undertaken using the R statistical language and environment.¹⁶ Analyses included simple descriptive statistics and distribution plots, reliability measures, demographic analysis, and classical test theory-based item analyses.¹⁷ This information is used at posttest meetings to review the standards of the assessment and identify items for review and possible exclusion. While statistical analyses guide the assessment, the decision to remove any item is at the discretion of subject experts attending the posttest meeting.

Table 1. Criteria for applied dental therapy knowledge test grade boundaries

Grade	Criteria
Excellent	Score is greater than or equal to the standard +1 standard error of measurement and is equal to or greater than 1 standard deviation above the mean.
Satisfactory	Score is greater than or equal to the standard +1 standard error of measurement, but less than the mean +1 standard deviation.
Borderline	Score is greater than or equal to the standard -1 standard error of measurement, but less than the standard +1 standard error of measurement.
Unsatisfactory	Score is less than the standard -1 standard error of measurement.

Results

Data for all students in each cohort were included in the study. The 2014-15 cohort (N=9) sat seven progress tests; the 2015-16 cohort (N=11) sat four progress tests; and the 2016-17 cohort (N=18) sat only one formative test in 2017. Table 2 shows the mean scores out of 100 marks achieved on each test occasion, averaged across all cohorts.

Progress of the DTH students in the 2014-15 and 2015-16 cohorts is shown in Figure 1 and Figure 2, respectively. The analysis showed growth in students' knowledge as indicated by increase in correct responses and reduction in incorrect and DK responses for the cohort in successive years. The differences between Year 1 and Year 2 were particularly noticeable, which coincided with increased clinical exposure of the students. The overall test-retest reliability for the seven sittings in this data set was 0.76.

Table 2. Performance of students in progress tests

Test Occasion	Cohorts Aggregated	Mean Score	SD	Correct	Incorrect	Don't Know
1	2014-15, 2015-16, 2016-17	35.57	10.90	44.3%	34.8%	21.0%
2	2014-15, 2015-16	53.92	7.66	59.9%	23.7%	16.4%
3	2014-15, 2015-16	52.01	4.07	58.6%	26.2%	15.2%
4	2014-15, 2015-16	59.88	6.33	65.1%	20.7%	14.3%
5	2014-15	69.31	2.97	74.1%	19.2%	6.7%
6	2014-15	63.19	7.33	68.9%	22.9%	8.2%
7	2014-15	67.56	5.94	72.5%	19.6%	8.0%

Note: Test 1 was conducted in Year 1; Tests 2, 3, and 4 in Year 2; and Tests 5, 6, and 7 in Year 3. Sample sizes for each cohort were 2014-15 N=9; 2015-16 N=11; and 2016-17 N=18.

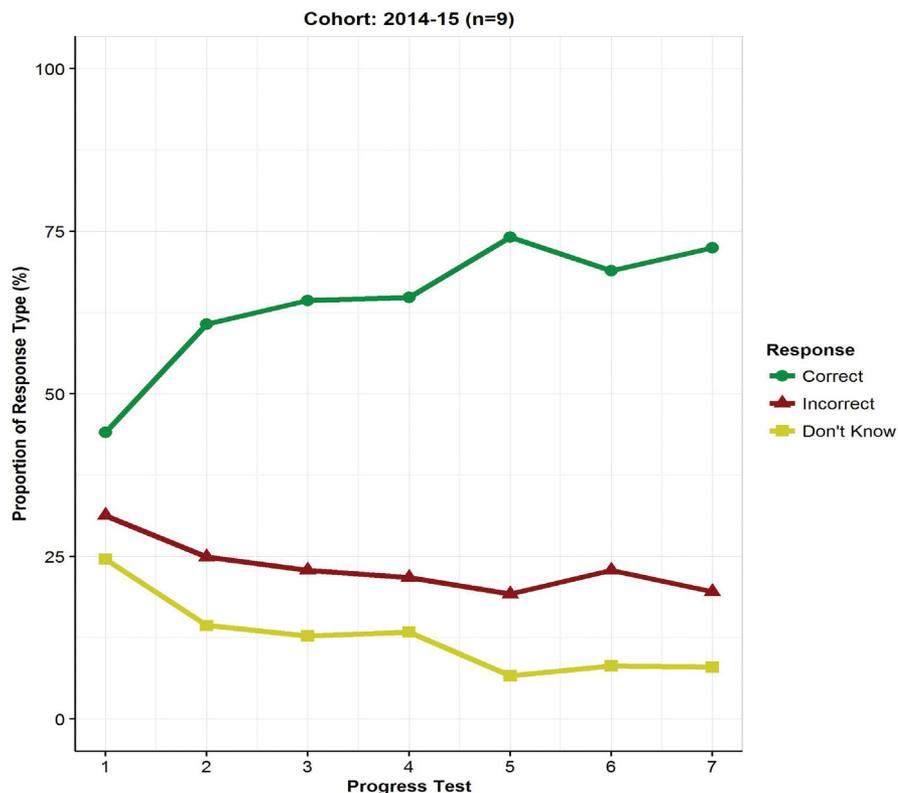


Figure 1. Performance of students in 2014-15 cohort: growth in knowledge over seven progress test sittings indicated by increase in correct responses

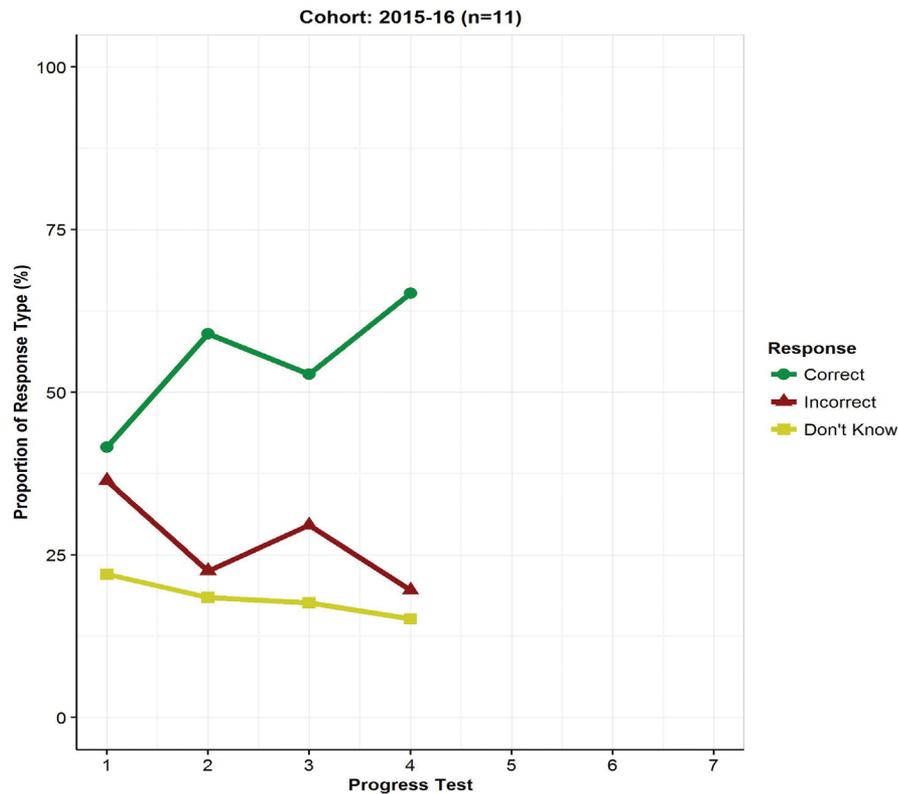


Figure 2. Performance of students in 2015-16 cohort: growth in knowledge over four progress test sittings indicated by increase in correct responses

Discussion

This was the first study to report on the establishment and use of progress testing as the principal form of knowledge assessment in an undergraduate dental hygiene and therapy program. Progress testing offers several advantages compared to traditional yearly assessments. First, testing at regular intervals over the course of an educational program allows close monitoring of the growth in applied knowledge. Setting the standard of questions at the level of a new graduate, progress testing facilitates assessment of the learning outcomes of an educational program in an integrated manner. Second, use of appropriate vignettes in questions provides context and relevance to clinical practice, which may enhance students' motivation for learning and facilitate their ability to generalize knowledge to clinical settings. Test items based on a carefully constructed clinical vignette are more likely to achieve this application than non-contextualized test items.¹⁸ Third, assessment of

functional knowledge encourages students to acquire information and develop understanding, breaking the link between learning and revision. Therefore, it may serve to break the relationship between the taught program and assessment.³ By contrast, traditional methods involving subject-based assessments at the end of each module or academic year may promote surface and rote learning of facts. Finally, progress testing provides vastly superior opportunities for feedback on internal and external evaluations. It allows students and their academic supervisors to identify the learning needs of individual students in order to improve their applied knowledge in subsequent years.^{2,3,19}

Development and use of progress testing are labor- and resource-intensive tasks. Development of a suitable question bank, multiple test administrations, and psychometric analyses of data require considerable faculty time.³ Moreover, students in early years may find the assessment challenging due to limited knowledge. Nevertheless, appropriate guidance and support by the academic staff may help to moderate

students' expectations in the first year. We aim to avoid repetition of questions for a class for the entire duration of the program. Preparation of test items in sufficient numbers to populate repeated tests is time-consuming and has placed a considerable load on the staff involved in progress testing for the DTH program. Unlike in medicine, there are no shared banks of DTH questions from which test items can be drawn.¹⁵ Perhaps future collaboration amongst institutions providing DTH education may facilitate the development of shared question banks to overcome this challenge and provide new and interesting opportunities for developing and evaluating teaching and feedback.

The results of this study demonstrate growth in the applied knowledge of the DTH students similar to that reported previously for medical and dental students.^{5,6,11} The DTH students' Year 1 mean score was 35.6, which may appear to be high. However, it needs to be reiterated that Year 1 students take their first test in the last term, by which time they have not only had a substantial proportion of their preclinical teaching in the simulated dental environment but have also started seeing patients in clinic. Moreover, some DTH students also have previous qualifications and experience including dental nursing. These factors may explain the apparently high score in Year 1. Within our data set, the growth in knowledge was most remarkable in the transition from Year 1 to Year 2, gradually reaching a plateau in Year 3. This trend may be related to the progress tests' becoming a high-stakes examination and a requirement to pass Year 2. Moreover, increased clinical exposure could also contribute to greater ability to apply knowledge to questions based on vignettes and clinical problem-solving.

Use of negative marking for incorrect responses with a penalty of -0.25 per incorrect response is consistent with practice for the undergraduate medical and dental progress tests at our institution.⁵ This approach is in line with our sister medical school.²⁰ Although negative marking is not used consistently in progress testing, the rationale is to discourage guess work by students, which may potentially lead to falsification of test scores. This approach may be appropriate for specialized assessments like progress testing, while a "number right" approach (scores based on right answers only) may be preferred for normal achievement tests.²¹ Inclusion of a DK option is aimed at reinforcing the need to recognize personal limitations in knowledge in clinical practice. This self-awareness is an important element of profession-

alism and patient safety. However, further research is required to evaluate the practice of negative marking in progress testing. Such research may involve qualitative interviews with the students to gain an understanding of their perceptions and approaches to negative marking.

Progress testing on multiple occasions in each academic year generates large amounts of data that can be used to provide feedback.²² The students at our school are required to reflect on their performance with their academic tutors at portfolio appraisals once per term. In addition, students receiving an unsatisfactory or borderline grade in a progress test are offered remediation and study skills courses to bridge the gaps in their learning—a task that the item-by-item and cumulative domain-level feedback helps to support.

A limitation of our study is the small sample size, and therefore, the results need to be interpreted with a degree of caution. Also, since the study was conducted in only one program, its results may not be generalizable to students in other programs. Nevertheless, we use several measures to evaluate the validity and reliability of progress testing for our DTH students. External validity is contributed to by involvement of subject experts and academics in the development and review of progress testing, blueprinting of questions to GDC learning outcomes, and review by external examiners. Predictive validity of progress testing has also been reported previously.² We run a number of different analyses, including looking at descriptives (mean, standard deviation, minimum, maximum, median, interquartile range, both overall and within cohorts); distributions including outliers (overall and within cohorts); proportions of response types within and between cohorts and tests; analysis of item facilities and response rates (within and between cohorts); differences in item facility between first and final stage students (growth); and scrutiny of response patterns (frequencies and proportions of each response option chosen) by students in each stage for each item. These analyses are used to give a statistical overview of the test, item, and cohort performance. The overall test-retest reliability currently averages $r=0.76$, indicating satisfactory reproducibility of the test and low level of random measurement error. We acknowledge that a larger sample size would be ideal to perform more robust statistical analyses. We are hopeful that, if other institutions involved in DTH education adopt progress testing in the future, it may be possible to undertake further analysis of test properties.

A variety of pedagogic approaches are used in DTH curricula. Previous studies have found that dental hygiene education programs are incorporating evidence-based approaches in teaching and learning.²³⁻²⁶ However, limited published literature is available on the assessment methods used to assess knowledge for DTH students. Progress testing serves as a useful longitudinal assessment tool to compare the growth in applied knowledge between different schools. However, further research is required to explore the feasibility and benefits of progress testing in DTH education. We welcome contact from those involved in other DTH programs nationally and internationally.

Conclusion

The results of this study support the idea that progress testing is a useful assessment tool to measure growth in applied dental hygiene and therapy knowledge and offers tremendous opportunities for structured feedback to address individual learning needs. Notwithstanding the challenges related to faculty time and resources, there is merit in considering the use of progress testing in dental hygiene and therapy programs.

Acknowledgments

The authors would like to thank all members of the academic and administrative staff who have contributed to progress testing in the DTH program.

Disclosure

The authors reported no conflicts of interest.

REFERENCES

- Schuwirth LW, van der Vleuten CP. The use of progress testing. *Perspect Med Educ* 2012;1(1):24-30.
- Schuwirth L, Bosman G, Henning R, et al. Collaboration on progress testing in medical schools in the Netherlands. *Med Teach* 2010;32:476-9.
- Van der Vleuten CPM, Verwijnen GM, Wijnen WHFW. Fifteen years of experience with progress testing in a problem-based learning curriculum. *Med Teach* 1996; 18:103-10.
- Blake JM, Norman GR, Keane DR, et al. Introducing progress testing in McMaster University's problem-based medical curriculum: psychometric properties and effect on learning. *Acad Med* 1996;71:1002-7.
- Freeman A, Ricketts C. Choosing and designing knowledge assessments: experience at a new medical school. *Med Teach* 2010;32:578-81.
- Nouns Z, Georg W. Progress testing in German-speaking countries. *Med Teach* 2010;32:467-70.
- Tomic ER, Martins MA, Lotufo PA, Benseñor IM. Progress testing: evaluation of four years of application in the school of medicine, University of São Paulo. *Clinics (Sao Paulo)* 2005;60(5):389-96.
- Al Alwan I, Al-Moamary M, Al-Attas N, et al. The progress test as a diagnostic tool for a new PBL curriculum. *Educ Health (Abingdon)* 2011;24(3):493.
- Aarts R, Steidell K, Manuel BAF, Driessen EW. Progress testing in resource-poor countries: a case from Mozambique. *Med Teach* 2010;32:461-3.
- Bennett J, Freeman A, Coombes L, et al. Adaptation of medical progress testing to a dental setting. *Med Teach* 2010;32(6):500-2.
- Ali K, Coombes L, Kay E, et al. Progress testing in undergraduate dental education: the Peninsula experience and future opportunities. *Eur J Dent Educ* 2016;20(3):129-34.
- GDC announces controversial decision on direct access. *Br Dent J* 2013;214(8):379.
- General Dental Council. Preparing for practice: dental team learning outcomes for registration. London: General Dental Council, 2011.
- Verhoeven BH, Van der Steeg AFW, Scherpbier AJJA, et al. Reliability and credibility of an Angoff standard setting procedure in progress testing using recent graduates as judges. *Med Educ* 1999;33:832-7.
- Cizek GJ, Bunch MB. Standard setting: a guide to establishing and evaluating performance standards on tests. London: Sage, 2007.
- R Core Team. R: a language and environment for statistical computing. At: www.R-project.org/. Accessed May 2017.
- McAlpine M. A summary of methods of item analysis. CAA bluepaper number 2. Glasgow: CAA Centre, 2002.
- Van der Vleuten CP, Schuwirth LW, Muijtjens AM, et al. Cross institutional collaboration in assessment: a case on progress testing. *Med Teach* 2004;26(8):719-25.
- Freeman A, Van der Vleuten C, Nouns Z, Ricketts C. Progress testing internationally. *Med Teach* 2010;32: 451-5.
- McHarg J, Bradley P, Chambelain S, et al. Assessment of progress tests. *Med Educ* 2005;39:221-7.
- Muijtjens AMM, van Mameren H, Hoogenboom RJI, et al. The effect of a don't know option on test scores: number-right and formula scoring compared. *Med Educ* 1999;33:267-75.
- Coombes L, Ricketts C, Freeman A, Stratford J. Beyond assessment: feedback for individuals and institutions based on the progress test. *Med Teach* 2010;32(6):486-90.
- Chichester SR, Wilder RS, Mann GB, Neal E. Incorporation of evidence-based principles in baccalaureate and nonbaccalaureate degree dental hygiene programs. *J Dent Hyg* 2002;76(1):60-6.
- Battrell A, Lynch A, Steinbach P, et al. Advancing education in dental hygiene. *J Evid Based Dent Pract* 2014;14(Suppl):209-21.
- Furgeson D, Kinney JS, Gwozdek AE, et al. Interprofessional education in U.S. dental hygiene programs: a national survey. *J Dent Educ* 2015;79(11):1286-94.
- Gadbury-Amyot CC, Bray KK, Austin KJ. Fifteen years of portfolio assessment of dental hygiene student competence: lessons learned. *J Dent Hyg* 2014;88(5):267-74.