Dissertation

„Teaching- and learning quality of the oral-surgical education in the undergraduate dental curriculum at the Medical University Graz“

“Lehr- und Lernqualität in der klinischen zahnärztlich-chirurgischen Ausbildung an der Medizinischen Universität Graz“

submitted by

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Declaration and Disclosures

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Abbrevations

ADEE	Association of Dental Education in Europe
CTT	Classical test theory
DPT	Dental Progress test
EAHE	European Area of Higher Educational
ECTS	European Credit Transfer System
EHEA	European Higher Education Area
EU	European Union
GDC	General Dental Council
ICC	Item characteristic curve
ICR	Inter quartile range
IMS^2	Item management system
IRT	Item response theory
MCQ	Multiple choice question
Mini-CEX	Mini clinical evaluation exercise
NBME	National Board of Medical Examiners
NEBEOP	Network of Erasmus Based European Orthodontic Postgraduate Programmes
OSCEs	Objective clinical structured examinations
PBL	Problem based learning
PCD	Profile and Competences Document
PT	Progress test
TNP	Thematic Network Project
UK	United Kingdom

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Zusammenfassung

Einleitung:
Basierend auf dem vor 20 Jahren initiierten Bologna-Prozess, haben die Europäischen Universitäten wesentliche curriculare Änderungen, vor allem in Richtung Harmonisierung und Vergleichbarkeit, vorgenommen. Dementsprechend wurde auch das Zahnmedizinstudium in Österreich 1998 implementiert und wird seither auch in Graz angeboten. Im präklinischen Abschnitt wird theoretisches Basiswissen vermittelt. Im klinischen Teil steht im Sinne einer Berufsausbildung eine umfassende praktische zahnmedizinische Ausbildung als Vorbereitung auf ein sicheres und unabhängiges Arbeiten als Zahnarzt/Zahnärztin im Vordergrund. Die Studierenden durchlaufen dabei im Wesentlichen die Fachbereiche Restaurative Zahnmedizin, Orale Chirurgie, Parodontologie, Prothetik und Kieferorthopädie. Trotz des subjektiven Eindrucks, eine qualitativ hochwertige Ausbildung anzubieten, entspricht die Qualifikation der Absolventen nicht immer den Erwartungen der Lehrenden. Aus diesem Grund wurde im Sinne einer Qualitätskontrolle die folgende prospektive Studie initiiert. Dabei werden erstmals mittels einer speziellen longitudinalen Prüfungsmethode – dem sogenannten Zahnmedizinischen Progress Test – Wissensniveaus und Wissensunterschiede in der oralchirurgischen Lehre standardisiert evaluiert.

Material und Methode:
Sämtliche Zahnmedizinstudierende im klinischen Abschnitt (Semester 7-12) wurden zwischen Sommersemester 2016 und Sommersemester 2017 zur Teilnahme am Oralchirurgie - Progress Test verpflichtet. Der Test wurde jeweils zum Semesterende angesetzt und fand dem entsprechend dreimal statt. Aus einem eigens für das Projekt kreierten, 375 Fragen umfassenden Fragenpool, wurden die drei einzelne Tests mit je 100 Fragen zusammengestellt. Die statistische Auswertung inklusive Rasch-Analyse erfolgte am Ende dieser Phase.

Ergebnisse:
Insgesamt nahmen 173 Studierende, bestehend aus Männern und Frauen im Verhältnis 1:0.7, an allen drei Tests teil. Im Post-Review mussten 6 Fragen ausgeschlossen werden. Die Ergebnisse zeigten ein ähnliches Anwortverhalten bei allen drei Tests für die Kategorien „richtig", „falsch" und „weiß nicht" (Test 1: 61.6%, 26.6%, 11.8%; Test 2: 56.0%, 27.8%, 16.3%; Test 3: 62.1%, 26.5%, 11.4%), welches auch mit der Literatur vergleichbar ist. Es konnte eine deutliche Zunahme der richtigen Antworten zwischen 4. und 5. Jahr mit $p < .001$

und zwischen 5. und 6. Jahr mit $p = .002$ verzeichnet werden, jedoch nur in Test 2. Eine signifikante Abnahme der "weiß nicht" Antworten zeigte sich in Test 1 und 2 von Jahr 4 auf 5 mit $p = .003$ und $p < .001$ und von Jahr 5 auf 6 mit $p < .001$ bei beiden Tests. Was die „falsch" Antworten betrifft, so konnte sogar ein signifikanter Anstieg, jedoch nur in Test 1 von Jahr 4 auf 5 ($p = .009$) und 5 auf 6 ($p = .022$) festgestellt werden.
Die Reliabilität der drei Tests bewegte sich zwischen 0.82 und 0.88. Die Rasch Analyse zeigte für die Tests 1-3 folgende Ergebnisse: T1: $\chi^2 = 51.071$, $df = 74$, $p = .981$; T2: $\chi^2 = 57.044$, $df = 67$, $p = .802$; T3: $\chi^2 = 58.443$, $df = 72$, $p = .876$. Weiteres konnte erhoben werden, dass die Fragenschwierigkeit, bezugnehmend auf die vier angewandten Themenbereiche, ebenso gleichmäßig verteil war.

Schlussfolgerung:
Der präsentierte Progress Test für Zahnmedizin erlaubte zum ersten Mal eine standardisierte Evaluierung und dynamische Darstellung des oralchirurgischen Wissensniveaus der Zahnmedizinstudierenden an der Medizinischen Universität Graz. Es konnten sowohl punktuell der aktuelle Wissensstand, als auch die Unterschiede innerhalb der Semester-Kohorten, abhängig vom Ausbildungsstand, erhoben werden. Weiteres konnten ein erfreulich homogenes Antwortverhalten, eine ähnliche Verteilung der ein- und ausgeschlossenen Fragen innerhalb der Tests und Fachbereiche und eine adäquate Schwierigkeitsgradverteilung gezeigt werden, was den Grundstein für weitere Projekte legt.

Abstract

Introduction:

Based on the Bologna process, which was initiated 20 year ago, higher education institutions throughout Europe have changed their study programmes significantly, targeting on harmonisation and comparability. The study programme of “Dental medicine” was introduced in Austria in 1998 and has, since then, also been offered in Graz. In the preclinical years scientific basics are taught. In the clinical part an all-encompassing practical education, by means of a vocational training, preparing students to become safe and independent dental practitioners, stands in the foreground. Students engage with the main dental disciplines including restorative dentistry, oral surgery, periodontology, prosthodontics and orthodontics. Despite the subjective impressions of offering a high qualitative dental education, student outcomes do not always meet the expectations of the educators on the daily basis. A prospective study was undertaken with the undergraduate dental students as a form of quality control. The intervention facilitated the evaluation of knowledge levels and differences regarding the oral surgery education in the undergraduate dental curriculum of the Medical University of Graz for the first time in a standardised way, using Dental Progress Test (DPT) as a recognised longitudinal assessment tool.

Material and methods:

DPT participation was introduced as a compulsory examination for all dental students passing their clinical education (terms 7-12) between summer term 2016 and summer term 2017. Assessments took place at the end of the term and were administered three times. Out of a specially created 375 items including question pool, three single tests were administered with 100 questions each. Following test delivery, descriptive and explorative, as well as Rasch analyses were used for evaluation.

Results:

Overall 173 students, (male: female/ 1:0.7), participated in all three tests. In the post-review process a total of 6 items was excluded. Item responses resulted in similar levels at all three test time points for the categories “correct”, “false” and “don’t know” (Test 1: 61.6%, 26.6%, 11.8%; Test 2: 56.0%, 27.8%, 16.3%; Test 3: 62.1%, 26.5%, 11.4%). These results were comparable to those reported in the literature. A significant increase in “correct” answers from 4th to 5th year with $p < .001$ and from 5th to 6th year with $p = .002$ was obsereved, how-

ever only in Test 2. A significant decrease of “don’t know” answers was seen in Test 1 and 2 from year 4 to 5 with $p = .003$ and $p < .001$ and from year 5 to 6 with $p < .001$ at both. Concerning “false” answers, even a significant increase occurred, however only in Test 1 from year 4 to 5 with $p = .009$ and from year 5 to 6 with $p = .022$. The reliability ranged from 0.82-0.88 at all three tests. Within the Rasch analyses the assumption of parallel ICC was met (T1: $\chi^2 = 51.071$, $df = 74$, $p = .981$; T2: $\chi^2 = 57.044$, $df = 67$, $p = .802$; T3: $\chi^2 = 58.443$, $df = 72$, $p = .876$) and item difficulties for the thematic fields were similarly distributed across the latent dimensions.

Conclusion:

The use of DPT resulted in the first standardised evaluation of applied dental knowledge related to the undergraduate oral surgical curriculum at the Medical University of Graz. Subsequently, knowledge levels as well as variation of knowledge between the term cohorts, depending on their education status, could be documented.

Results showed a favourable, homogeneous response behaviour, along with a similar distribution of included and excluded items within the separate tests and fields. Furthermore, an accurate range of difficulty of the questions could be drawn from the collected data, which provides the basis for further research.

1. Introduction

1.1. Research issue and aim

With respect to dental education in Austria a significant change in systems took place in 1998. At that time postgraduate specialist dental training after graduation as a medical doctor was transformed into an undergraduate degree study programme “Dental medicine”. (1,2) This process was based on the specifications of the European Union (EU), which aimed to create a harmonised university landscape, the so called EAHE (European Area of Higher Education), together with all member states of the Bologna process. (3,4) The rationale behind this was to facilitate the promotion of the Intra-European Academic Exchange and to improve the comparability of studies and degrees. (3,5)
In Austria access to dental education was limited and since then it has been variously regulated between the public and private university locations, which have been acting autonomously and have created their separate curricula. Even though 20 years have passed since the launch of Bologna process, there is still a lack of uniformity in dental education within the Dental faculties in Austria and Europe. (2,6-10) As a result of this and based on Austrian law (11), it makes it difficult to compare the quality of the education and graduates nationwide.

At the Medical University of Graz currently 24 study places are available for freshers per year, chosen by an entrance examination. The degree study of “Dental medicine” is divided into three parts with the minimum consecutive study period of twelve terms, over six years. After well-founded modular scientific and general medical teaching, the third and clinical part is concentrated on patient-centered practical training. This is of utmost importance, because of the priority around the creation of a qualified and well-educated vocational practitioner; where graduating means being fully licensed and the authority to provide independent patient-care without any further compulsory training. For this reason, highly competent graduates have to be guaranteed in providing sophisticated, safe and affordable state of the art dental care for the general public now and in the future. (2,4)

Although the subjective impression of offering a high-quality oral surgery education is present, it seems that despite a small number of students, a low lecturer-student ratio and a practice-oriented curriculum, learning outcomes are not always on the same high level as expected from educators. Reasons therefore, can be manifold and might be related to multidimensional learning contents, a lack of teaching quality, organisational problems, lack of authentic assessments as well as inadequate quality of students. As a result of this the aim of this prospective study was undertaken to focus on teaching and learning quality in undergraduate dental education at the Medical University of Graz for the first time. Therefore, a special form of assessment method for the clinical education element (with a focus on oral surgery) the so-called Dental Progress test (DPT) (12), was developed and implemented with the following aims.

- To achieve an ad hoc overview about student’s knowledge.
- To get an overview about knowledge variations over the course of the third study section.
- To evaluate, if the test is suitable for the target group
- To compare the developed test with data from the literature.
- To initiate curricular changes where appropriate to be prepared for the educational challenges in the next decade.
- To initiate an assessment method for better comparability both nationwide and internationally with the aim of supporting collaboration with other teaching faculties, and to be able to react with the adaption of curricula such as the Bologna process suggests.
- To establish a base for further extension of novel assessments into the entire dental medicine undergraduate programme.

1.2. Background

1.2.1. Teaching and learning quality

It is challenging being a teacher in a higher education institution, because as Hageman-White (1976, translated from German) has previously defined *"There is no other possibility of learning how to be a university teacher (other) than choosing employment limitations. Those who are solely focused on learning how to teach during this time, will not be able to continue their job, because of a lack of research work."* (13) Although this quote still might have its right to exist, it is still difficult to define the term of teaching quality itself. (14) Although quality assessment in teaching is clearly seen as an indispensable process (15) and it has a long-standing tradition, there is no general consensus about it in literature. (14,16-18) It can be considered that the interpretation of teaching excellence is closely connected with the role of those, who are interpreting the term. (14) This can widely vary between educational staff, amongst students and graduates as well as politicians and employers. (14) This is further influenced by a changing social, economic and political context. (19) Brusoni et al. (2014) (20) found that excellence in teaching is closely connected with the individual spirit of each single teacher and how learning objectives are embedded into well-organised lectures. They also see a key element in how tutors interact with students and engagement based on mutual respect. Additionally, it can be seen in the context of how students are satisfied as well as how high their assessment results are. (20) Excellence in quality can be interpreted by the efficiency of the taught material, which allows students to achieve high levels in their exams. Additionally, it could may be related to impetus towards self-directed studying and developing a deeper understanding and knowledge. (20) In this context Elton (1998) (18) defined that teaching excellence is multidimensional. To be developed, excellent teaching has to be recognised and rewarded, evaluated similar like research as far as those who are judging are familiar with high quality teaching. Furthermore, training for the trainers is of utmost importance and links staff development with the field of quality assurance. (18)

Individual teaching excellence is a prerequisite; however, it is not enough to ensure outstanding student learning. Furthermore, it is imperative to have a sufficient support from the teaching institution, which can be complement the initiatives of individual faculty efforts. (18) As reported by Gunn and Fisk (2013) (14), between two concepts of excellence can be distinguished. The first one is related to individual teachers' attitudes and methods and the second one is related to circumstances such as the teaching field and specifies from the higher education institution. (14,16) Gibbs (2008) (21) summarised that in the context of excellence in

teaching the student should be in the main focus and a wider focus on the development of curricula is more essential than just a micro-focus. Furthermore, innovations which influence others in teaching and the scholarship of teaching itself play essential roles. (21) While, excellence can also be defined norm-referenced, relative to the performance of others, or criterion-referenced, relative to a predefined standard. (16) In any case, diversity of higher education institutions, targeting individual objectives should be included. (17) An interesting aspect to consider is noted by Bradley et al. (2015) (22) with their investigation of teaching excellence from a student's point of view: they identify the most important factors influencing student learning including the enthusiasm of a teacher towards the subject, the motivation of students to achieve higher goals, the approachability and a positive attitude towards learners.

Considering possible metrics of teaching quality, Berk (2005) (23) offers twelve points, which allow to investigate teaching effectiveness either formative or summative, or both including "*student ratings; peer ratings; self-evaluation; videos; student interviews; alumni ratings; employer ratings; administrator ratings; teaching scholarship; teaching awards; learning outcome measures; and teaching portfolio"*. In this context it has to be mentioned, that these might serve as a rich source for individual teacher's reflection. For inter-institutional comparison however, they are described to be less useful, because of their qualitative and institution-specific nature. In this context quantitative aspects such as in- and output metrics, process metrics and rankings seem to be more relevant. (16)

Overall, the definition of teaching quality, is indeed difficult, not least because there is little data available about the academic point of view. This may be related to difficulties in articulating what is specifically meant by teaching quality. Students however have clear ideas what a good teacher should stand for. (22,23) Nevertheless measuring teaching quality is a highly important subject, which on the one hand can be seen from a formative point of view, to improve the own performance and on the other hand from a summative point of view, to find decisions around teacher's employment. (23) In Austria quality control in higher education is regulated by law (24), and validated by accreditation, audit, analyses and reports or consulting from the Agency for Quality Assurance and Accreditation: in the case of supporting higher education institutions, as highlighted in the Bologna process. (25)

1.2.2. Dental education in Austria up to 1998

For the purpose of a Europe-wide comparability of educations and the growing competitiveness, dental education was fundamentally changed in 1998 in Austria. Up to this date, a dual-system prevailed. On the one hand a non-academic "dentist" training and on the other hand a postgraduate academic qualification in dentistry with a joint degree in medicine was offered. By definition a "Dentist" was a non-academic dental technician, who went through theoretical and practical courses after final apprenticeship examination after a duration of three years in total. This group, offering parts of dental medicine, was entitled to the description "dental practitioner" by Austrian dentist law § 6 section 1. (1,26) Because of this parity with academic dentists, Austria was sued by the European commission in 2005. (27) However, with the termination of this kind of education in 1975 the number of practicing "dentists" decreased proportionally. (1,28) To date 11 remaining "dentists" are carrying on their occupational activities in Austria. (28)
Academic dental education was offered at the three public university locations Vienna, Graz and Innsbruck. After graduating in medicine, a 3-year course of gradual education enabled a 'specialism' in dentistry, which was associated with the coverage of the complete spectrum of general dentistry. With changing challenges in the last decade of the 20th century and in adjustment with the EU regulations, this university education was also terminated in 1998 (1,28) and followed by the implementation of an EU-validated study programme "dental medicine". (1,2,6,7)

1.2.3. Digression – Bologna process

Sorbonne joint declaration

Nationwide and international comparability of university teaching and learning, is an essential requirement. It plays an important role when targeting quality control and further pan-European movement on the labor market. Therefore, European efforts have been taking place during the last 20 years to promote this harmonisation. (3,29)
For a better understanding of this evolution, we have to consider the landscape in 1998 to recognise why the university education in Europe has undergone such a great change over the last 20 years. This process is by no means complete today and affects any person in connection with university work. (3,5,29,30)
The impetus for the process of change was the celebration of the 800 anniversaries of the Sorbonne University in Paris on 25 May 1998. On the occasion of this, the education ministers of France, Germany, Italy and the United Kingdom found that the common Europe should not only be defined by a common currency, but also by a common policy on higher education. This idea resulted in the so-called "Sorbonne Joint Declaration", a joint declaration on the harmonizing of the European higher education landscape, by the then-acting education ministers Claude Allegre (France), Luigi Berlinguer (Italy), Tessa Blackstone (UK) and Jürgen Ruettgers (Germany). These ministers and interestingly not the European commission, identified a high need for change in higher education across European countries. In particular, the migration of students, faculty and graduates, the dissemination of knowledge, adaptation to the requirements of the labor market, the international comparability of courses of study, as well as the shared recognition of university levels of education and the promotion of inter-university cooperation, the need for a common path has been defined and laid down in the form of the Sorbonne Joint Declaration. (5,29-31)

Bologna declaration

On June 19th, 1999, one year after the signing of the Sorbonne Joint Declaration, the start of the so-called "Bologna Process" was launched. The Italian conference venue "Bologna" thus became the name giver for the declaration of the same name and the process that was initiated by it. The selection of Bologna was a deliberate act, the symbolism as the oldest university location in Europe was showcased. With the signing of the "Bologna Declaration – Joint Declaration of the European Ministers of Education", the decision was made to launch a "European Higher Education Area" (EHEA) on the basis of voluntary work. No less than 30 European countries, both EU members and non-members, took part in this unique project and presented the competitiveness and attractiveness of European higher education, the promotion of mobility and employability in the European area with shared recognition of fields of study and academic training, as well as the need for quality assurance in the foreground. As an economic model, therefore, education-related borders should be easier to cross, and this process was scheduled to completed by 2010. (5,29,31,32)

Aims of Bologna process

In order to establish the EHEA and to better position European higher education worldwide, the Bologna declaration defined 6 primary objectives. (5,29,31,32)

1. The introduction of easy-to read, understandable and comparable academic degrees, as well as the installation of a "diploma supplement", which provides a proof of the completion of a study. As a result, the internationalization of the employability of the individual European citizens should be given.
2. The introduction of a more cyclic system with subdivision into an under-graduate and a post-graduate phase with corresponding degrees as bachelor, master and finally doctor. The possibility of access to postgraduate training is regulated by the successful completion of the under graduate phase, which should last at least 3 years. The academic degree following the completion of the first training cycle should reflect the qualification of the graduate and be relevant to the European labor market. The second training cycle should lead to a degree such as master and finally a doctoral degree.
3. The implementation of a counting system for the teaching and learning extend under the model of the "European credits transfer system" (ECTS), which contributes significantly to the betterment of student mobility and can also be applied in the context of lifelong learning.
4. A fundamental endorsement of intra-European mobility for students as well as for academics, researchers and administrative staff with appropriate recognition and appreciation of the time spent abroad.
5. The promotion of internal European quality assurance with a long-term perspective, to design common criteria and instruments for evaluation and monitoring.
6. The Establishment of a European mindset when it comes to higher education. Above all, this concerns the development of curricula, inter-institutional cooperation, study programmes, training programmes and research. (5,29-32)

These six target definitions were valid at the time of signature of the declaration and still underpin the European basic idea of creating a common "European Area of Higher Education" by the year 2018. However, the cultural differences, differences in language and education systems, as well as the autonomy of individual universities were identified as potential issues which needed to be addressed. Follow-up meetings once every two

years to report on the implementation of these goals were agreed. It is important to note that this undertaking can be seen as a consequence of the idea of European integration, which has been pushed forward since the 1950s, and no less than 4000 institutions with over 16 million students were included instantly to form a common European path. From today's point of view, it can be said that the Bologna process, with its actual 48 member-states, represents a unique reform, which even seems to be the most essential structural change in a higher education area. (3,5,29-32)

1.2.4. National modifications in Austrian higher education

Austria reacted swiftly at the legal level: With the amendment 1999 on the University Law of Studies, the University Law 2002, the “University of Applied Sciences“ Law of Higher Education 2002 and the Higher Education Act 2005, the legal basis for the introduction of bachelor and master studies, the application of the ECTS, the diploma supplement, the establishment of joint study programmes of different universities/joint degree programmes and the amended PhD-like doctorate programmes were introduced. (10,33,34)

The establishment of a three-cycle or triple tier training system at universities is probably the most noticeable change that the Bologna process has brought. (35) Until the beginning of the turn of the millennium, educational programmes in Austria primarily awarded a diploma qualification. This has fundamentally changed over the last 20 years, even though system changes did not receive a positive reaction everywhere. (32,34,36-39,39)

The first cycle now concerns the so-called "Bachelor" degree. The Bachelor degree should comprise three years and have an amount of 180-240 ECTS points. During a Bachelor degree, scientific basics, methodological competence, as well as professional field-related qualifications should be taught. (38)

Within the framework of the second cycle – the master's training – there is a double-tracked system. Firstly, master programmes are organised in the form of short post-graduate courses lasting 1-2 years with 60-120 ECTS points. On the other, there are master programmes which follow the Bachelor degree and comprise a duration of 3-4 years with 180-240 ECTS points. In general, a master's training should be of two years duration.

The third cycle relates to doctoral studies with the doctorate/PhD degree. Programs cover an amount of work of 3-4 years in full-time employment, but do not need to specify ECTS since 2006. (32,34,37,38)

As already mentioned, the diploma degree courses are already in the minority and include areas of human medicine and dentistry, which is regulated by Austrian law. (10,11,38) Diploma studies are divided into 2-3 sections of comprehensive studies with a study period of up to 12 semesters and a degree with diploma thesis and diploma examination. (10,38) Especially in Austrian medical and dental education, a transition from diploma studies to a bachelor's and master's degree, similar to Germany (40,41), is basically not planned in the foreseeable future at public universities. (10,11) By definition, the Bachelor's degree is a professional qualification. (4,42) Thus, an independent medical activity after three years training cannot be expected and therefore, the medical and dental diploma studies may be more difficult to modify to follow this pattern. (43,44) However, to improve the practice-relevance and professional qualifications, the medical universities have modified the sixth year of the diploma course in human medicine as a clinical year. (43,45)

Concerning dental medicine; 72 weeks traineeship including a third study section has contributed to creating conditions for practical training since its introduction in 1999. (2,6,7) Despite the efforts to implement the Bologna programme as faithfully as possible, Austria still needs to catch up with the description of concrete local and nationwide learning objectives, which would be an essential and urgent step to enable and increase national and international comparability. (37,44)

1.2.5. Two decades after Bologna

As part of the Ministerial Conference in Leuven 2009, it was noted that in the course of the previous decade it had been possible to establish the EHEA in the 46 participating countries. Thus, the goal of the Bologna declaration was basically achieved. However, it was also necessary to realise that not all points could be fully implemented and that the progress of the implementation also varied in different countries. Subsequently, it was decided to continue the Bologna process past the year 2010 and to define further target definitions for the coming decade. (29,35,46) In May 2018, 48 member-state ministers met again in Paris to discuss the progress made within the EHEA over the previous 20 years. In general, major reforms in higher education across Europe demonstrate what a joint effort and continuous dialogue among governments and the higher education sector can attain. As the 2018 "Bologna Process Implementation Report" (Paris communique) shows, advances have been made, while implementation still remains uneven between policy areas as well as countries. (29) So, there are still points as noted in the Paris communique on what member-states have to work on. For instance, recognition of qualifications and study periods throughout the EHEA still have to be amended. Therefore, automatic and full appreciation of ECTS credits is necessary. Moreover, an implementation and digitisation of diploma supplements for supporting student's data exchange should be encouraged and ECTS short-cycle qualifications, to provide higher education to a broad public, should be expanded. However, a long-lasting success of EHEA significantly depends on the concerted efforts of national policymakers who originally ratified commitments, authorities, institutions, employees, students and other stakeholders. (29,46) However in this context the continuation of the Bologna process over the year 2020 has not been defined so far. (47)

As far as medical education is concerned, there are indeed trends and proposals for the further implementation and expansion of Bologna adapted training models. (8,9,43,48,49) Between Austrian Dental faculties however, this process seems to be impeded, based on the local circumstances, such as the national University law. (10,11)

1.2.6. Dental education in Austria after 1998

Development and overview

As already mentioned, in adjustment with the EU (and with the ratification of Bologna process) a new era was initiated in dental education, including in Austria. From that date only one legal academic dental education, degree study programme “Dental medicine”, graduating with the academic degree of “Doctor medicinae dentalis” (Dr. med dent.), has existed. (1,3,44) An aim of this development was to enable comparability between the majority of central European countries with the perspective of satisfying mobility within the EHEA, one of the main principles of the EU and the Bologna process. (3) In Austria, the programme is divided into at least 12-terms, over six years, including university study. This can currently be completed at three public (Vienna, Graz and Innsbruck) or two private universities (DPU Krems, SFU Vienna). It is divided into first, second and third segments, over which the final is focused over a 72-week all-encompassing and practice-oriented dental education. This revolves around the main fields of dentistry, including soft skills ethical, social and communication abilities. First and second phases, including 60 and 120 ECTS credits, have the task to support the acquisition of scientific as well as preclinical and medical competencies prior to the third phase which completes the required amount of 180 ECTS credits. (2,6-9,50,51) Access to the study programme “Dental medicine” is limited to public and private universities. At public locations it is regulated with an entrance examination based on the issues “scientific basic knowledge”, “text comprehension”, “cognitive skills”, “social-emotional skills” and “manual skills”, resulting in 72, 24 and 40 available study places for freshers in Vienna, Graz and Innsbruck respectively. After graduation no further, mandatory practical education is provided in Austria. (1,2,6-9,50,51) Post graduate doctorate programme as well as PhD can be continued after undergraduate education for at least a further three years optionally, but is mandatory for all who wish to pursue a career in academic dentistry. (34,52,53)

The degree study programme “dental medicine” is largely founded on the former specialist in dentistry education programme and trains students to become competent dental professionals with sufficient training for a smooth transition into their professional career. There is a focus on acquisition of scientific knowledge combined with practical skills which provide the foundation for a successfully practicing dentist. Furthermore, the educational programmes are aimed at the promotion of life-long learning and a critical thinking approach. (2,54,55)
In the context of Dentistry, the main disciplines of “restorative dentistry”, “prosthodontics”, “periodontology”, “oral surgery” and “orthodontics” as well as “maxillo-facial surgery” are concerned with provision of direct patient-care. (2,54,55) The challenge in Austria is, that all three public and two private Dental faculties are acting autonomously by law and there is no centralised regulatory authority as the General Dental Council in the UK. (10,11,56) As a result of this, the respective rectorate operates largely independently and in isolation from the other universities. (10,11) Besides basic predetermined framework conditions (4,10,11), which are also held responsible to the Agency of Quality Assurance and Accreditation Austria (25), there are so essential differences concerning performance and content of the curriculum; this includes lectures, examinations, learning objectives and practical education, existing. Because of different departmental compositions at the university clinics, practical teaching is given varying degree of priority in the curriculum and is not longer directly comparable between different higher education institutions. (2,6-9,51)

The study programme of dental medicine in Graz includes 360 ECTS credits held over 12 terms in the form of modules containing lectures, exercises, seminars, workshops, work shadowing and traineeships with the amount of 72 weeks (40 h per week) (2,54,55), as predetermined and already explained. (11) The first study section includes first two terms, respectively the first year, and has 60 ECTS credits. This part of education is similar to the local medical curriculum, which is provided in a modular format. It consists of mandatory tracks and modules in occupational practice (Weeks 1-3), basic sciences such as physics, chemistry or histology (PM I, PM II, Weeks 2-15), basics in dentistry (Weeks 2-8), first life aid (Weeks 2-3) and anatomy (Weeks 4-8). (Figure 1) (2,54,55)

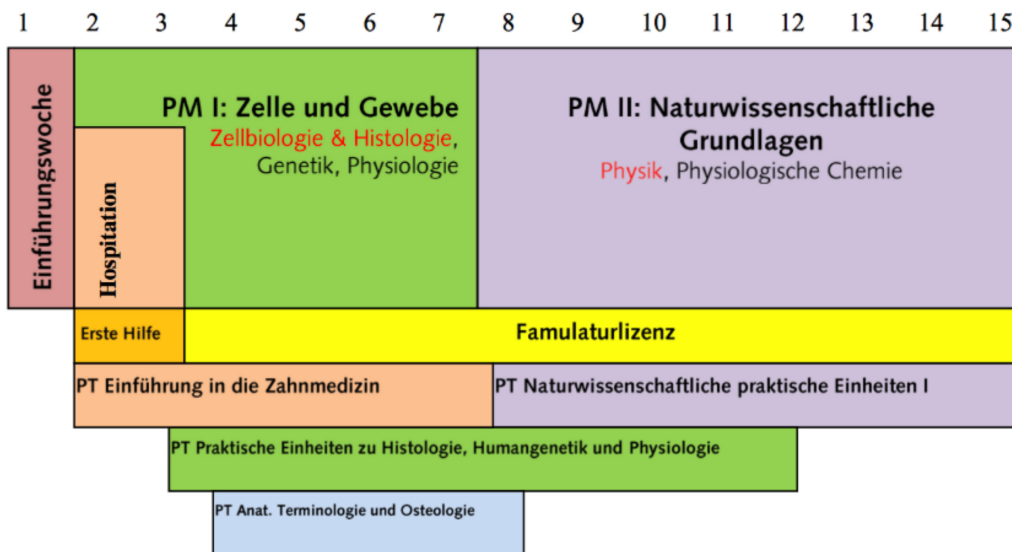


Figure 1: Example for the modularisation in the first study section, first term, distributed in weeks 1-15; (reproduced from the Curriculum of Dental Medicine Version 14 (57) with permission of the publisher (Medical University of Graz) [German])

The second study section includes 4 terms, in the second and third year, and includes 120 ECTS credits. Mandatory tracks and modules are taught, as shown in figure 2 (Figure 2), and comprise pre-clinical subjects such as histology, pharmacology, physiology or pathology as well as medical clinical basics ranging from internal medicine over pediatrics, radiology and orthopaedics (ZPM XIV) to neurology or dermatology (ZPM XV and XVII), otolaryngology (ZPM XVII) including head and neck anatomy (ZPM XVI) and many more. Meanwhile, the last term of the third year focuses on specific fields of dentistry in preparation for upcoming patient treatment. (2,54,55)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

ZPM XIV: Anästhesiologie, Chirurgie, Radiologie, Orthopädie	ZPM XV: Harn- und Geschlecht sorgane	ZPM XVI: Anatomie des Kopf-Hals-Bereichs	ZPM XVII: Kopf-Hals-Bereich HNO, Dermatologie, Kieferchir., Augenheilk.
Wissenschaftliches Arbeiten I			

Figure 2: Example for the modularisation in the second section, fifth term (reproduced from the Curriculum of Dental Medicine Version 14 (57) with permission of the publisher (Medical University of Graz) [German])

The third study section addresses the clinical dental education, including patient treatment. It consists of 6 terms including a 72 weeks traineeship within 180 ECTS credits. Within this phase students learn to apply theoretical knowledge into practical patient care and it engages with all clinical departments of the University clinic of dental medicine and oral health at the Medical University of Graz, starting with basic restorative dentistry, periodontology and oral surgery first. Prosthodontics, advanced restorative dentistry and orthodontics are included later in the years 5 and 6. Additionally theoretical and practical aspects of maxillofacial surgery are included. (2,54,55)

Graduation takes place with the academic grade of “Doctor medicinae dentalis”, given by the Medical University of Graz itself, following the successful completion of all examinations and defense of their diploma thesis and a practical case presentation. (2,54,55)

1.2.7. Diversity of Dental education in Europe

Although the Bologna process and the European Union unites European countries, they still have their own national autonomies in higher education. Therefore, it is clear, that on the basis of historical and country-specific interests, differences in dental trainings are still existing. (5,29,31) At the moment higher educational landscape in Europe is diverse and consistent of around 200 dental faculties, operating autonomously within their own countries. (49,58,59) To illustrate this aspect, an internet search, based on the EU Manual 2015 (60) and on website information from 1 to 3 representative universities of each EU country, was done to highlight common features and differences between the following EU member states. (Figure 3-6) (2,40,41,56,58,60-91) According to the number of 28 present EU member states, 26 were identified hosting dental faculties. (Figure 3, 4) These 26 countries are offering one or two cycled undergraduate dental training programmes, which lead either a bachelor's, a master's, a diploma or doctoral degree. Two of the 26 countries are still offering a bachelor's degrees (Bachelor of Dental Surgery) (Figure 3). Five countries are offering a combined bachelor's and master‘s degree. However, just three of them have separated both cycles, while the other two have integrated the bachelor‘s into master‘s degree. In contrast, 10 countries are still awarding the “doctor degree” for the undergraduate education, while three are only awarding the diploma „dentist “. (Figure 3) In these programmes, the doctor degree can be achieved after practical work and completion of a thesis, however this is not equivalent to the post-doctorate study of “Doctor of Health sciences”.

There is greater consistency in the award of ECTS credits (Figure 5): From 21 out of the 26 investigated countries, availability of the ECTS system could be found. 14 offer 300 ECTS credits, whilst seven offer more. For five countries no information could be found. The intended period of study is over five years in 17 and 5.5 years in one country, while eight member-states have 6-year programmes. (Figure 6) This cannot be understood in the context of mandatory practical education after graduation. Just three countries demand a mandatory practical training after graduation, while further three demand this before entering their national insurance system. Concerning postgraduate doctorate and PhD degree, the situation is even more diverse and the investigation was difficult, because a lack of structured information. (Figure 4) However, it could be found, that only one country, Belgium, has already implemented the real three cyclic system (undergraduate and postgraduate combined) as suggested by the EU. All other countries have mixed systems with either postgraduate doctorate or PhD education after undergraduate bachelor, master or doctorate. Postgraduate specialisation in different fields of dentistry, however, was not included in the present evaluation. (2,3,40,41,56,58,60-91)

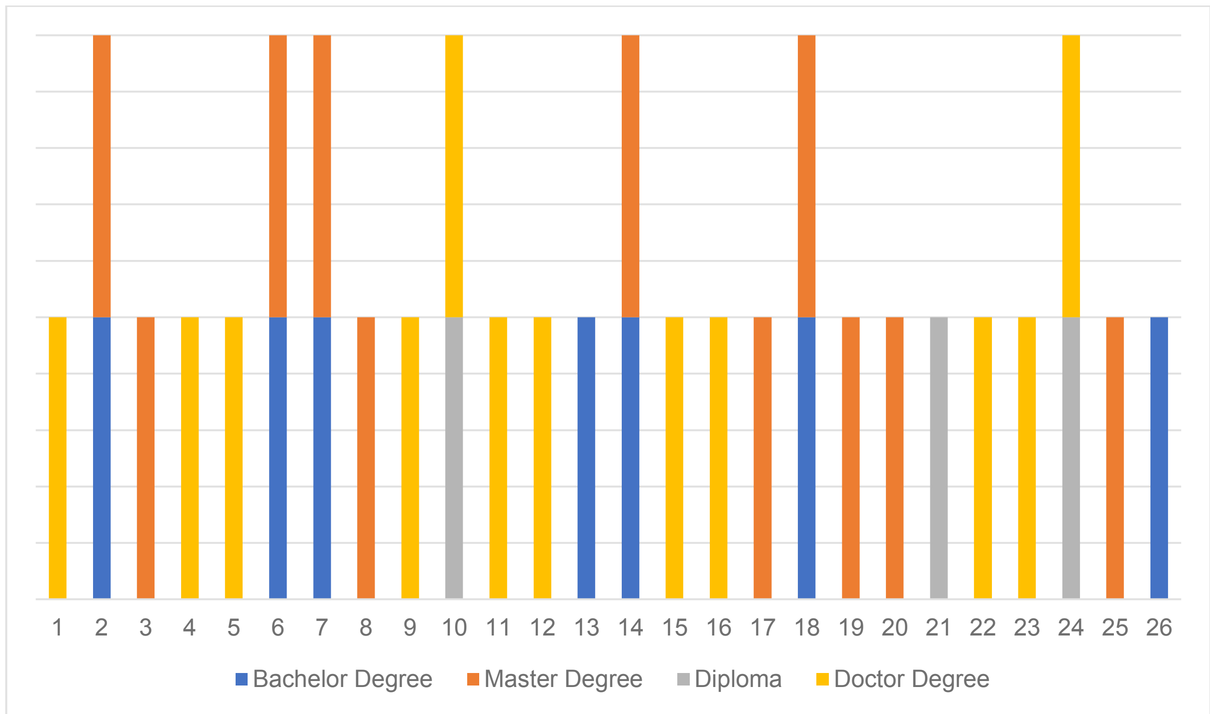


Figure 3: Undergraduate degrees in dentistry (y-axis) distributed in 26 EU countries (x-axis)

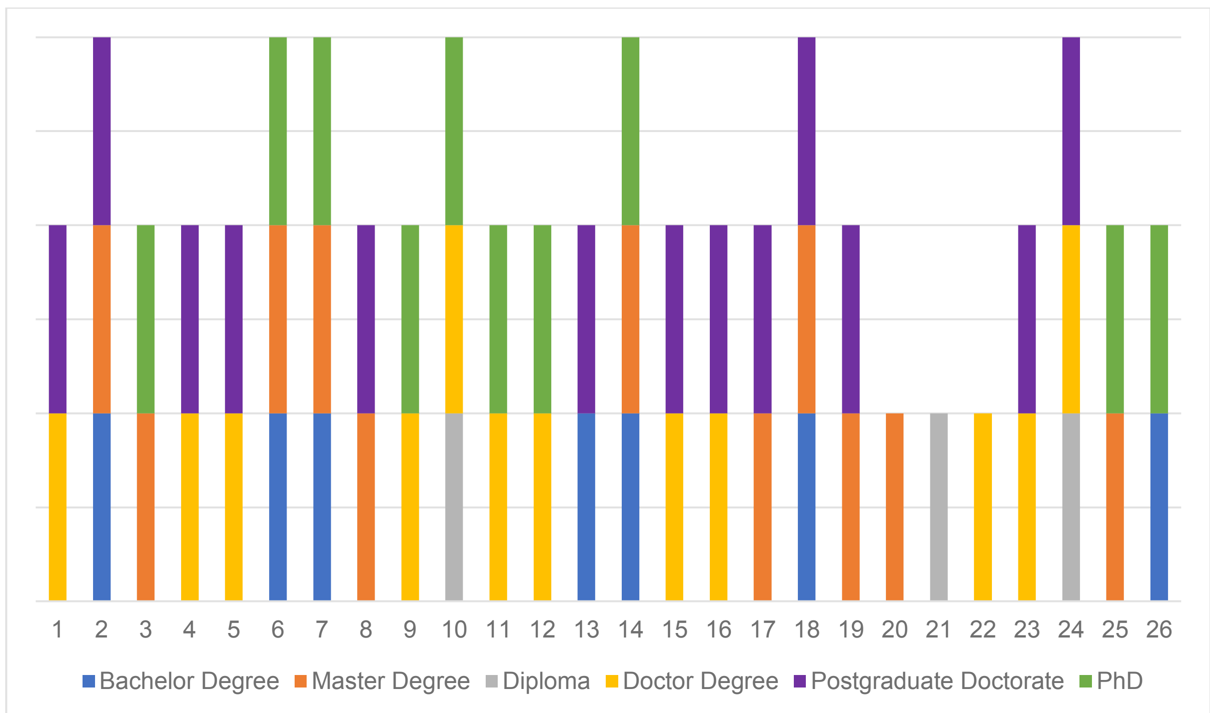


Figure 4: Undergraduate and postgraduate degrees (y-axis) in dentistry in 26 EU countries (x-axis)

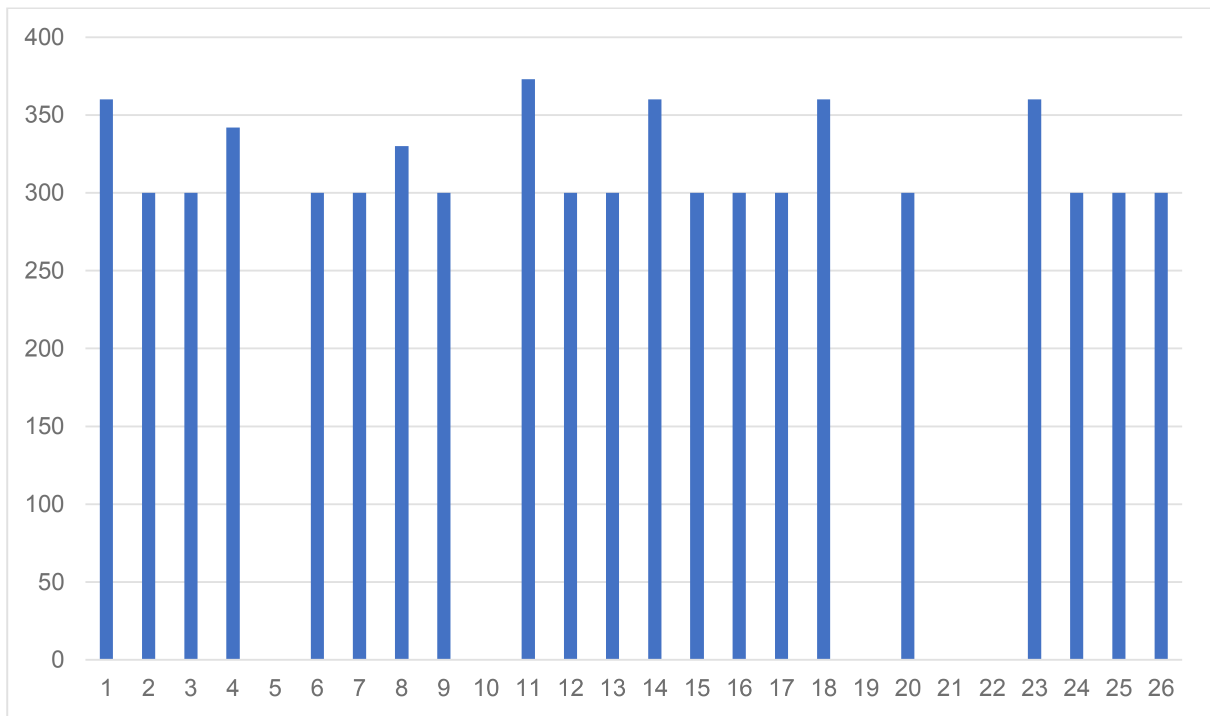


Figure 5: ECTS credits (y-axis) in dentistry in 26 EU countries (x-axis)

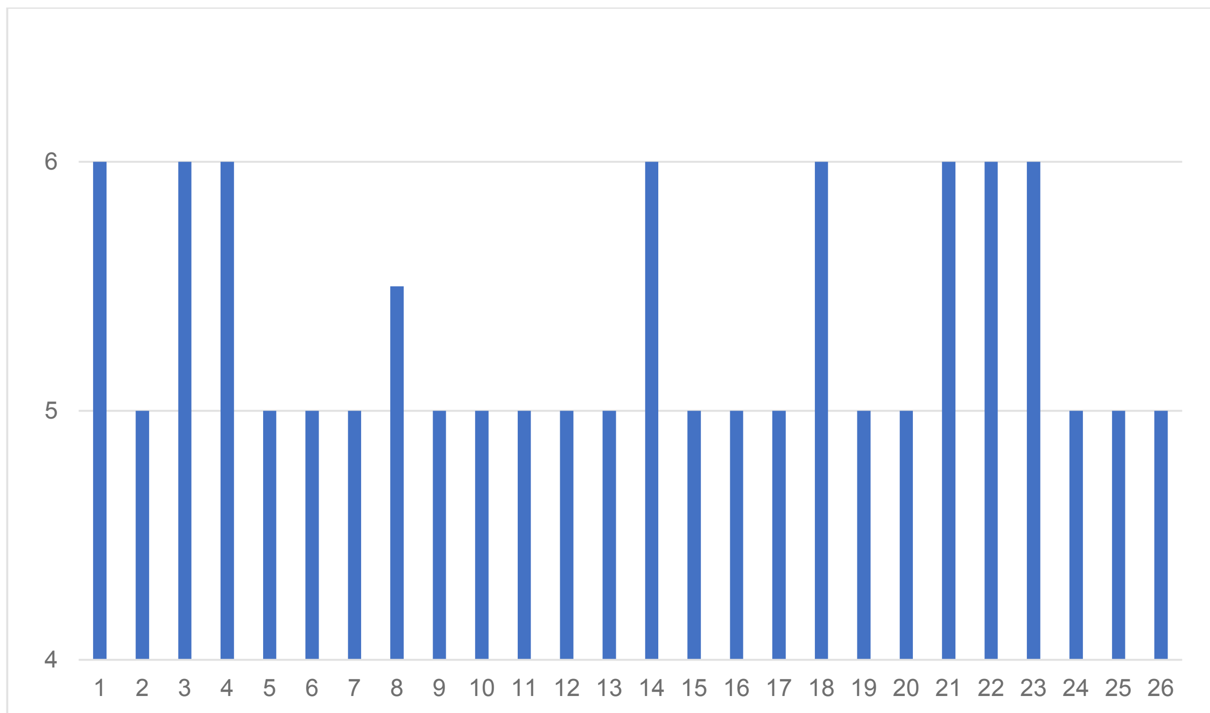


Figure 6: Duration of undergraduate dental studies in years (y-axis) in 26 EU countries (x-axis)

Overall Belgium can be seen as a trend-setter in embracing and implementing EU recommendations in higher education. It is the only EU country so far, which has already implemented the suggested three-cycled system with separated bachelor, master and postgraduate doctor degree. (92) Beside this, Switzerland, as a non-member state of the EU, but member of the EAHE, has also followed this route. (93) In the other member states, a clear trend towards an undergraduate dental master's degree can be seen. However, countries like Austria, Croatia, the Czech Republic, Hungary, France, Greek, Latvia, Lithuania, Slovakia, Slovenia and Spain are still retaining to their traditional doctoral degrees. This might be related to deep historical connections with former traditional systems. On the contrary, the UK and Ireland are still offering their bachelor degree for their undergraduate programmes. Varying nomenclature of degree across Europe, poses difficulties in authentic comparisons across universities. (5,29)

On the other hand, in Germany graduation requires successful completion of a state examination called "dentist". Doctor degree can be achieved subsequently after completion of a doctoral thesis. (40) The most consistent element seems to be the length of the study programme. Only one third of countries have programmes longer than five years. A close association between the duration of the programme and award of a doctoral degree can be observed.

With regard to ECTS credits, countries still show variations between 300 and up to 360 or more credits. At least 50% have already decided on 300 credits. The remaining give more ECTS or no information was available. However, if no results were found, this does not mean that there are no ECTS credits available. This data collection was by no means comprehensive and gaps in information still exist due to lack of information provided by the Universities on their web pages. (2,3,40,41,56,58,60-91)

1.2.8. Oral surgery education at the Dental school, Medical University of Graz

In the following section the clinical oral surgery education within the study programme of dental medicine at the third study section at the Medical University of Graz is explained. (2) This is relevant, because of local specificities and differences with the other Austrian Universities, maintaining their autonomy by law (11), as well as for the better understanding of the presented study.
Oral surgery education takes place in the third study section of dental education. (2,54,55) Based on the Swiss catalogue of learning objectives (94), pre-defined learning objectives exist for each oral surgery topic area. The teaching reflects a mixture of traditional and problem-based learning structures. Short theory units are grouped into thematic fields and reinforced by patient-centered units. Examination of the students is mainly performed orally, parallel to long term supervision and portfolios, which is related to the small number of available places. Furthermore, oral surgery education not only encompasses surgery learning objectives, but also the disciplines of oral radiology and oral medicine. (2,54,55) Since the completion of this study, organisational curriculum changes were implemented: the changes in curriculum before and after the start of the winter term 2017/2018 are reported. (2,54,55,57) In the original curriculum, students started with the third and clinical part was divided into a winter and summer term cohort. The third section began twice every academic year with a cohort of 12 students with the teaching lessons (events ranging from 7th to 12th term) also taking place twice a year. Within the 7th and 8th term students were prepared on lectures, exercises and hands-on trainings on phantom heads parallel to their first restorative education including periodical patient treatment. At the end of term 8 surgical knowledge and skills were finally learnt and examined in groups of two in a human cadaver course by supervision (mini-CEX) acting as a gate keeper function before practical work. This included exercises in local anesthesia, forceps extraction, incision techniques, inferior alveolar and lingual nerve preparation as well as surgical sinus closure. In term 9, respectively in student’s second year of patient contact, 10 weeks of practical patient care at several places of the department took place. Students worked side by side with experienced staff, getting to know the whole range of oral surgery. Oral medicine and implant surgery were also taught. Furthermore, students had to fulfill a comprehensive portfolio of proceeded surgical services ranging from detailed focal finding survey, incisions, extractions and third molar surgeries to root resections and even more complex surgical procedures such as cystectomies and sinus closure. At term 10 students left the department for other learning contents beyond oral surgery, however maintained in contact with patients targeting general dental patient care. The last term was allocated for encompassing patient treatment and a deepening of surgery knowledge with final surgery lectures and deepening skills with two remaining weeks working at the surgery divi-

sion, including a “chief surgery”, surgical third molar removal or root resection, assisted by the head of the department. (2,57) Several organisational changes where completed in the last two years, as part of a comprehensive curriculum review, which started in autumn 2017. Contents, however, are largely similar. Since then 24 students start once a study year, each in the autumn, with the third section, respectively 4th year. The majority of surgery lectures and courses are blocked before practical patient care in oral surgery and restorative dentistry now starts simultaneously during term 7. Initial oral surgery traineeship is now split over 12 months instead of former one term. However, not the number of practical weeks, but the time period is now prolonged and held parallel to initial restorative patient care. A major advantage therefore, is, that temporal distance between theory units as well as simulations and traineeship is now reduced to a minimum and not interrupted by initial restorative practical work. Spiraling of oral surgery skills, including mandatory surgical procedures, still takes place in the last study year. (2,54,55)

Most importantly the oral surgery education in Graz emphasises safe provision and competence in basic oral surgery procedures, which is not a consistent feature amongst other university locations in Austria. As a result of this, graduates are now expected to be able to perform oral surgery patient care, independently and safely, as required by the dental health insurance system. (2,54,55) This is important, as in Austria there is no postgraduate oral surgery specialisation (95), as offered for instance in Switzerland or Germany. (96,97)

As far as the teaching is concerned, this is carried out by several clinicians including the head of the department, by an assistant professor, by experienced senior physicians as well as by young university assistants and university lecturers. A great advantage is the low tutor to student ratio, which is almost 1:1. This has allowed the implementation a tutor system, in which every student has their personal medical contact person for individual discussion of study progress. Therefore, mainly oral examinations and immanent examinations by supervision during traineeships have been implemented. Written examinations are limited as there is a recognition that written assessments are less frequently required due to the small number of students who are closely supervised. (2,54,55)

Didactic education for the medical staff varies between faculty members due to multiple reasons; firstly, the variation is related to their duration of employment contract, as well as the type of contract at the University clinic (i.e. either clinic or university contract). Secondly, didactic education is offered by the Medical University of Graz, but course participation is largely voluntary and has still a lower level of importance compared to research, when focusing on an academic career. Reason therefore, is that teaching does not contribute directly to visible output in the form of impact points. (13,98) So, theoretical and practical teaching mostly runs alongside patient care and research. Organisational aspects belong to a restrict-

ed group of staff with an interest in education. Furthermore, there is no standardisation regarding introduction of new staff, which would be essential in quality improvement. (99)

1.2.9. What a European dentist should be capable of

Historic developments

The ADEE – Association of Dental Education in Europe – was founded in 1975 in Strasbourg. Since then it can be considered as the most influential association for the promotion, development and harmonisation of dental education in Europe. With a humble beginning from an office in Dublin, the work of ADEE now extends to 160 dental schools out of about 200 in Europe. Therefore, that ADEE is now the official body overseeing the dental education in Europe. (59,100,101) The dental school of the Medical University of Graz, however, has not joined as member yet.

"All Member States must recognize the profession of dental practitioner as a specific profession distinct from that of medical practitioner, whether or not specialized in odonto-stomatology. The Member States must ensure that the training given to dental practitioners equips them with the skills needed for prevention, diagnosis and treatment relating to anomalies and illnesses of the teeth, mouth, jaws and associated tissues. The professional activity of the dental practitioner must be carried out by holders of a qualification as dental practitioner set out in this Directive (XV/E/8316/7/93-EN, European Commission, Directorate General XV and Directive 2005/36/EC)", was predetermined by the Commission of the European Communities in 1995 as a directive of the European Parliament and of the Council, reported by Plasschaert et al. (2005) and repeated in 2005. (4,42,100) Furthermore, it was emphasised, that undergraduate dental education should last 5 years, and provide theoretical learning and practical training. Performance and quality assurance of education should be provided by a University or an equivalent body. This element was also adapted in 2005. (4,42,100) As a result of this between 1997 and 2000, parallel to the launch of Bologna process, the European Union initiated a Thematic Network Project (TNP) named "DentEd". This was responsible for uniting institutions promoting higher standards in dentistry and dental education. A second named "DentEd Evolves", whereof "Development of Professional Competences" document resulted, followed in 2000 to 2003. These projects gave the impetus for building a network and making an inventory of existing curricula for dental education in Europe. At this time point ADEE and TNP "DentEd" where the two pillars in promoting dental education. The third "DentEd" project "DentEd III" followed in 2004, whereof outcome was initial "Profile and Competences document" (PCD). It was sent to all European dental schools for a consultation. The reviewed PCD was finally unanimously accepted by the General Assembly. Since

then it is considered to be one of the most important documents to inform curriculum development in European undergraduate dental programmes. (100,102,103) The PCD document may be used to achieve multiple goals in dental education in Europe including the following:

(i) *"Act as a leading document for curriculum revisions in European dental schools in harmonizing and converging towards a European Dental Curriculum whilst respecting national and regional socio- economic and cultural differences;*

(ii) *Assist deans of dental schools in internal and national discussions;*

(iii) *Be used by teachers, curriculum coordinators and students in dental schools in Europe;*

(iv) *Help to facilitate staff and student exchange within Europe;*

(v) *Help in global meetings on dental education in order to converge globally;*

(vi) *Help to raise the quality of the dental care provided by dentists educated Europe;*

(vii) *Serve as basic document on activities towards benchmarking and best practice."*

(100)

Out of this PCD document the key attributes of the profile of a European dentist can be summarised as follows: First, graduating dentists should "*have a broad academic and dental education and be able to function in all areas of clinical dentistry",* second, "*be trained sufficiently in dental science",* third, "*be able to work together with other dental and health care professionals in the health care system; should have good communication skills",* fourth*, "be prepared for life-long learning and continuing professional development",* fifth, "*be able to practice evidence-based on a problem solving approach, using basic theoretical and practical skills"*. (59,100) Dental education is unique and it is a particular challenge to create graduates who are safely able to practice independently, unsupervised as general dental practitioners, immediately after leaving the university. (59,100)

Predetermined competencies, at the graduation, are abilities which need to be demonstrated by a dental student at graduation and before embarking on independent dental practice. Competencies include professional behavior, knowledge and skills to be able to cope with the challenges of a dental practice. This also includes the ability to perform at a specific level of speed and accuracy, while taking the patient's well-being into account. Moreover, it includes a degree of self-awareness about acceptable performance under changing circumstances and self-reflection for improving one's performance. (56,59,104) The social role of a dentist in contemporary era follows the requirement to see oral health in a holistic context. Therefore, it is of utmost importance that a dentist is in possession of generic and subject-specific competences that equips him or her to work unsupervised and independently. This aim should be achieved by the time of passing the final examination. (59) Competencies should include the multiple disciplines dentists face and which affect patient care. In this context ADEE's PCD should serve as a guidance with benchmarks for reviewing, redefining and restructuring an undergraduate curriculum. Furthermore, it should act as an instrument for quality assurance when reviewing and improving student's evaluation. Finally, it should be used as a tool to develop and introduce outcome measures for the evaluation of the effectiveness of a programme in the undergraduate education. (59) Publication of "competences" statements was a landmark step to promote transparency and further harmonisation in a European context. (49,59) Although many countries such as the UK who have produced learning outcome documents (56) or Germany with their national competence-based catalogue of learning objectives (40) and Switzerland with their Swiss catalogue of learning objectives (94,105), there are many European countries, including Austria, who are yet to do so. (49,59) However, many have taken a step into the right direction, most schools have produced their own documents with learning specific outcomes and this process is still ongoing, as reported by Harzer et al. (2017) (49). At the Dental school in Graz this issue is also being addressed, where the oral surgery learning objectives have been outlined, but still needs for other topics and subject areas. (2)

The connection between competence and learning outcomes must be explained. While competencies are acting as benchmarks for a curriculum in general, learning objectives are specific well-defined statements concerning a single learning unit, based on predefined competences. Learning objectives reflect what a student should be able to know and understand as well as being able to demonstrate at the end of a learning unit. (102,106) Furthermore, the definition of learning outcomes is absolutely necessary for designing appropriate assessments. (106) Manogue at al. (2011) (106) therefore, suggests four essential points, which should be considered in context with learning objectives. They have to do with a precise definition for each learning unit and offered in an adequate number. The wording has to be simple and unmistakable, while further with the integration of specific and measurable verbs, they should differentiate between knowledge and skills. (106)

Coming back to PCD, which was reevaluated in 2009 and published again in 2017. (59,103,107-111) The original seven domains have been reduced to more focused four. (Table 1) Furthermore, every domain is subdivided into areas of competences which define in detail what a graduating dentist should be able to demonstrate. (59,103,107,108,111)

	2009
I	*Professionalism*
II	*Interpersonal, Communication and Social Skills*
III	*Knowledge Base, Information and Information Literacy*
IV	*Clinical Information Gathering*
V	*Diagnosis and Treatment Planning*
VI	*Therapy: Establishing and Maintaining Oral Health*
VII	*Prevention and Health Promotion*

	2017
I	*Professionalism*
II	*Safe and Effective Clinical Practice*
III	*Patient-Centered Care*
IV	*Dentistry in Society*

Table 1: Reclassification and reclarification of CPD domains (reproduced from Field 2017 (103), with permission of publisher (Wiley))

The domain professionalism is composed of the following three essential points – First, "ethics", second, "regulation" and third, "professional behavior". For a dentist it is essential to have knowledge about ethical, legal and regulatory aspects of the profession, because *"professionalism is a commitment to a set of values, behaviors and relationships, which underpins the trust that the public hold in dental professionals"*. If these aspects are not acquired at an early stage of the curriculum, it affects establishing a rapport and professional relationship with patients which can have an adverse impact on the trust of public in the dental profession. (112)

Concerning "*ethics"*, a dentist has to be equipped with core principles, which let him or her distinguish between ethical or unethical decisions, even when financial aspects play a role. Further ability to respect decision making with patients as well as courage to act when a colleague is putting someone at risk is expected. Also, in the age of digitalisation dealing with patient data, social media or digital communication have to be handled in line with legal regulations. (112)
Concerning "*regulation"*, a dentist must be familiar with the specificities of the country in which he or she works. Furthermore, he or she has to be able to reflect on local guidance, including the appropriate registration. (112) A dentist has to *"apply the law and guidelines relating to consent to all patients, including children and adults unable to consent for themselves and adhere to the code or accepted standards of practice on advertising in all media"* (112) Additionally, familiarity with medical legislation is a necessary prerequisite for a competent health care professional. (112)
Concerning "*professional behavior"*, this should be seen as an overarching term for good dental practice and responsibility for high quality oral health care. A dentist must be able to communicate effectively, demonstrate patient centered care and act under self-awareness and self-reflection whilst identifying their own boundaries. Furthermore, a dentist has to choose and qualify therapy options that are in the best interest of each patient's individual requirements. Thereby the compatibility with present regimen and consistency with human rights, sustained health care philosophy and medical economics have to be included into patient affecting considerations. (112)

Competences expected from a graduating dentist in Europe – “Save and effective clinical practice”

Safe and effective clinical work, defined by the five points “evidence-based practice”, “management and leader-ship”, “teamworking and communication”, “audit and risk management” and “professional education and training”, means that educators are responsible for taking students to the point where they are ready to begin treating real patients safely and successfully perform basic surgical procedures. This should be preceded by a gate keeper, such as a robust assessment instrument. Moreover, escort should be given to every learner until the end of undergraduate education in the programme. (109)

Concerning “*evidence-based practice”,* a graduating dentist must be able to include scientific rigor into the daily work such as medical sciences, possible ways of knowledge collection, scientific approaches and evidence evaluation. This is an essential requirement to be able to evaluate novelties from within the industry and published research concerning benefit, risk and costs. (109)
Concerning “*management and leadership”*, students have to learn their value and position as a manager in a team. Therefore, a dentist must be able to create safe working conditions in which members of the dental team are well-integrated. Further, a dentist has to be familiar with the handling of short and long-time adverse events as well as with time and economic resources with the capability of implementing efficacy and sustainability changes within the dental practice. (109)
Therefore, *“teamwork”* is a main pillar of a dentist, which underlines his or her role of taking leadership. A dental practitioner must be able to assign several members of the dental team their specific role and position in targeting patient-focused health care. This also includes the teaching and sharing information and knowledge in the different forms verbal, written or electronically and the cooperation with other medical colleges such as extended members of the team like dental technicians. Moreover, a dentist has to be able to discuss with patients suitable treatment planning, describe and inform them about materials used and inform patients, independent of their age, regarding available treatment options within the dental medicine. It is the dentist’s role to educate patients about their current status of oral health, explaining patient's role in maintaining their oral health and any need to provide individualised professional dental care. (109)
Concerning “*audit and risk management”*, it is essential for a dentist to recognise errors, identify the reasons and take actions against them. Thus, a dentist must be able to perform accurate documentation in the form of a patient record, as well as comment, classify and

review radiographs and additional diagnostic images and perform appropriate risk-assessment around hazards such as cross-infection or ionising radiation. Further quality control and maintenance of used devices and dental equipment are key attributes of a dentist. (109)

Concerning "*professional education and training*", dentists should be aware of the necessity of life-long learning. They should be motivated and interested in a continuous process of knowledge acquisition. Therefore, a dentist must be able to review knowledge, skills and performance, their own and that of the team, and arrange training or support if needed. This should ideally happen with the compilation of a portfolio as a current educational instrument, including clinical treatment procedures, which should provide a review mechanism and a continuous learning process in the clinical and professional practice.
(109)

Competences expected from a graduating dentist in Europe – "Patient centered care"

This domain is summed up in the four points "applying the scientific basis of oral health care", "clinical information gathering" and "diagnosis", "treatment planning and establishing and maintaining oral health". It is well known that patients feel more comfortable and let themselves participate more actively in a treatment process when the practitioner is able to take patient's individual social-economic, cultural, demographic and linguistic background, into consideration. (110)

"*Applying the scientific basis of oral health care*"; The clinical practice of a dentist must be underpinned by scientific principles as applicable to "*the etiology, pathology, diagnosis and management of oral diseases and disorders including (but not exclusively): i) caries, ii) tooth surface loss, iii) gingival, periodontal and peri-implant diseases, iv) apical periodontitis, v) temporomandibular joint dysfunction and occlusal disharmony, vi) mucosal conditions and salivary pathology, vii) odontogenic cysts and tumors, viii) craniofacial disorders, dental and maxillofacial trauma and orofacial pain".* (110) In addition, a dentist should be able recognise normal and abnormal growth and development of cranio-facial structures, tooth development, the change of dentition and age-related alterations of hard and soft tissues. Moreover, relevant aspects of social and behavioral sciences are essential. A dentist is expected to fully understand and implement protocols related to health and safety including sterilisation and cross infection; ionising radiation protection; materials and drugs used in dental practice; and recognition and referral for non-accidental injuries related to potential abuse. (110)
"*Gather, record and interpret records*"; A dentist must be able to obtain a medical, dental and social history to identify individual needs and expectations. Skills in the extra- and intraoral examination with radiographic evaluation of tooth decay, periodontal diseases, joint function, jaw bone cysts and tumors and trauma at teeth and surrounding structures. This also means the interpretation of orofacial pain with consideration of different individual risk factors.
Further a dentist has to know about the indication of special diagnostic features and tests and to synthesise information and data to formulate a definitive diagnosis. (110)
Concerning "*treatment planning*", to formulate a structured and comprehensive treatment plan, which addresses each individual's oral health care needs is one of the most important skills expected from a dentist. Therefore, he or she must be able to choose, prioritise and individualise treatment variants, including psychological and social components as well as patient's individual expectations and desires. This also includes the integration of systemic diseases and prescribed medication and further the appropriate recommendation of restorations, implants or removable prostheses with adequate monitoring. (110)

It is an essential competence to organise for a quick and adequate transfer of patients, which may suffer from life-threatening diseases such as malignancies and to be aware of their own knowledge and skills as well as limitations in the general dental setting. They also need to recognise cases which are beyond the scope of practice and refer patients requiring orthodontics, oral medicine and pathology, implantology or the use of general anaesthesia. (110)

"*Establishing and maintaining oral health"*; A graduate must be safe in performing dental treatments including dental preservation, pain management, basic oral surgical procedures, offering dental restorations, treating basic malocclusion and engaging with dental implant planning. The latter however is usually considered after appropriate postgraduate training. Furthermore, the management of dental emergencies and medical emergencies during dental treatment need to be managed appropriately by the dentist. (110)

Dental treatment should not be seen solely in the context of management of dental diseases but more holistically as treating individuals with dental problems. With globalisation and migration, a dentist must be able to respond to population demography and health care trends. Therefore, it is vitally important, that dentists also include a wider context into their way of thinking as well as consider needs of the society, to be actively integrated into general and oral health and changes in the healthcare systems. (111)

So, concerning "*dental public health"*, a dentist must be able to define, describe and discuss dental public health strategies, considering oral and systemic diseases and their connection with risk factors influencing public health. (111)
In relation to "*health promotion and disease prevention"*, a dentist must be familiar with the pillars of general and oral health and relevant social aspects including behavior changes. Further dental practitioners have to be able to describe the necessity of the involvement of dental care for reaching changes in the population's general health as well as to understand and implement strategies for the promotion of health and prevention of diseases. (111)
Concerning "*population demography, health and disease"*, a dentist must have knowledge about demographic changes and implications, trends of oral diseases and epidemiological structures. Finally, dental practitioners have to be able to discuss nation-wide and international health trends, including political, social and economic aspects and integrate promotion of oral and systemic health. (111)
Concerning "*health care systems"*, it is necessary to know how they work nationally and internationally, taking account of disadvantaged groups. Finally concerning "*planning for health and oral health"*, a dentist must be able to discuss strategies of successful public health care, working together with local communities. (111)

1.2.10. The idea of a united dental education in Europe:

As explained above, ADEE sees itself as a representative of the European dental education. Although this association recognises on diversity and authority of each university, several suggestions what a curriculum should stand for, to have a genuine European, rather than a purely national dimension, were given in the last years. The most essential question thereby is, whether a three-cyclic bachelor-master-doctor education is enforceable in dental education. (106) As the Bologna process recommends a bachelor's degree in dentistry would consist of 3-4 years of education with 180-240 ECTS credits. This, however, would not meet the expectations of being a dental practitioner defined in the EU Parliament's Directive in 2005. (4,42,102,106) An appropriate suggestion would be a 5-year full-time study with 300 ECTS and ending with a master's degree. (102) Similar ideas are also discussed in the world of medical education by several authors. Described by Cummin et al. (2010) (48) two different models of a bachelor's and master's qualification adaptable for a dental setting can be distinguished. (113) The first model would consist of only basic science education in the first three years, resulting in a bachelor's degree. The following second cycle would consist of clinical medicine, resulting in a master's degree and followed by medical practice. The third cycle, non-mandatory doctorate cycle, would contain science and research in preparation of an academic career. The second possible model wouldn't entail in clear separation of basic science and clinical medicine. It would rather be an integrated approach and the first cycle would consist of 50% basic science and 50 % clinical education. The second cycle would consist of 20% science and 80% clinical work, followed by medical practice. Furthermore, the non-mandatory third cycle would include science and clinical education in reverse percentage distribution to the second. (48) Switzerland and Belgium have already implemented a 3-cycled system in dentistry, which could act as a model for the other European dental faculties, including Austria. (48,92,93)

Concerning practical dental work after five years and graduation as a master, 1-2 years vocational training for the dental graduate would be preferable before having freedom to practice within the state funded system. Because of inconsistency in this issue freedom in movements of graduates has not been achieved so far. (49,102,106)

When considering the form of a curriculum, this should be organised in a modular fashion. A modular curriculum is organised in discrete units based on themes and where each module description should contain the following aspects: Name of the lesson and the ECTS amount as well as the learning outcomes, followed by a definition of the process. Teaching and learning methods and planned assessments should also be included. This would also result in a

comprehensive implementation of the diploma supplement as a uniform depiction of the dental education for the graduates. (102,106) A vision for the future would be the implementation of core curricula, which would allow the student, in addition to the basic training, and optional study units during undergraduate education. (106)

Concerning oral surgery education, the issue is more difficult. According to the CPD document a general dental practitioner has to be able to manage basic surgical procedures to be able to fulfill basic dental care. (59,103,109,110) However, this does not equate to a specialisation in oral surgery and implantology, which is achieved in many different training programmes in Europe. In Austria, there is no postgraduate specialisation in oral surgery existing, which is regulated by law and consequently not easily changeable. (95) Germany and Switzerland in contrast are offering this option. (93,96,97) Accordingly, local undergraduate education is in need to be adapted to this situation and designed differently as opposed to countries offering a postgraduate specialisation, to enable graduates provide adequate oral surgery care. A vision for the future might be to regulate postgraduate oral surgery education similar to that of orthodontics, which is aligned to the so called NEBEOP programme (Network of Erasmus Based European Orthodontic Postgraduate Programmes) in 2008. (95,114) This allows a specialisation in orthodontics based on a 3-year postgraduate course with certification as a specialist. (95,114)

1.2.11. Assessment

What is a test and why do we need it?

A test can be defined as *"a scientific procedure for the acquisition of one or more empirically identifiable psychological traits to be able to provide a statement about the degree of individual characteristic expression as precise as possible"* (translated from German) (115). This may appear scientific, but it is just that, what we need when we want to assess students in their course of education. Testing is not just arbitrary, but it has indeed important functions. These can be split into didactic and social functions. Didactic means to look at the issue from a pedagogical point of view. Thus, tests have to measure if candidates have achieved the learning objectives. This is called diagnostic function. Further tests have a feedback function, to verify which learning objectives have been achieved by the student and what are their additional learning needs. (116) In the sense of the sentence *"Assessment drives learning"* (117) which highlights that tests have a motivational function to inspire students to learn in a targeted and intensive manner, in order to enhance their understanding as opposed to surface learning. (117) However, this statement is also viewed as controversial within the literature. (117,118) Moreover, tests have a disciplinary function for learners. (116) Depending on the value of the examination itself, for example when it is to do with final graduation, assessment has a social function. From this point of view examinations therefore, have the function to socialise. Certification after assessment allows the graduate to play their role as a professional in the society. Further, tests have the task of selection and recruitment, as well as serving as a barometer to predict future performance after graduation. Moreover, the performance of students in assessments allow educators, social scientists and politicians to evaluate quality of teachers, curricula, schools and educational systems. (116) Poor performance in assessments can also serve as a warning sign for gaps in curriculum, teaching and training which may be applicable to an educational system, a programme or restricted to a cohort of students. Therefore, assessments can provide crucial information in the context of quality of education and inform future planning and decision-making. (119)
In the context of healthcare education, assessments can be a tool to achieve three important goals: As defined by Epstein (2007) (117) assessments can promote learning during an educational programme, ensure patient-safety by identifying incompetent physicians and finally serve as a benchmark for selection in advanced and specialist training programmes.

Furthermore, assessments serve to direct the learning process, which is possible if they are of a certain frequency and representative of the learning objectives. (119,120) Subsequently the three effects “pre-“, “true“, and “post-assessment effect” can be derived. The “pre-assessment effect” means the learning process due to different sources of information about the next test. This can be for instance former tests, notes from the teacher or information from advanced students. The “true assessment effect” means the learning process within the exam itself, which strengthens the long-time memory. And finally, the “post-assessment effect”, which influences the individual learning based on each student’s test results. (119) Depending on what tests should target and which special aims they should fulfill, they can be of formative or of summative nature. (121) Formative are not used for grading the students, but influence future learning behavior, providing feedback and stimulating reflection to activate intrinsic motivation by offering benchmarks. Whereas summative testing means judging about competences and readiness to practical work or to progress to the next step to further levels of responsibility. When it comes to the use of summative formats test leaders have to be careful about robustness of the chosen format to justify its barrier function. (117,121-123) Indeed summative examinations are essential tools in the medical world, because medical education has to guarantee to the public to produce competent and safe acting doctors. However, from the learner’s point of view, feedback resulting from frequent formative assessments, is far more essential to promote each individual’s learning history. (124) Overall, assessment should not be a single instrument, rather it is useful to combine many different tools, where strength and weaknesses of each single method balance each other. (124) A useful way thereby is the application of longitudinal assessment formats with the combination of first formative formats with summative grading at the end of university education. (125,126) Moreover, it has to be mentioned that creating assessments needs competent staff, who are directly involved with the educational program and well-trained and experiences in developing and implementing examinations. That means to be highly competent in the field as well as to have an expertise in the role of an examiner is of utmost importance. This is a further key feature to enable high quality in educational programmes. (119) At the end students need to feel comfortable in an assessment and learning environment, in which mistakes can be made and rectified. These in turn can be helpful promoting a new learning process. Although medical students are used to being high achievers, an “assessment for learning” approach should initiate a rethinking in which errors identify each individual’s learning needs. (119)

“What”, “why”, “how”, “where”, “who” and “when” are the questions which should be asked before planning an exam. (127) The assessment should always target on the aim it should fulfill. In other words, an assessment should target “what” is closely connected with the pre-defined competences and learning outcomes including knowledge or skills or both. (116) With the help of the Bloom’s taxonomy and the graphical representation of Miller’s pyramid, the learning objectives can be divided and assigned to a hierarchy. (Figure 7) (121)

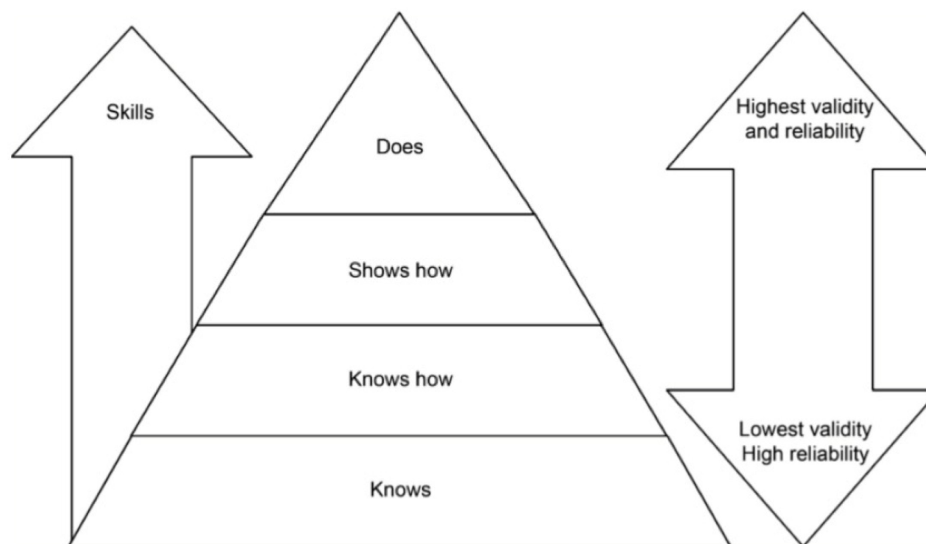


Figure 7: Miller’s Pyramid (reproduced from Mattheos et al. 2009 (121), with permission of publisher (Wiley))

Subsequently, it is possible to assign the examination formats to the corresponding levels “knows”, “knows how”, “shows how” and “does” as also shown by Mattheos et al. (2009) (118,121). (Figure 7). The “why” refers to the formative or summative format, while the “how” refers to the actual method. In this way, the three key features are met. (127) Place, person and time points can be than chosen subsequently. However, it has to be recognised that all methods of assessment have their own strengths and intrinsic flaws and no method alone can assess all competencies. Nevertheless, the use of multiple formats over the course of a curriculum can at least partially compensate those flaws. Moreover, the more quality each single assessment has, the more impact it has on the depth of learning. (117,119,127)

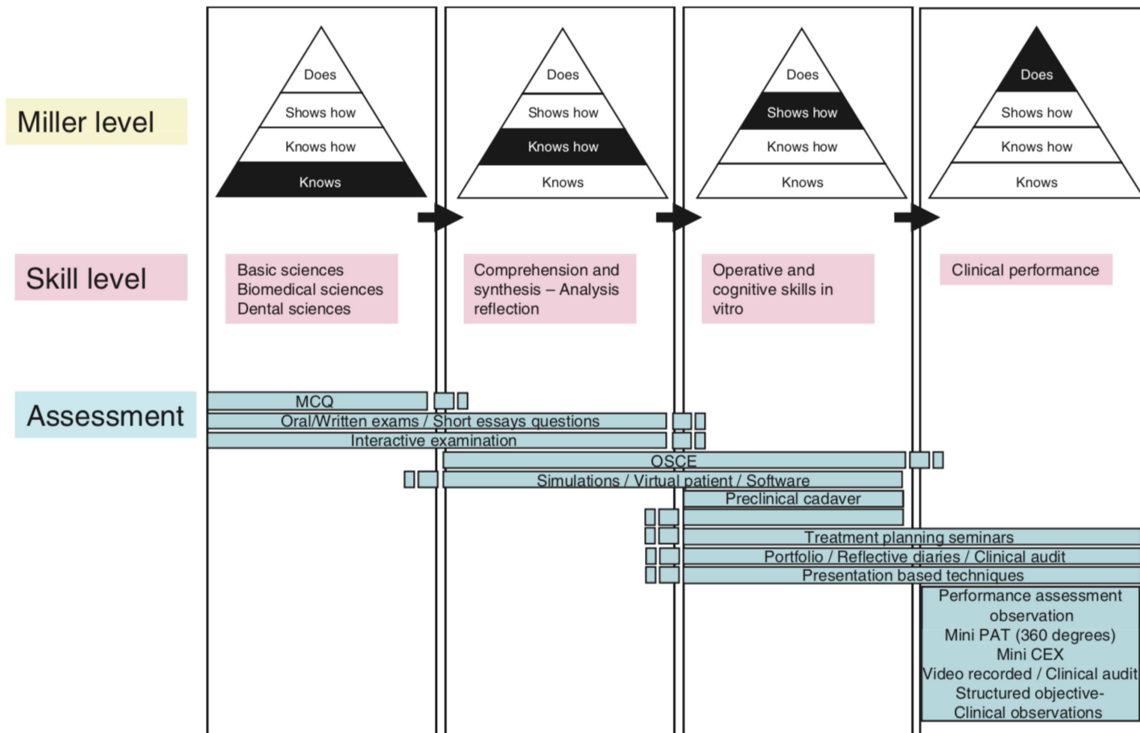


Figure 8: Assessment methods of knowledge and skills as related to the Miller's Pyramid (reproduced from Mattheos et al. 2009 (121), with permission of publisher (Wiley))

Generally, medical exams can be divided into written or oral examinations, assessments derived to supervision, simulations done in a clinical context and assessments which are based on many different methods, while they are applicable for different levels of Boom's taxonomy. (117,121) The individual components are addressed for better understanding in the following section.

Assessments in written form:

This format can again be generally divided into “open ended” or “multiple choice”. Both can be written in a context-rich or context-poor way, which influences their cognitive level. That means that context-poor items are focusing on plain facts testing basic factual knowledge on the level of “knows”. Context-rich items on the other hand, are written around a specific clinical situation and let the examinees relate it to a realistic scenario. Therefore, next level “knows how” is included. (117,121,123) “Multiple choice questions” (MCQ), as the best explored format, are a frequently used method, because a single assessment can include a large number of items addressing a wide range of topic areas. Another positive effect is, that they can be administered in a manageable time-period, while the evaluation can easily be performed by software programmes. These features make it easy to assess a large number of examinees in a standardised and economical way. (117,127) Items usually consist of a stem (clinical case presentation) and/or the lead-in (question) and a number of options - mostly five. Of these options, the “key” is the correct one and the “distractors” are the incorrect ones. Therefore, two basic types are available: The “true/false” family, which requires the students to indicate all responses that are appropriate and the “one best answer” (Type-A). Furthermore, many subtypes of both are available. (128) Case and Swanson (2001) (128) clearly prefer “single best answer” formats, because at “true/false”-questions the distinction between true and false is often unclear. As a result of this, according to the NBME (National Board of Medical Examiners) in the USA, true/false formats have completely been eliminated. On the other hand, type-A items have been favored, because literature shows the use as well as the active application of knowledge can be better assessed by one-best-answer questions. (128) However, Epstein (2007) (117) or Van der Vleuten (2004) (129) recommend multiple choice questions which are rich in context, which are demanding to write and this results in a time-consuming process. (117, 129) If item writing does not happen in an appropriate way, unwanted cueing effects such as test-wiseness creeps in. Written formats such as “short answer questions” or “structured essays” can be considered as alternate assessment formats. Nevertheless, also these formats have pros and cons which influence quality of a test. (117)

Assessments with oral performance:

"Oral examinations" are still a common assessment format and have a long tradition in undergraduate and post graduate medical education. (130) However, due of several reasons this format which usually involves two or more examiners assessing a student and neither questions nor responses are consistently documented in writing may have several weaknesses. (127,131) Although depth of knowledge, clinical or practical problem-solving, communication skills and professionalism are cited as positive aspects, negative effects as assessing only plain factual knowledge and the subjectivity of this format are also reported. (127,131) However, a structured form with clear predefinitions can increase reliability as reported by Wass et al. (2003) (130). Furthermore, used as a formative format, the positive aspect of the close face-to-face contact between teacher and examinee is also recognised. (127,132)

Assessments addressing “shows how” and “does”

Simulations in a clinical context:

So-called “objective clinical structured examinations” (OSCEs) were developed in 1970s by Harden et al. (1975) (133) and are now an established instrument in assessing skills in a fair and practical way. (117,127) This assessment consists of a series of “stations”, including simulated patients, each focused on a different task. Thereby an extended number of competencies, physical examination, patient interaction, empathy, interpretation of findings and practical performance can be assessed. Grading follows after processing a predefined checklist with high reliability. So, passing 15 to 20 stations within 5-10 minutes each all students get the chance to carry out same tasks in the same time. However, OSCEs can be challenging for administrators because of the planning, recruitment of staff; finding an adequate environment, timely rotation of students and troubleshooting during the exam considered. (117,127,133)

Examinations based on supervision:

Supervising over a period of time seems to be one of the most frequently used instruments to evaluate student’s performance in interacting with patients. However, if there is a lack of standards, subjectivity can be a negative aspect. (117) As a more successful way so-called “long-case” and “mini-CEX” (mini clinical evaluation exercise) are described by Norman (2002) (134) and Norcini et al. (2003) (135) to assess clinical skills of students on patients. Reliability is described to be as high interacting with actual patients as with simulated ones. (134,135) A positive aspect of this form of assessment is the simulating of a realistic doctor-patient scenario in which the communication skills, empathy and professionalism of students can be evaluated. However, a single-point assessment, irrespective of student performance, does not reliably predict consistency in future performance. Therefore, an increased number of “long cases” would be necessary to increase the reliability. (136)

Long term assessments based on multiple methods:

As already mentioned, no single assessment is ideal of assessing different constructs. (117) Therefore, so-called “multimethod assessment”, respectively the “portfolio method”, could be used for a more comprehensive assessment. It seems to be obvious that only by combining different examination formats over time a deeper insight into interpersonal abilities and practical performance can be given. This means that on the one hand, multiple choice questions which assesses knowledge, followed by a standardised oral examination, management of a simulated patient to assess clinical skills, and finally a case report or research dissertation provide an overall picture in the form of a portfolio. (117,137) A portfolio of evidence tapping into a range of attributes provides an optimal form of assessment as shown by Gadbury-Amyot et al. (2014) (138), who reported on the successful use of a portfolio in dental education over a period of 15 years.

1.2.12. The Progress test as a special form of assessment

Background

After McMaster Medical school in Canada, the Maastricht Medical school was the second which launched a curriculum based on problem-based learning (PBL) in 1974. This new approach of learning was focused on promoting life-long learning. That made it necessary to rethink the examination formats, targeting on first, to evaluate the learning process itself and second, to measure not only factual recall, but also higher cognitive skills. (125) Self-assessment methods alone, as later confirmed in literature, have not shown to be adequate to assess the learning outcomes in a PBL curriculum. (139)
This provided impetus to the development of an innovative assessment, referred to as, of progress test (PT) in 1977. (125) Parallel to this, PT was also developed in Missouri/Kansas and later at the McMaster Medical School in Canada. (140,141) Today, in the Netherlands (the cradle of PT) 10 000 students from 6 universities are assessed in the national PT four times a year. (142)

Structure of a Progress test

PT is a special form of longitudinal and feedback-oriented assessment performed at regular intervals (12), at least annually or twice a year, though it is done more frequently at several universities i.e., up to four times per year. (12,125,129,140,142,143) Although it is a tool primarily used in medical education (125,144,145), PT is also utilised in other disciplines such as psychology and behavioral sciences. (146) As described in literature, it is neither restricted to PBL curricula, nor to a special question format. (125,145) However, formats other than MCQ clearly show lower reliability. (135,147) So far MCQ formats have been used in PT most commonly, instead of open-ended questions. (125,129) Single tests mostly consist of around 100-250 multiple-choice items, which can also differ in format such as single best and the true/false items (12,125,144,148). Provided there is enough data from the items and cohort mean scores, in general less items would be necessary for the evaluation. (148) Single-best MCQs are now preferred, because certain intrinsic disadvantages could affect true/false questions. (128) Each test, containing different items, but based on a predefined blue-print, may be benchmarked against the level of knowledge expected from a new graduate. All students from freshers to graduates sit the same test at the same timepoint. Therefore, in con-

trast to the usual multiple-choice items an additional "don't know" option exists to prevent students from guessing and to identify learning objectives they have not mastered yet. Items are usually taken from a pool, previously compiled by specially trained educators, that reflects predefined learning objectives. (12,125,129,149) Including items developed in-house as well as shared items through collaboration at regional, national or international level. (150) As a consequence, progress over the course of a curriculum monitored both for individuals as well as for the cohort, including Tio et al. (2016) and Ali et al. (2016) (126,142). (Figure 9, 10)

The basic ideas of the PT were primarily to act as a feedback instrument. (142) (Figure 9) and to minimise test driven learning, while promoting deep, meaningful and continuous education (145,151), which was appropriately defined by Pugh and Regehr (2016) (151) as "assessment for learning" instead of "assessment of learning". (151) In this respect, PT initially followed a formative design. (125,141) Formative means that the results do not contribute to the overall grading. Given this test is well established itself, many institutions also use it for summative assessments. Most often, however, a pass/fail decision on the PT is made only at the end of the program. (126,142,149)

Standard setting for PT can be done using a variety of methods based on norm and criterion referenced assessments. (142,143,152-155) Ricketts et al. (2009) (155) showed it is possible to get a useful benchmark with the help of triangulation of standard setting data, using a number of different approaches. Furthermore, graduate's performance can in general be classified at around 60-70% correct answers at a PT, while beginners achieve around 20% or even lower scores. (126,155) This may also be related to lack of formal preparation for PT by students unlike traditional assessments, whereby students devote substantial time to memorisation of factual information. (125)

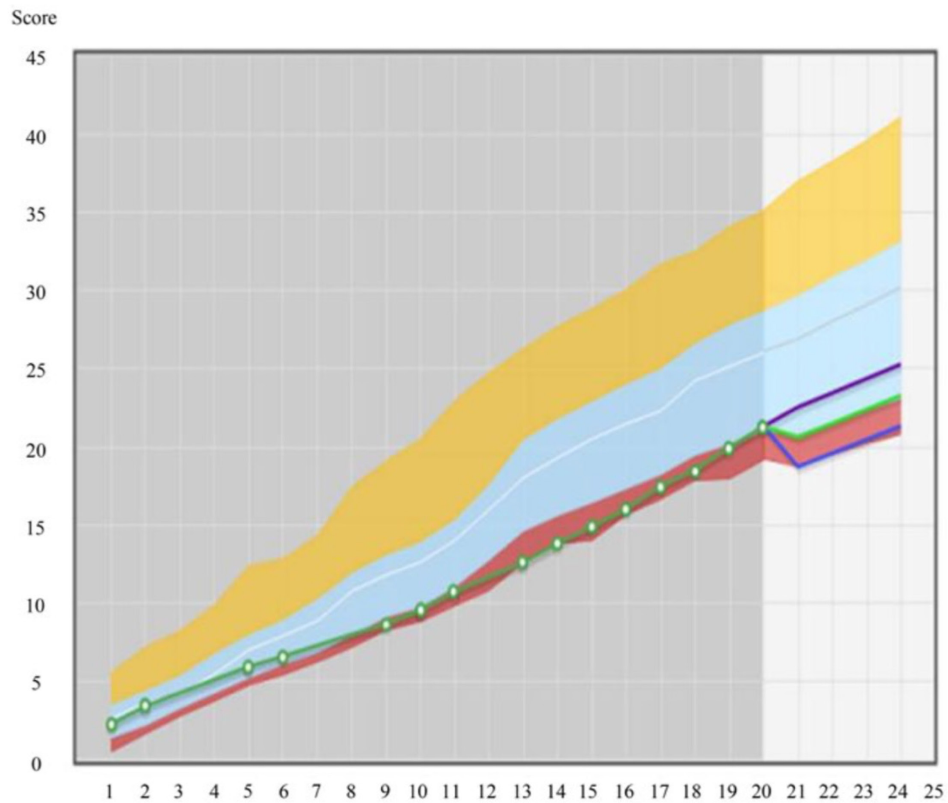


Figure 9: PT as a feedback and predicting instrument. Former test results of one student reflecting the position relative to good (yellow), pass (blue) and fail (red) area and future forecast (dark-blue line). (reproduced from Tio et. al 2016 (142), published with open access from Springer. This article is distributed under the terms of the Creative Commons Attribution License which permits any use, distribution, and reproduction in any medium, provided the original author(s) and the source are credited.)

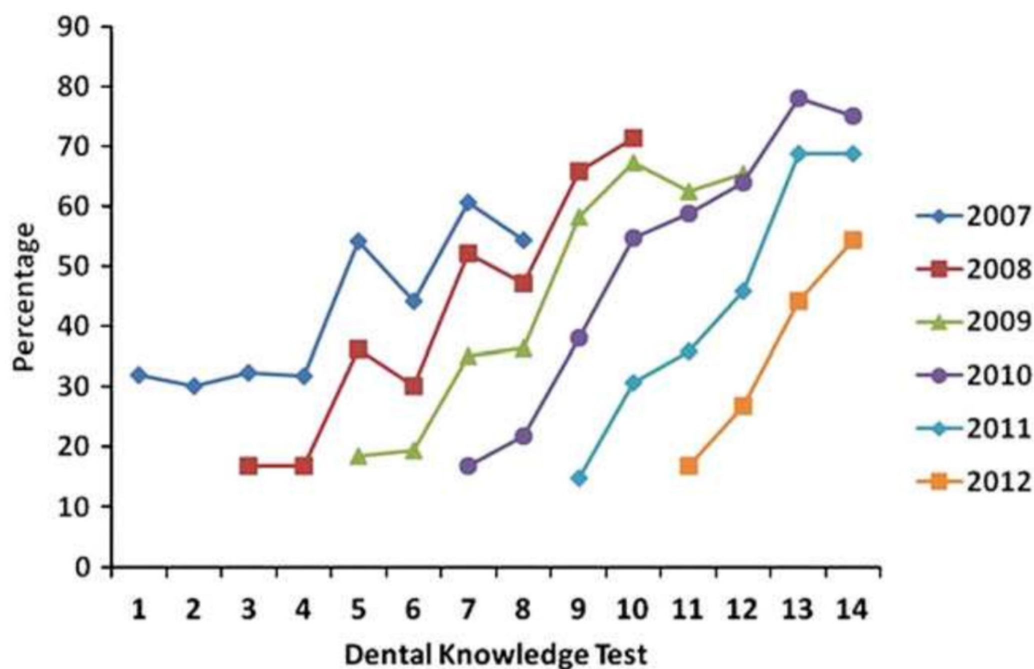


Figure 10: Progress of individual cohorts in successive progress tests (reproduced from Ali et al. 2016 (126), with permission of publisher (Wiley))

<u>"Don't know" question option:</u>

The "don't know" option, which carries zero mark, is a specific feature of the PT. It has been introduced to give participants an option, to identify their learning needs. (143) It should enable students to avoid guessing without a negative consequence, which should lead to a reduction of random errors. (143,156) Furthermore, according to Muijtjens et al. (1999) (157) and Tio (2016) (142) it is a tool to teach students that they cannot know everything in their life. Moreover, the "don't know" is appropriate because many questions are too difficult for students of lower educational years, based on the nature of the PT, compared to the abilities of their graduating colleagues. (143) The application of the "don't know" option implies the so-called "formula scoring", in which the number of incorrect answers, counted with -1 or -0,25, are deducted from the number of correct answers, counted with + 1. This happens in contrast to "number-right" scoring, where only correct answers are counted. (126,156,157) In literature, is critically reviewed, because the "don't know" options may be influenced either by knowledge or risk-taking tendencies. (150,156,157) Thereby Ravesloot et al. (2015) (156) reported that "don't know" weakened the construct validity by introducing construct-irrelevant variance. Furthermore, they concluded that number right scoring means deciding between bias and random measurement error. Moreover, "don't know" choosing frequency is also influenced by the test format itself. That means if tests are formative, other answering strate-

gies, with more often guessing than “don't know“ option are chosen by the students than during summative formats. (150)

Benefits:

The most important purpose of progress testing is the longitudinal evaluation of the growth of knowledge during the course of an educational program, motivating students to break the link between learning and examination and initiating life-long learning. (12,125,129,143,151) Instead of plain repetition of facts they have learned, examinees are encouraged to call up and apply acquired information from their long-term memory. (12) Unlike traditional tests, students are not expected to prepare by memorisation of factual information, thereby reducing the stress and fatigue amongst the students. (12,125,129,140,145,158) Consequently, the PT is a tool from which students as well as educators can benefit in many various ways. (142) It helps to trace the educational development of students, it is predictive of future performance, it allows detailed feedback, and identifies gaps in knowledge. (125) Especially combining results of repeated tests helps to increase the reliability of pass/ fail decisions and its validity. In addition, PT is comprehensive and suitable for internal and external evaluation over the boundaries of courses and curricula as reported in literature. In summary PT is valid, reliable and authentic assessment which can inform quality assurance and further curriculum development in an educational program. (12,125,129,142,144,145,150,158-161)

Challenges:

Even though there are many benefits, the use of progress testing is challenging and poses some risks. PT is a tool which has to be handled with care in judging freshers. Usually around 20% of items relate the learning objectives in the first year, freshmen’s results are generally poor. Therefore, special instructions and explanations have to be given before and after first test completion as mentioned by Van der Vleuten et al. (1996) (125). Furthermore, there is a need of central organisation for developing and administration, because, as it emerges from the beginning, development, implementation and administrative workload are time consuming and costly. (125,162) Substantial resources are needed in item writing, reviewing, rewriting and administration which is a multistage process. (125,126) As described by Osterberg et al. (2006) (160) usually a large number of question authors are needed: in the case of Berlin’s PT more than 200 authors are utilised. Item writing is difficult and can indeed exceed 1 hour of time per question. (129) Thereafter, each item has to be reviewed factual accuracy and consistency in format and design, ideally in groups. (126,129) After each test sitting poor questions have to be excluded and amended prior further use during a post-review process. Additionally, results have to be statistically evaluated and individual

feedback has to be created for each student. Recycling of items in the question bank entails additional review with regard to accuracy, consistency and item performance, which has time and cost implications. (125,160) Thereby it is obvious, if PT is used with inter-institutional collaboration, cost-effectiveness is improved (125,145), as practiced in the Netherlands and Germany. (145,162,163)

Global Use of Progress Testing in Medical and Dental Curricula

As Van der Vleuten et al. (1996) (125) mentioned, PT is not restricted to any curriculum. Nevertheless, it is more widely used in the medical educational world. Freeman et al. (2010) (164) also reported, that this tool is wide spread in medical education all over the world. Reaching 10 000 students per year from 6 out of 8 universities, the Netherlands use progress testing most frequently in medical education. (142,162) At the German-speaking universities, the University of Charité Berlin plays a lead role in PT for the human medical curriculum. A German-speaking PT was developed and introduced in the year 2000 based on the change to a PBL curriculum. In the meantime, 17 universities are collaborating, also including the three Austrian public medical Universities Graz, Vienna and Innsbruck. (144,160,163,165) To develop progress testing the Medical University of Graz has used this test format periodically since 2008 with the last 704 participating human medical students. (166) In contrast use of progress testing is not common in dental education. A literature search resulted only in results for a dental progress test (DPT) for a Bachelor of Dental Surgery Programme and for a Dental Therapy and Hygiene Programme in the Peninsula School of Dentistry in Plymouth, UK. (12,149,167) So far, no reported German-language DPT is available, except the newly implemented one at the Medical University of Graz, described by Kirnbauer et al. (2018) (12).

Relationship between DPT and Bologna process

Although on the first view there might be no connection between the further development of DPT and the Bologna process, DPT could essentially influence the European harmonisation process in dental education. First, implementing a DPT means developing documents of learning objectives. These documents reflect clearly what is actually taught and forces responsible employees and stakeholders to critically reconsider the actual education system. (106) These contents could be compared between universities with regard of the local speci-

fications. This would be a first step toward harmonisation. Out of the learning objective documents individual item banks could be created, as it is done in human medicine. (142,162) With the expansion of the DPT a mixture of items with different origins would be used and, as a result, student's performance and further dental education would be more comparable nation-wide and internationally. From the assessment results individual strengths and weaknesses in dental education could be derived. This could lead to local adaption and harmonisation of curricula. (125,142,162,160) As a result of this movement of students and graduates throughout Europe would also be easier and comply with the Bologna process. (3,5,29) Therefore, DPT should follow the example of the Netherland's (142,162) and Berlin's PT (144,160) in human medicine and further cross language barriers.

2. Material and Methods

Study design

This study reflects a prospective investigation, aimed at the development and implementation of a Dental Progress test (DPT). The tool of DPT implements a special form of assessment method, developed for the clinical oral surgery education at the Dental school of Medical University of Graz, to evaluate the teaching and learning quality. (12)

Duration and setting

This study was performed within the years 2016 and 2017 at the Dental School of the Medical University of Graz. Therefore, all 7th to 12th term, respectively 4th- to 6th-year, students were recruited for participation in this prospective project. The attendance was planned to be compulsory and accordingly the approval was given by the Local Advisory Committee on Dental Study Affairs. Depending on the school's group capacity of twelve students per term, no more than 72 students were enrolled. Participants consisted of male and female trainees, mainly from Austria. Depending on the admission to studies, students from Germany and Southeastern European countries were also included. (12)

Ethics approval

According to the Ethics Committee of Medical University of Graz, no concerns about this study were identified. (12)

DPT development

The DPT project history can be seen in figure 11. The project was developed by a senior staff member at the Division of Oral Surgery and Orthodontics who has 10 years of experi-

ence in dental education and is specially trained in the formulation of multiple-choice questions. First a pool of single-best and true/false (K-type) MC items, 375 in number, was designed within a period of one year. This was mapped against the local document of learning content and to current teaching literature. Storage was password protected at the local available IMS[2] (Item Management System - Umbrella Consortium for Assessment Networks, Heidelberg, Germany). Every single item contained an explanatory introduction (also known as case vignette) and the question text itself. The author decided on five to six possible answers with only one correct key answer. As a special feature of a progress test, a “don’t know” option was included. In context on the field, the author chose either three or four distractors. Negative as well as double negative formulations were avoided. The difficulty level of all items was at final-exam level targeting the four fields of “oral surgery”, “oral medicine”, “oral radiology” and “cases.” Depending on the local catalogue of learning objectives and the subjects pursued during the local clinical dental training, fields also included correlating subcategories. Clinical images and radiographs were also included in 95 items for a better connection to the daily dental practice and to reach a higher discrimination. (Figure 11-15) (12)

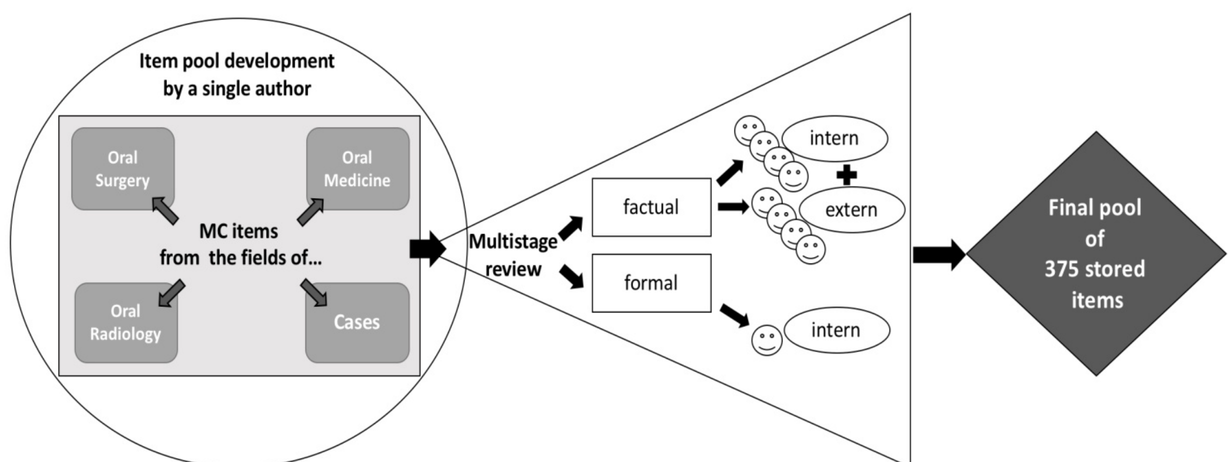


Figure 11: Description of item pool development (reproduced from Kirnbauer et al.2018 (12), with permission due to License Agreement with Wiley for publishing CC-BY-NC)

Sample questions original from IMS Software (German):

Entity Id: 329330 | Item Id: 592585 | Version: 7
Kurztext: Radiologie_Verfahren_Definition_Rechtwinkeltechnik

Autor: Kirnbauer, Barbara

Fach: Zahnheilkunde / Unterfach: Mund-,Kiefer-, Gesichtschirurgie

Ein Kleinbildröntgen kann unter verschiedenen Gesichtspunkten durchgeführt werden.

Die Definition der Rechtwinkeltechnik/Paralleltechnik lautet:
(Bitte kreuzen Sie **eine** Antwort an!)

(A) ☐ Wird der Bildempfänger nicht parallel zur Zahnachse platziert, kann der Zahn nur dann korrekt dargestellt werden, wenn der Zentralstrahl durch den Apex senkrecht auf die Winkelhalbierende gerichtet wird.
(B) ☒ Der Bildempfänger liegt parallel zur Zahnachse. Der Zentralstrahl fällt im Winkel von 90 Grad auf den Bildempfänger.
(C) ☐ Der Bildempfänger liegt parallel zur Zahnachse. Der Zentralstrahl fällt halbwinkelig auf den Bildempfänger.
(D) ☐ Wenn der Zentralstrahl durch den Apex senkrecht auf die Winkelhalbierende gerichtet ist, wird die Wurzellänge korrekt dargestellt.
(E) ☐ Weiß nicht

Figure 12: Single best question from the field of "oral radiology" (reproduced from IMS Software 06/13/1018 [German])

Entity Id: 373702 | Item Id: 600696 | Version: 5
Kurztext: Fall_Notfall_Kollaps_LA

Autor: Kirnbauer, Barbara

Fach: Zahnheilkunde / Unterfach: Mund-,Kiefer-, Gesichtschirurgie

Frau A. (18 Jahre) kommt zur retinierten Weisheitszahnentfernung in Ihre Ordination. Anamnestisch ist eine Hypothyreose bekannt. Nach Durchführung der Leitungsanästhesie zeigt die Patientin folgende Symptome: Blässe, Schwindel, Kaltschweißigkeit, Tachykardie.

Zu welcher/n der folgenden Notfallmaßnahmen sind sie als Zahnarzt primär verpflichtet?1: Schocklagerung, 2: Sublinguale Applikation eines blutdrucksenkenden Medikamentes, 3: Überwachen der Vitalzeichen, 4: Sofortige Verständigung des Notarztes
(Bitte kreuzen Sie **eine** Antwort an!)

(A) ☐ 1+2+3
(B) ☒ 1+3
(C) ☐ 2+4
(D) ☐ Nur 4
(E) ☐ Alle
(F) ☐ Weiß nicht

Figure 13: K-type item with rich context from the field of "cases" (reproduced from IMS Software 06/13/1018 [German])

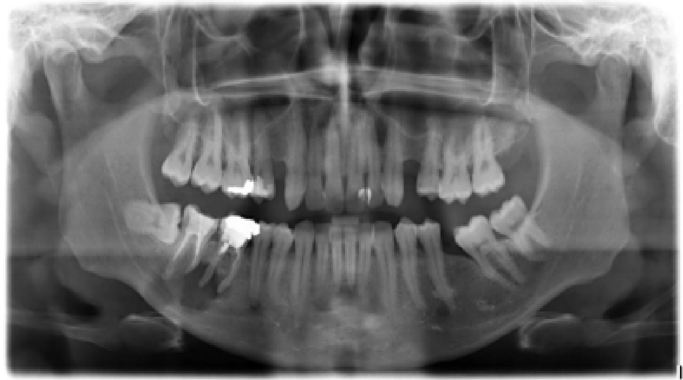
Entity Id: 333945 | Item Id: 592563 | Version: 4
Kurztext: Radiologie_Pathologie_Zysten_Diagnose_Radikuläre Zyste

Autor: Kirnbauer, Barbara

Fach: Zahnheilkunde / Unterfach: Mund-,Kiefer-, Gesichtschirurgie

Zystische Läsionen weisen unterschiedliche radiologische Zeichen auf, auf Grund derer eine Verdachtsdiagnose gestellt werden kann.

Welche Verdachtsdiagnose ist bei der abgebildeten zystischen Läsion im Unterkiefer am wahrscheinlichsten?



(Bitte kreuzen Sie **eine** Antwort an!)

(A) ☐ Keratozystisch odontogener Tumor
(B) ☒ Radikuläre Zyste
(C) ☐ Follikuläre Zyste
(D) ☐ Parodontale Zyste
(E) ☐ Solitäre Knochenzyste
(F) ☐ Weiß nicht

Figure 14: Singe best item from the field of "oral radiology" with included panoramic radiography (reproduced from IMS Software 06/13/1018 [German])

Entity Id: 353707 | Item Id: 586013 | Version: 2
Kurztext: Chirurgie_Instrumente_Zange_26

Autor: Kirnbauer, Barbara

Fach: Zahnheilkunde / Unterfach: Mund-,Kiefer-, Gesichtschirurgie

Die Zangen für die Extraktion von Zähnen unterscheiden sich in ihrer Form.

Für welche Zahnextraktion ist die folgende Zange vorgesehen?

(Bitte kreuzen Sie **eine** Antwort an!)

(A) ☐ 34
(B) ☒ 26
(C) ☐ 11
(D) ☐ 18
(E) ☐ Weiß nicht

Figure 15: Single best item from the field of "oral surgery" with included image (reproduced from IMS Software 06/13/1018 [German])

MCQ review

A multistage review process was performed question by question for all items. First a factual review was done conducted internally, with a group of four senior academics in-house. A second independent review followed. Finally, senior academics at Dental School of Medical University of Vienna did a third review round. An additional formal review by the local examination department, after which final question pool was completed, was also carried out. (Figure 11) (12)

Test schedule and content details

Three progress tests were administered within three terms from the summer term 2016, over the winter term 2016/2017 to the summer 2017 (Figure 16). 100 items were randomly chosen for each test. The selection was made on the basis of a predesigned blueprint, referring to the four categories “oral surgery”, “oral medicine”, “oral radiology”, and “cases”. Thereby a specific number of items per test was chosen from each category, described as follows. 30 items came from “oral surgery” targeting on issues such as diagnostics, treatment indications, surgery techniques, instruments, complication a d risk management as well as implant surgery. A further 30 were chosen from “oral radiology” including radiography techniques, radiation protection and image interpretation. The next 20 came from “cases” reflecting clinical vignettes as encountered in clinical practice, and another 20 items were selected from “oral medicine”, which also included five “local anaesthesia” and five “acute pain management” items. A repetition of any item was prevented. All tests were computer-based with an overall limited time of three hours. A primary a score of +1 was given for correct answers and -1 for incorrect answers. “Don’t know” options were scored with 0. Students participation was mandatory, but based on the formative design, DPT performance did not influence any pass/fail decision. Feedback was given on student’s scores concerning number of correct, incorrect and “don’t know” responses. Their rank in class and their rank in the total cohort was also communicated separate to each student. The best performers were rewarded, to enhance student motivation. (12)

			Study year						
			4		5		6		
			Term						
Items n=375			7	8	9	10	11	12	Students (n)
100 out of 375	Test 1	Cohorts	A	B	C	D	E	F	55
100 out of 275	Test 2	Cohorts	G	A	B	C	D	E	62
100 out of 175	Test 3	Cohorts	H	G	A	B	C	D	56
									173

Figure 16: Performance of Tests 1,2 and 3 (100 items each out of 375) with progressing students cohorts A to H (→) in the course of education between term 7-12, respectively year 4-6 and number of students (n) per test and in total (reproduced from Kirnbauer et al. 2018 (12), with permission due to License Agreement with Wiley for publishing CC-BY-NC)

Post-test review

A post review was completed after each test. Exclusion criteria were defined and applied prior the final analyses of the results. For instance, technical issues during test administration such as problems with the image visualization or items with errors in the assignment of the correct answering options, were considered as a justification for an item exclusion. (12)

Statistical analysis

Data analysis was done anonymously and blinded after the third test, using descriptive and explorative analyses as well as IRT analysis. First student's response behavior was computed as mean, median, standard deviation, minimum and maximum values for each test separated in terms and years. Furthermore, the range of results was also described. Due to the changing cohorts and items per test, the response behavior was not calculated for all three tests together. Further test data were calculated as median and inter-quartile range (IQR) or absolute and relative numbers. After the extensive descriptive and exploratory analyses, Rasch analysis (IRT) was used to evaluate the test and to identify misfitting items. After that,

in preparation for Rasch analysis, the response categories “don’t know” (0) and “false” (-1) were changed and summarised into only “false”. In the case of only correct or only false answers questions were to be excluded from investigation. (12) “Item parameters and person parameters were estimated using response patterns and were expressed on a common log-odds scale”. (12) Important requirements for Rasch analysis are uni-dimensionality of data, local independence and sample independency. (168,169) If all items tap into only one dimension, uni-dimensionality is given. Only in this case the interpretation of an overall score is meaningful. Local dependency, which can inflate reliability, refers to the fact, that another dimension causes dependency among responses. Therefore, responses to the items are not only influenced by the analyzed dimension but also by another. Our tests include four thematic fields. Therefore, local dependency may be introduced by these thematic fields. An advantage of item response theory to classical test theory is, that estimated parameters are not dependent on the sample used for estimation. This so-called sample independency has to be analysed. Further, infit and outfit measures (mean square statistics) and the Wald test were also applied. The reason for this was to identify items that did not match within a uni-dimensional model or had varying item parameters ($\hat{\beta}$) in subsamples of respondents (sample independence). To analyse local independency a second analysis was made grouping the items of the four thematic fields into four polytomous item. (12) “To evaluate the assumption of parallel item characteristic curves (ICC), Andersen’s likelihood-ratio tests for goodness-of-fit with mean split criterion were calculated.” (12) Furthermore, the preparation of person-item maps followed: a person-item maps shows the ability, distribution of the examinees and the distribution of difficulty parameters of the items. Therefore, the fit of the difficulties to the tested sample can be evaluated. The person separation reliability was calculated for the presentation of the internal consistency. For the datasets of four polytomous items the reliability was also calculated. (12) The analyses were done test per test with the appliance of the R-package eRm (Version 0.15-7) (170) and mirt (Version 1.27.1) (171). (12) Rasch analyses were done by Dr. Alexander Avian (Institute for Medical Informatics, Statistics and Documentation, Medical University of Graz)

3. Results

3.1. Descriptive and explorative evaluation Test 1

Participants and items

A total number of 100 items were included in the test. Two had to be excluded at the post-test review, which resulted in 98 evaluated items. (Table 2) The reason for exclusion for both were incorrect clinical images.

Fields	**n**
Case	18
Oral Medicine	22
Oral Radiology	30
Oral Surgery	28

Table 2: Test 1: Items n separated in fields after post review

The first test resulted in a total number of n=55 participating students from the terms 7-12 consisting of 32 men and 23 women. The numerical allocation to the semesters ranged from 5 to 14 persons and as shown in figure 18. (Figure 17)

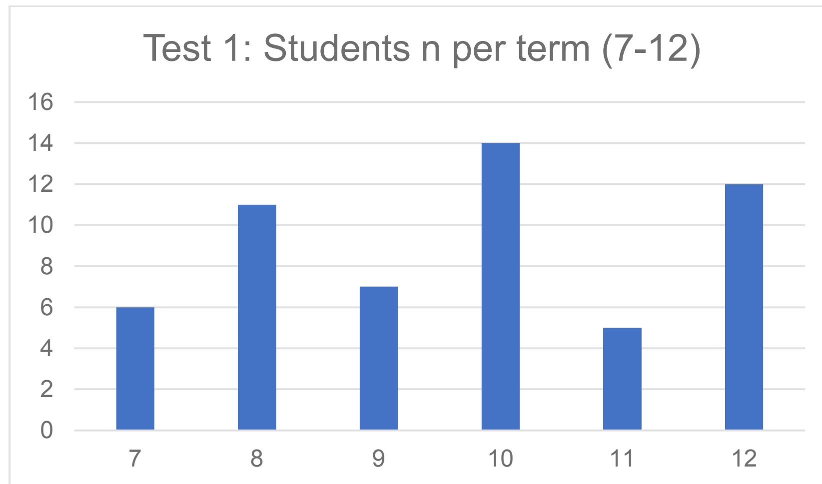


Figure 17: Test 1: Students per term

Response behavior

The number of correct answers of each student at the first test is shown in figure 18. (Figure 18) Results are displayed in students and terms. The best performer was a graduate in the 12th term achieving 82 correct answers out of 98 answered items, closely followed by two students, one from the same term and one from the 9th term. Minimum number of correct answers were achieved by a student from the 11th term with 25 correct answers, followed by colleagues from the 8th, 10th and 12th term. (Figure 18)

Figure 18: Test 1: Number of correct answers per student (y-axis) per term (x-axis)

The response behavior of test 1 is shown with mean, median, standard deviation, minimum and maximum values per term in the tables 3-5 and figure19-20. Results are separated into correct, don't know and false response behavior. 7th term starts with a mean value of 51.7 (range 13) correct answers. The mean values of the correct answers increased up to the 9th term at a value of 67.1 (range 20), followed by a decrease in term 10 to 56.7 (range 40). The level of term 9 is reached by term 12 again with 66.5 (range 40) mean correct answers. False results show the lowest level in term 8 with a mean of 18.5 (range 19) and highest level in term 10 with a mean of 32.6 (range 36). The "don't know" answers showed a negative change from 7th to 12th term with the lowest level in term 12 with a mean of 2.67 (range 9). Thereby it is remarkable that in the terms 9-12 at least one student did not use this option at all: the 11th and 12th term cohorts showed the lowest values. After the term-wise depiction (Figure 19), response behavior is also shown separated by years. Thereby correct answers increase from 4th to 6th year, while "don't know" answers decreased and false answers decreased and stagnated at the end. (Figure 20)

Correct responses						
Term	7	8	9	10	11	12
Mean	51.67	59.82	67.14	56.71	57.80	66.50
Median	52.50	61.00	65.00	56.00	62.00	69.00
Standard deviation	6.06	12.62	7.18	13.71	19.85	12.12
Minimum	45	34	59	36	25	42
Maximum	58	75	79	76	76	82

Table 3: Test 1: Mean, median, minimum and maximum values and standard deviation of correct answers from 7th -12th term

Don't know responses						
Term	7	8	9	10	11	12
Mean	23.67	19.73	8.29	8.71	12.60	2.67
Median	27.5	14.00	11.00	4.00	2.00	2.5
Standard deviation	11.48	13.25	5.79	10.15	23.78	2.77
Minimum	3	8	0	0	0	0
Maximum	36	45	16	36	55	9

Table 4: Test 1: Mean. Median, minimum and maximum values and standard deviation of don't' know answers from 7th -12th term

False responses						
Term	7	8	9	10	11	12
Mean	22.67	18.45	22.57	32.57	27.40	28.83
median	20.00	19.00	7.00	31.5	23.00	25.00
Standard deviation	11.20	5.52	8.52	11.01	10.24	11.98
Minimum	12	8	14	14	18	16
Maximum	37	27	35	50	42	51

Table 5: Test 1: Mean, median, minimum and maximum values and standard deviation of false answers from 7th - 12th term

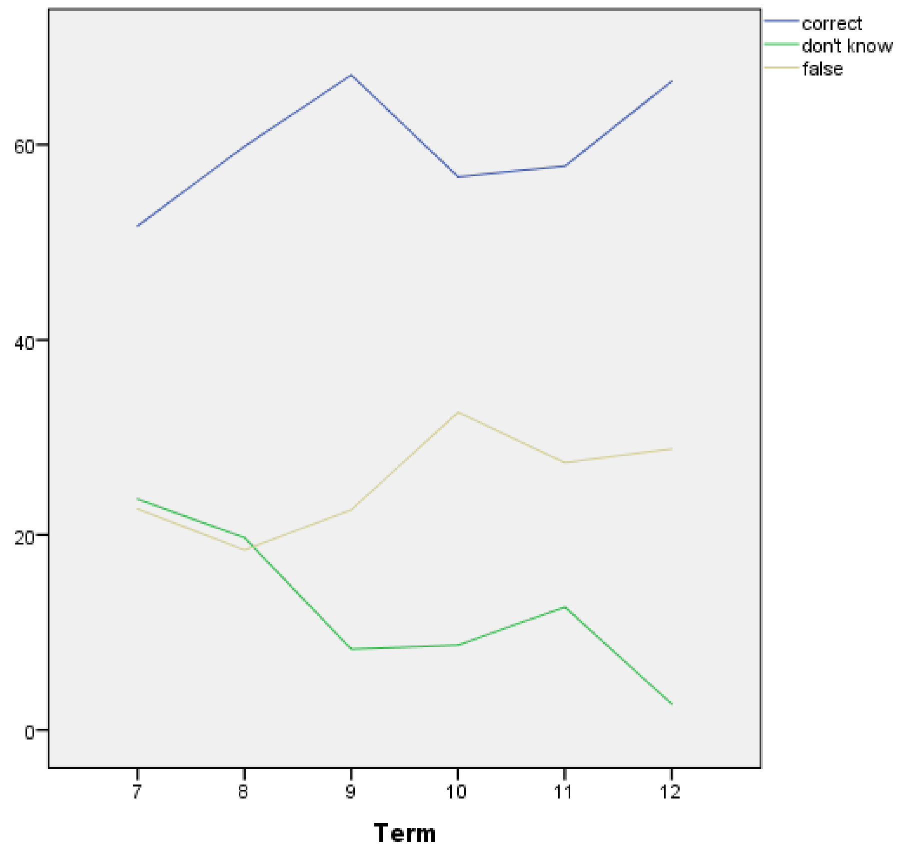


Figure 19: Test 1: Mean values (y-axis) of response behavior distributed by term (x-axis)

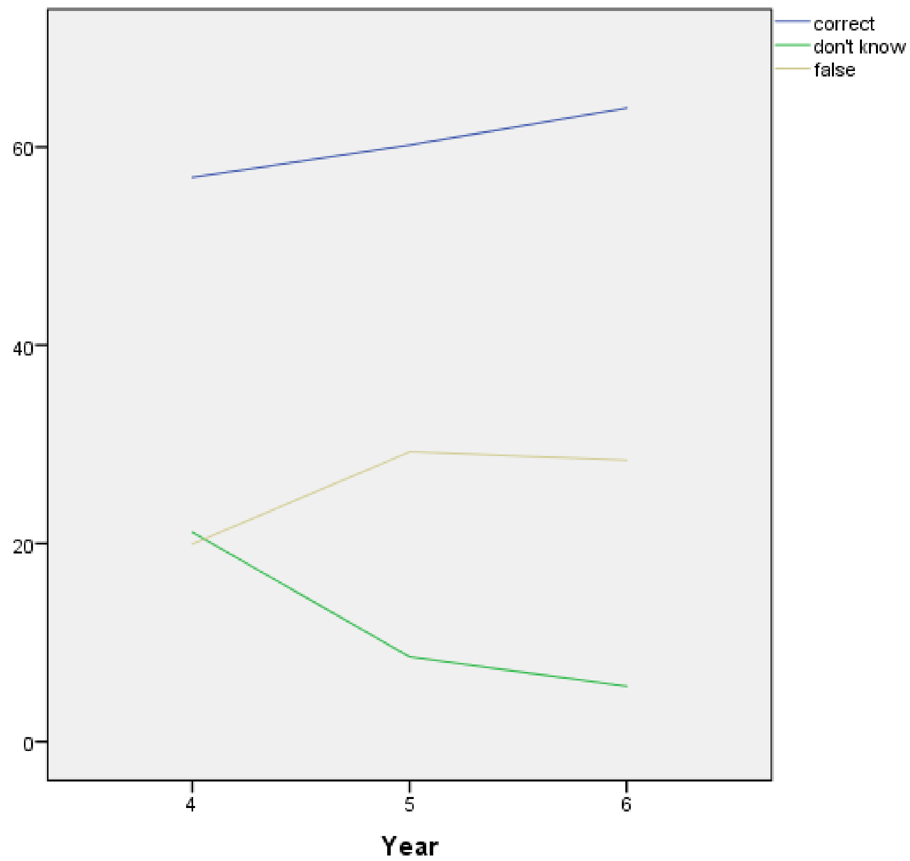


Figure 20: Test 1: Mean values (y-axis) of response behavior distributed by years (x-axis)

Boxplots of the correct answers of test 1 are shown in figure 21. Most homogenous results are showing the boxplots of term 7 to 9, while the widest range is reflecting term 10. Negative outliers were identified in terms 8, 11 and 12. (Figure 21)

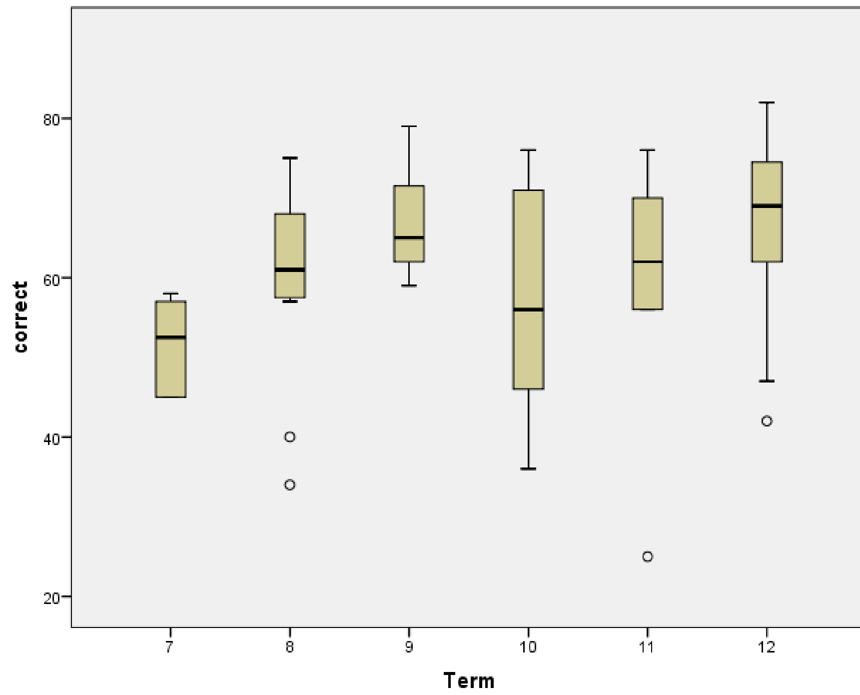


Figure 21: Test 1: Boxplots of correct responses (y-axis) distributed by term (x-axis)

In figure 22 the values of the don’t know response behavior is shown. Values decrease till term 11 and 12. The widest range can be seen in term 8, except outliers in term 7,10 and 11. (Figure 22)

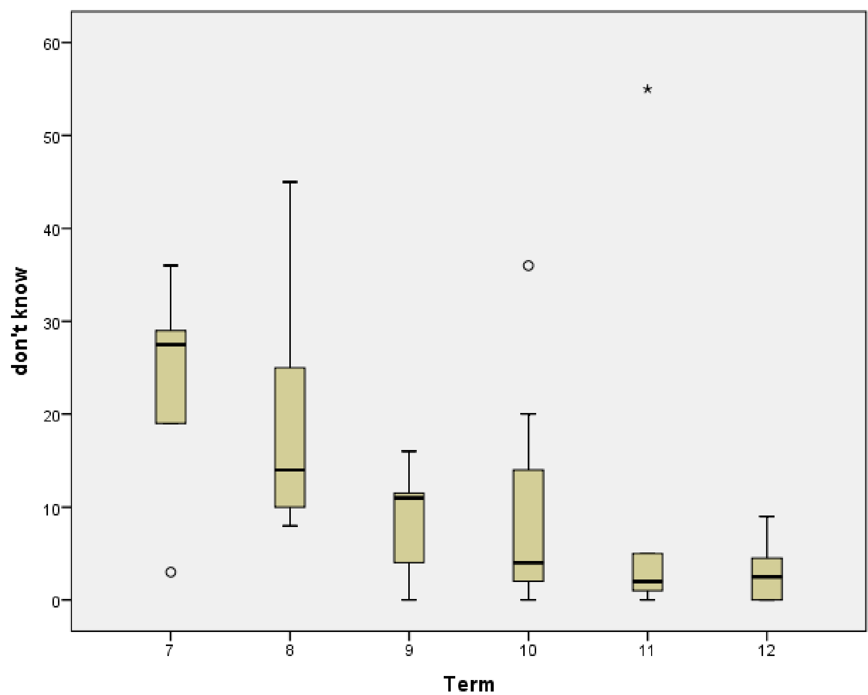


Figure 22: Test 1: Boxplots of don't know responses (y-axis) distributed by term (x-axis)

The distribution of incorrect responses showed a wide range, except in term 8, highest levels in term 10 and 12. (Figure 23)

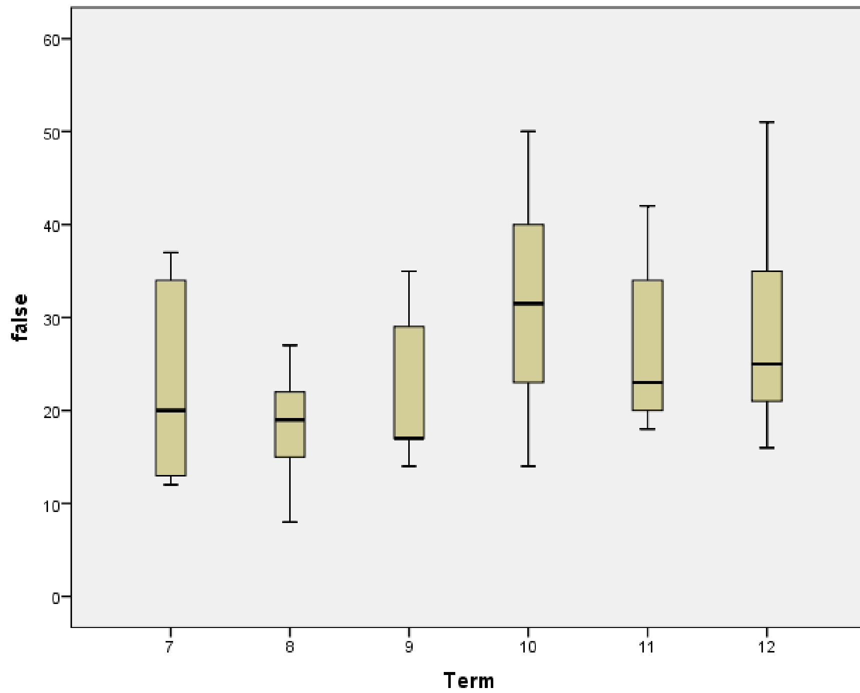


Figure 23: Test 1: Boxplots of false responses (y-axis) distributed by term (x-axis)

Results separated in years are shown in the following tables and boxplots. (table 6-8 and figure 24-26) Mean values of correct answers were at 56.9, 60.2 and 63.9 from 4th to 6th year, while mean “don’t know” results are 21.1, 8.6 and 5.7. For incorrect responses, mean values are ranged from 19.9 over 29.2 to 28.4.

Correct responses			
Year	4	5	6
Mean	56.94	60.19	63.94
Median	58.00	61.00	68.00
Standard deviation	11.28	12.77	14.70
Minimum	34	36	25
Maximum	75	79	82

Table 6: Test 1: Mean. Median, minimum and maximum values and standard deviation of correct answers from 4th -6th year

Dont’know responses			
Year	4	5	6
Mean	21.12	8.57	5.59
Median	19.00	6.00	2.00
Standard deviation	12.44	8.78	12.98
Minimum	3	0	0
Maximum	45	36	55

Table 7: Test 1: Mean. Median, minimum and maximum values and standard deviation of don't know answers from 4th -6th year

False responses			
Year	4	5	6
Mean	19.94	29.24	28.41
Median	19.00	26.00	25.00
Standard deviation	7.91	11.13	11.20
Minimum	8	14	16
Maximum	37	50	51

Table 8:Test 1: Mean. Median, minimum and maximum values and standard deviation of false answers from 4th - 6th year

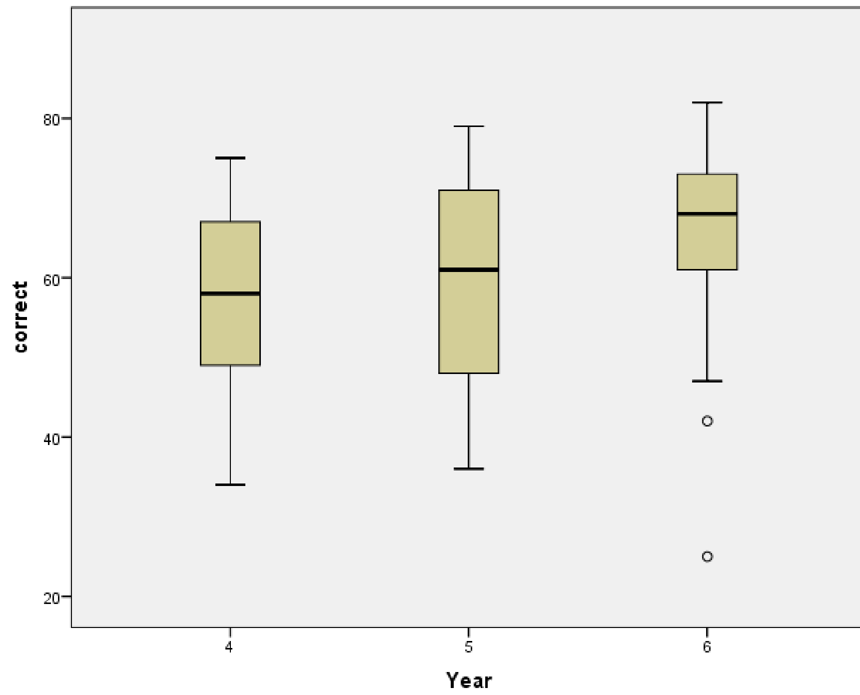


Figure 24: Test 1: Boxplots of correct responses (y-axis) distributed by years (x-axis)

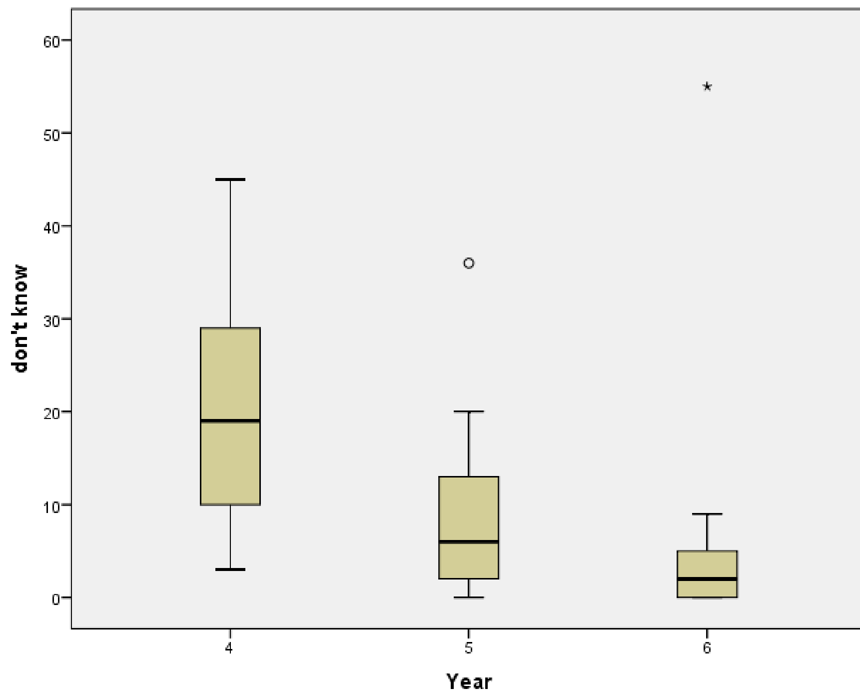


Figure 25: Test 1: Boxplots of don't know responses (y-axis) distributed by years (x-axis)

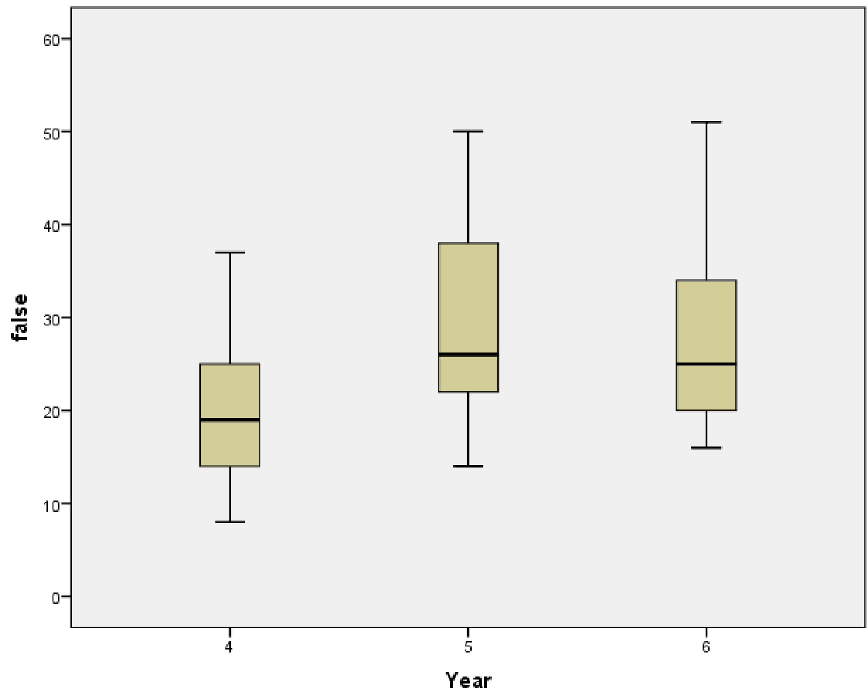


Figure 26: Test 1: Boxplots of false responses (y-axis) distributed by years (x-axis)

3.2. Descriptive and explorative evaluation Test 2

Participants and items

A total of 100 items were included. One had to be excluded after test review, which resulted in 99 evaluated items. (Table 9) The reason for exclusion was incorrect options.

Fields	n
Case	20
Oral Medicine	20
Oral Radiology	30
Oral Surgery	29

Table 9: Test 2: Items n separated in fields after post review

The second test resulted in a total number of n=62 participating students from the terms 7-12 consisting of 36 men and 26 women. The numerical allocation to the semesters ranged from 5 to 20 and is depicted in figure 30. (Figure 27)

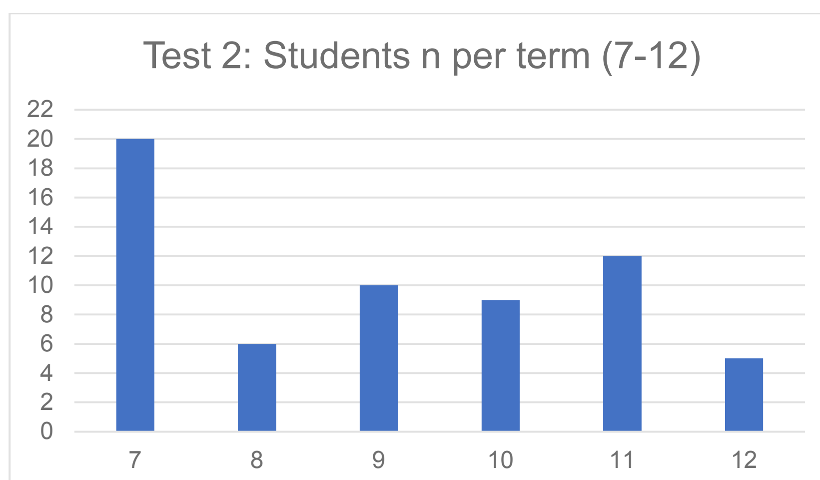


Figure 27: Test 2: Students per term

Response behavior

The number of correct answers of each student is shown in figure 28. Results are separated in students and terms. In this test the best performer from 9th term scored again 82 correct answers out of 99 items, closely followed by a peer from 8th, 9th and 12th terms. A minimum score of 14 correct answers was reached by a student from the 7th term. Second worst result was at 30 correct answers, further followed by students from the 10th and 11th term. (Figure 28)

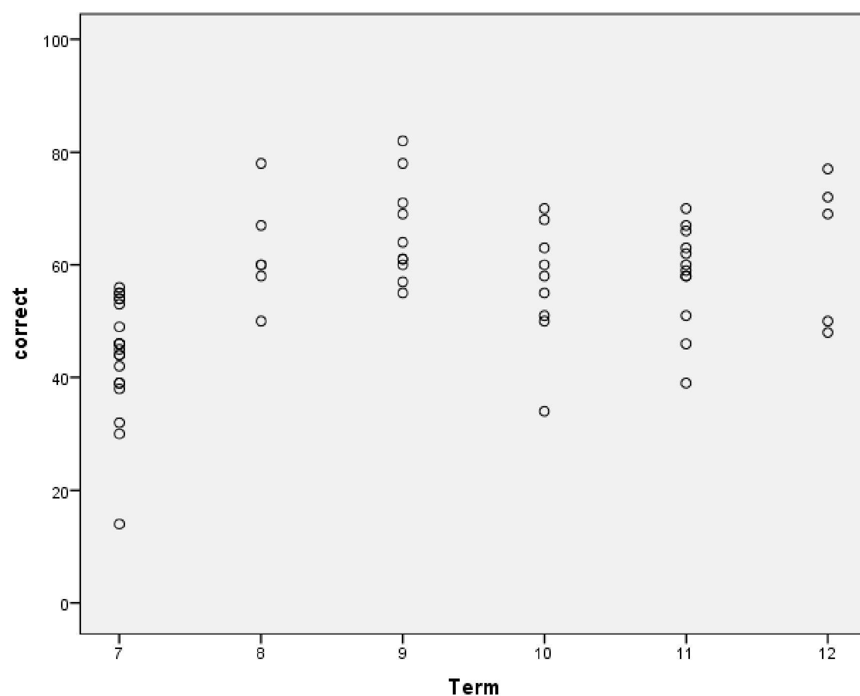


Figure 28: Test 2: Number of correct answers per student (y-axis) per term (x-axis)

The response behavior of test 2 is shown in mean, median, standard deviation, minimum and maximum values per term in tables 8-10 and figure 29. Results are separated in correct, false, "don't know" answers. 7th term begins with a mean value of 44.1 (range 42). Correct answers showed an increase up to the 9th term at 65.8 (range 27), followed by a decrease in term 10 at 56.6 (range 36). The mean value of correct answers increased until the end again up to 63.2 (range 29). False results show lowest levels in term 8 and 9, while "don't know" values show a steady decrease from 7th to 12th term from 29.5. (range 70) to 1.6 (range 6). At least one student in term 9 and one in term 12 have not chosen the don't know option at all. (Table 9) Concerning response behavior separated in years an increase of mean correct

answers with a slight decrease at the end as well as a decrease of mean don't know answers, but also an increase of mean false answers was observed. (Figure 30)

Correct responses						
Term	7	8	9	10	11	12
Mean	44.05	62.17	65.80	56.56	58.25	63.20
Median	45.50	60.00	62.50	58.00	59.50	69.00
Standard deviation	10.35	9.48	8.98	10.91	8.99	13.29
Minimum	14	50	55	34	39	48
Maximum	56	78	82	70	70	77

Table 9: Test 2: Mean, median, minimum and maximum values and standard deviation of correct answers from 7th -12th term

Don't know responses						
Term	7	8	9	10	11	12
Mean	29.45	13.00	8.90	11.67	10.75	1.60
Median	24.00	10.00	5.50	10.00	9.50	0.00
Standard deviation	15.79	8.46	7.99	5.85	8.59	2.61
Minimum	10	4	0	5	1	0
Maximum	80	28	22	22	33	6

Table 10: Test 2: Mean, median, minimum and maximum values and standard deviation of don't know answers from 7th -12th term

False responses						
Term	7	8	9	10	11	12
Mean	25.50	23.83	24.30	30.78	30.00	34.20
Median	24.50	22.50	24.50	28.00	29.50	30.00
Standard deviation	9.16	13.23	5.58	12.76	7.87	14.96
Minimum	5	10	16	17	21	20
Maximum	41	45	34	60	46	51

Table 11: Test 2: Mean, median, minimum and maximum values and standard deviation of false answers from 7th -12th term

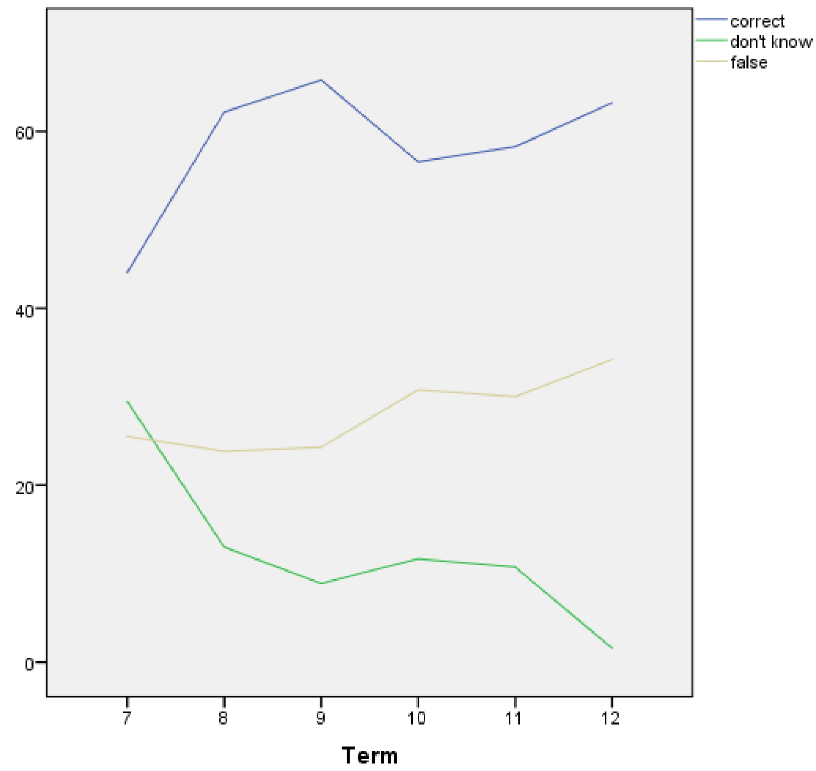


Figure 29: Test 2: Mean values (y-axis) of response behavior distributed by term (x-axis)

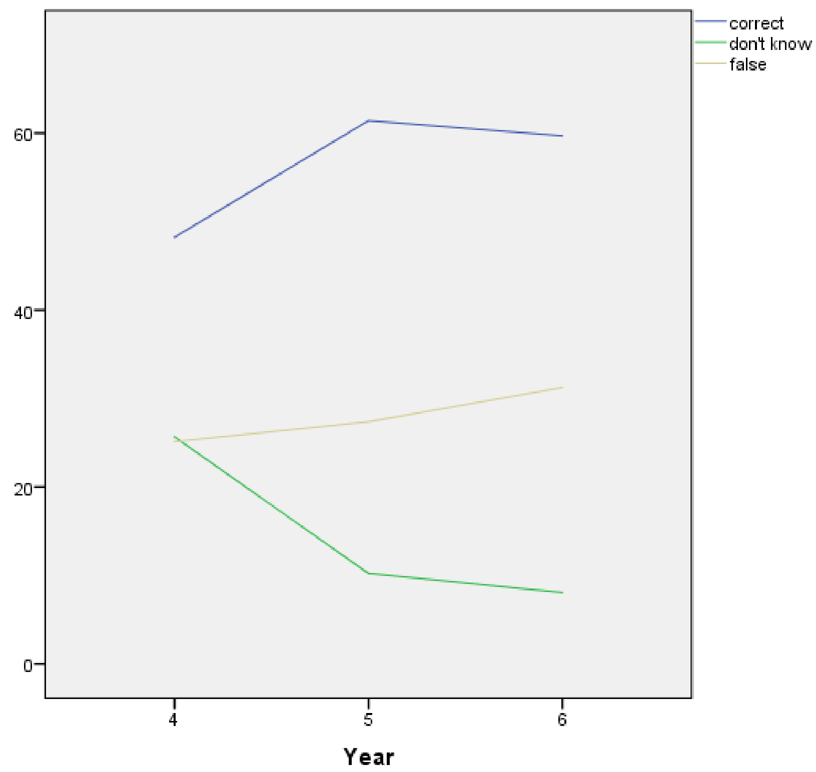


Figure 30: Test 2: Mean values (y-axis) of response behavior distributed by years (x-axis)

Values of correct answers are shown in figure 31, depicted with boxplots. Except two outliers in term 7 and 11, results are homogeneous with the highest levels in term 9. (Figure 31)

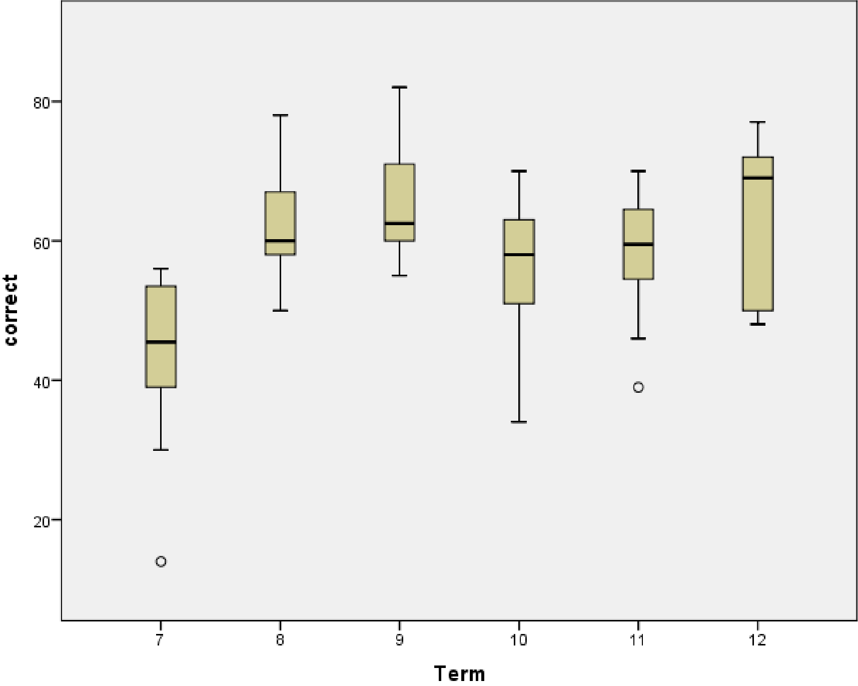


Figure 31: Test 2: Boxplots of correct responses (y-axis) distributed by term (x-axis)

The frequencies of don't know responses showed a decrease till the 12th term with widest range in term 7 and three outliers in term 7, 11 and 12. (Figure 32)

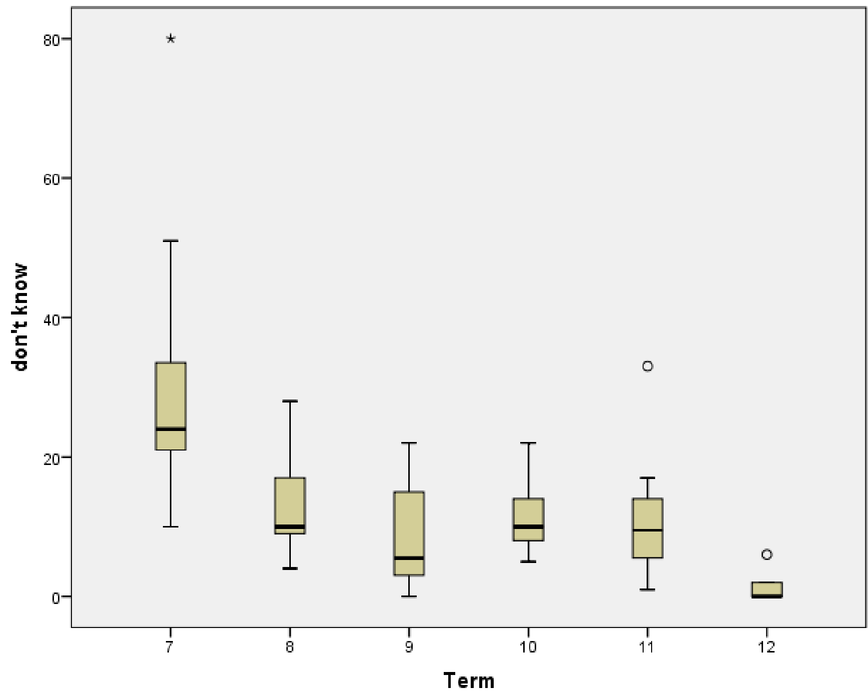


Figure 32: Test 2: Boxplots of don't know responses (y-axis) distributed by terms (x-axis)

Boxplots of false responses showed wide ranges over all terms, except in term 9 and higher frequency in term 12. (Figure 33)

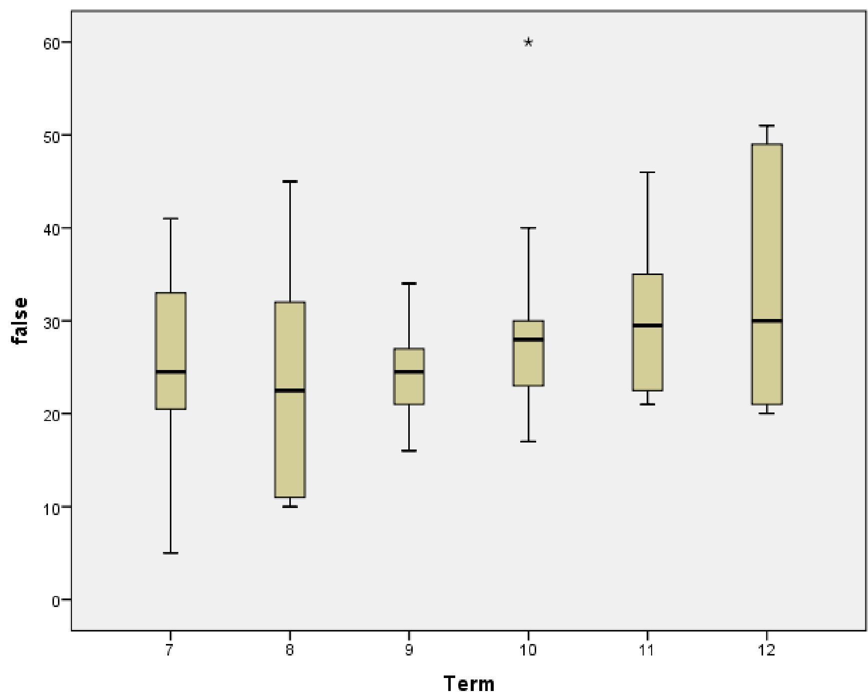


Figure 33: Test 2: Boxplots of false responses (y-axis) distributed by term (x-axis)

Year-wise results are shown in the following tables and figures. (Table 12-14 and Figure 34-36) Mean values of correct answers were at 48.23, 61.42 and 59.71 in years 4,5 and 6, while don't know answers were at 25.65, 10.21 and 8.06. Mean values of false responses ranged from 25.12 over 27.37 to 31.24 from 4th to 6th year respectively.

Correct responses			
Year	4	5	6
Mean	48.23	61.42	59.71
Median	47.5	61.00	60.00
Standard deviation	12.65	10.76	10.25
Minimum	14	34	39
Maximum	78	82	77

Table 12: Test 2: Mean, median, minimum and maximum values and standard deviation of correct answers from 4th -6th year

Don't know responses			
Year	4	5	6
Mean	25.65	10.21	8.06
Median	23.00	8.00	7.00
Standard deviation	15.93	7.01	8.42
Minimum	4	0	0
Maximum	80	22	33

Table 13: Test 2: Mean, median, minimum and maximum values and standard deviation of don't know answers from 4th -6th year

False responses			
Year	4	5	6
Mean	25.12	27.37	31.24
Median	23.5	27.00	30.00
Standard deviation	9.97	9.95	10.12
Minimum	5	16	20
Maximum	45	60	51

Table 14: Test 2: Mean, median, minimum and maximum values and standard deviation of false answers from 4th -6th year

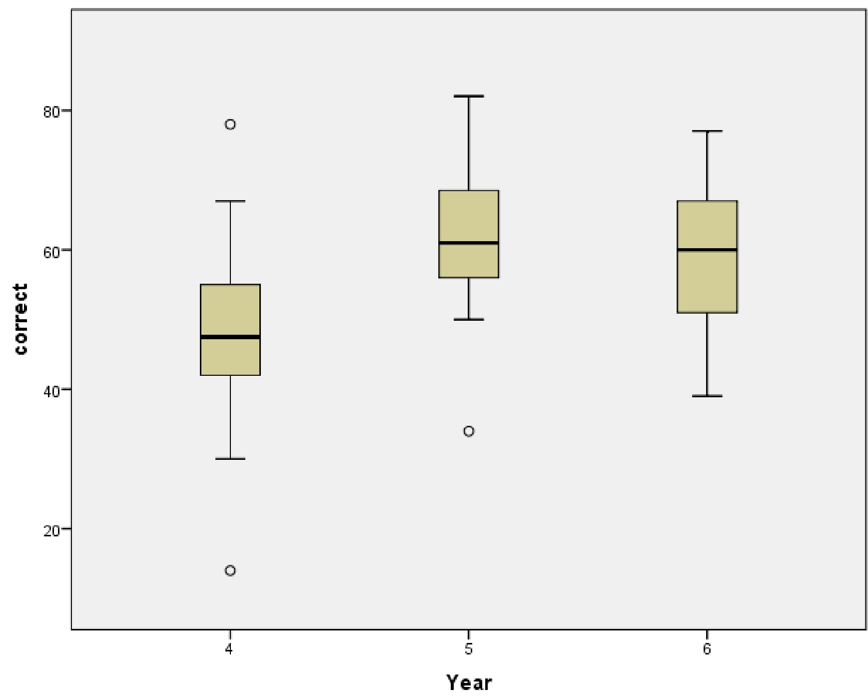


Figure 34: Test 2: Boxplots of correct responses (y-axis) distributed by years (x-axis)

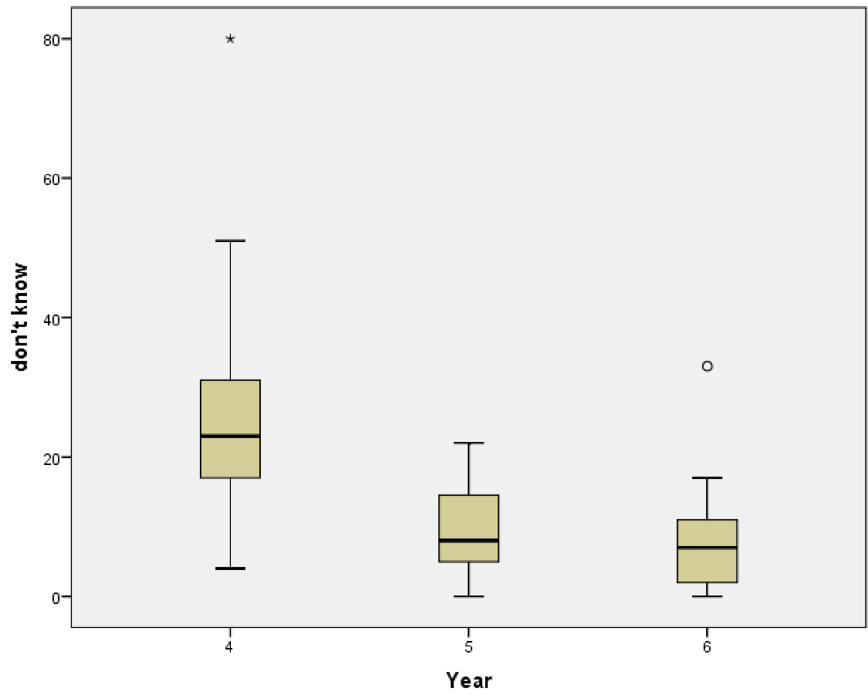


Figure 35: Test 2: Boxplots of don't know responses (y-axis) distributed by years (x-axis)

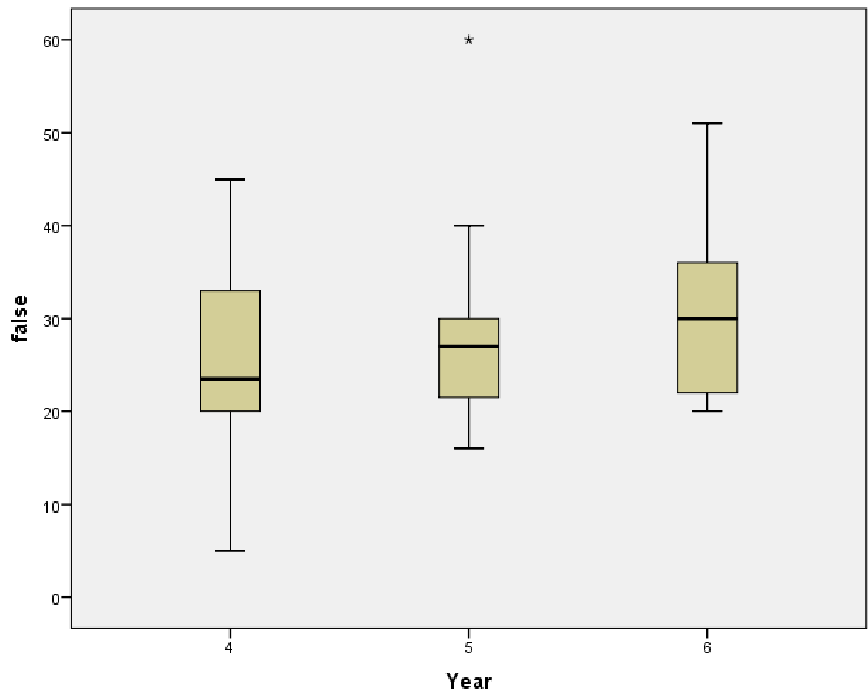


Figure 36: Test 2: Boxplots of false responses (y-axis) distributed by years (x-axis)

3.3. Descriptive and explorative evaluation Test 3

Participants and items

Primarily 100 items had been included. Three had to be excluded after test review, which resulted in 97 evaluated items. (Table 15) Reason for all three was an incorrect image display.

Fields	n
Case	20
Oral Medicine	20
Oral Radiology	30
Oral Surgery	27

Table 15: Test 3: Items n separated in fields after post review

The third test resulted in a total number of n=56 participating students from the terms 7-12 consisting of 33 men and 23 women. The numerical allocation to the semesters ranged from 3 to 12 participants and can be taken from figure 37. (Figure 37)

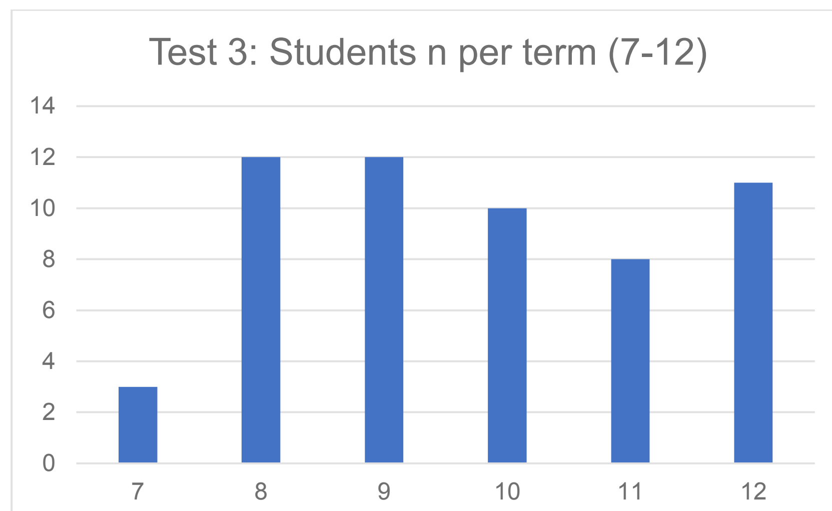


Figure 37: Test 3: Students per term

Response behavior

The number of correct answers of each student is shown in figure 38. Results are separated in students and terms. At this test both best performers reached 76 correct answers out of 97 items. They came from 9th and 11th term, closely followed by a colleague from 11th and 12th term. Minimum result of 37 correct answers was reached by a student from the 8th term and 10th term, followed by students from the 11th and 12th term. (Figure 38)

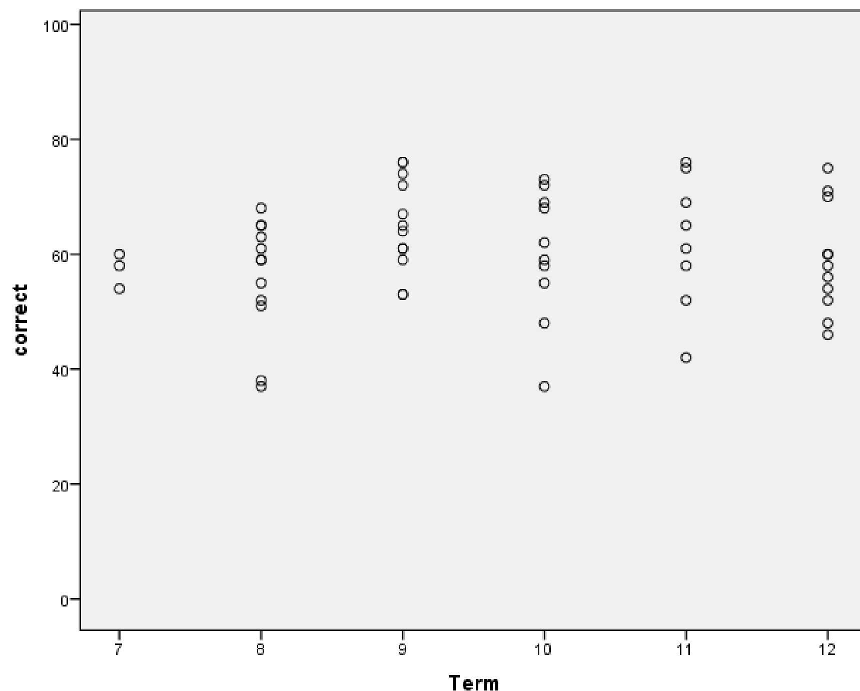


Figure 38: Test 3: Number of correct answers per student (y-axis) per term (x-axis)

The response behavior of test 3 is shown in mean values per term as well as in median, standard deviation, minimum and maximum levels in tables 16-18 and figure 39. Results are separated into correct, false and don't know. The 7th term stars with a mean value of 57.3 (range 6) of correct answers. Correct answers increase up to the 9th term at 65.1 (range 3), followed by a decrease in term 10 at 60.1 (range 36). The mean value of correct answers is slightly lower at a value of 59.01 (range 29) in term 12. False results show lowest levels in term 8 and 9. In this test don't know options were used in maximum 10 times in term 7 and even never in terms 8, 9 and 11.

Correct responses						
Term	7	8	9	10	11	12
Mean	57.33	56.08	65.08	60.10	62.25	59.09
Median	58.00	59.00	64.50	60.50	63.00	58.00
Standard deviation	3.06	10.11	8.16	11.38	11.59	9.47
Minimum	54	37	53	37	42	46
Maximum	60	68	76	73	76	75

Table 16: Test 3: Mean, median, minimum and maximum values and standard deviation of correct answers from 7th -12th term

Don't know responses						
Term	7	8	9	10	11	12
Mean	12.00	13.92	8.50	13.70	8.38	10.00
Median	11.00	11.50	7.00	11.00	8.00	9.00
Standard deviation	2.65	10.24	6.84	11.01	6.72	7.22
Minimum	10	0	0	3	0	1
Maximum	15	38	24	36	21	26

Table 17: Test 3: Mean, median, minimum and maximum values and standard deviation of don't know answers from 7th -12th term

False responses						
Term	7	8	9	10	11	12
Mean	27.67	27.00	23.42	23.20	26.38	27.91
Median	29.00	27.00	23.50	19.00	25.00	25.00
Standard deviation	5.13	4.37	6.16	12.99	9.96	9.41
Minimum	22	21	14	10	13	13
Maximum	32	34	33	52	43	42

Table 18: Test 3: Mean, median, minimum and maximum values and standard deviation of false answers from 7th -12th term

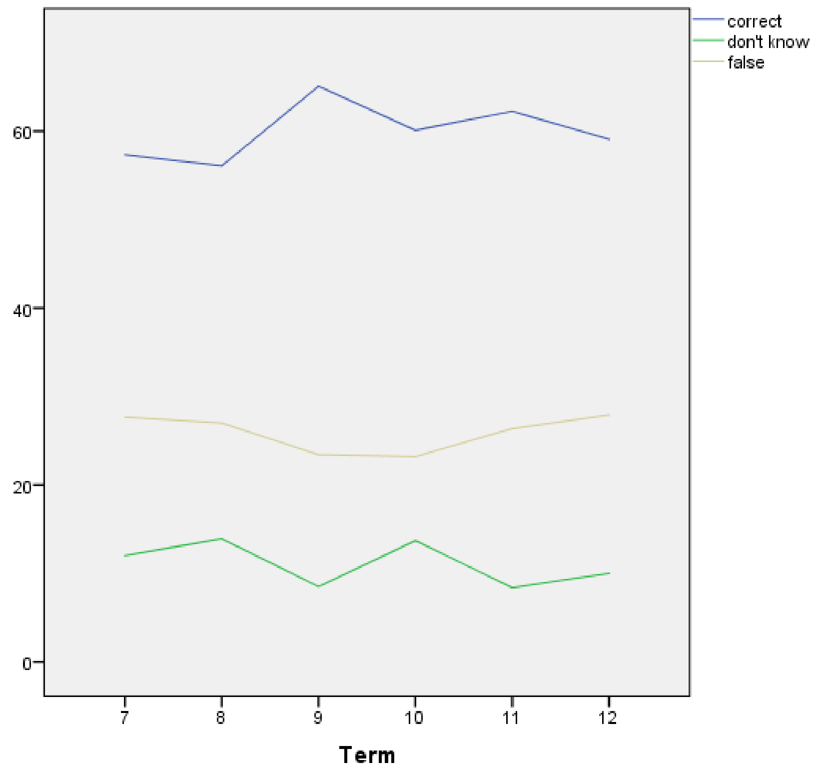


Figure 39: Test 3: Mean values (y-axis) of response behavior distributed by term (x-axis)

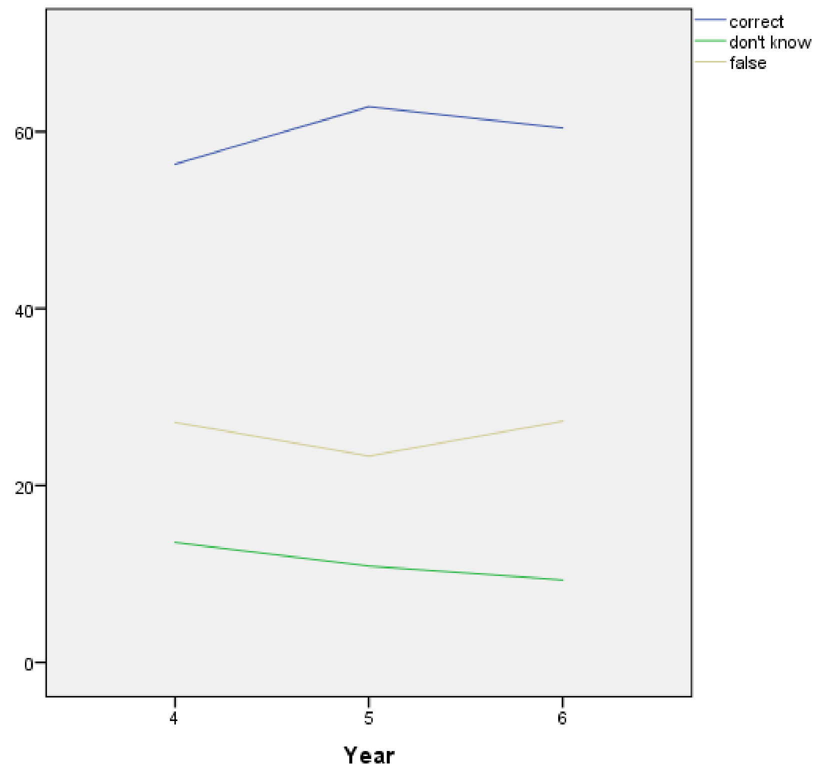


Figure 40: Test 3: Mean values of response behavior (y-axis) distributed by years (x-axis)

With regard to correct answers, the boxplot in term 7 showed the most homogeneous response behavior, but showed wide variations in terms 8, 10 and 11. (Figure 41)

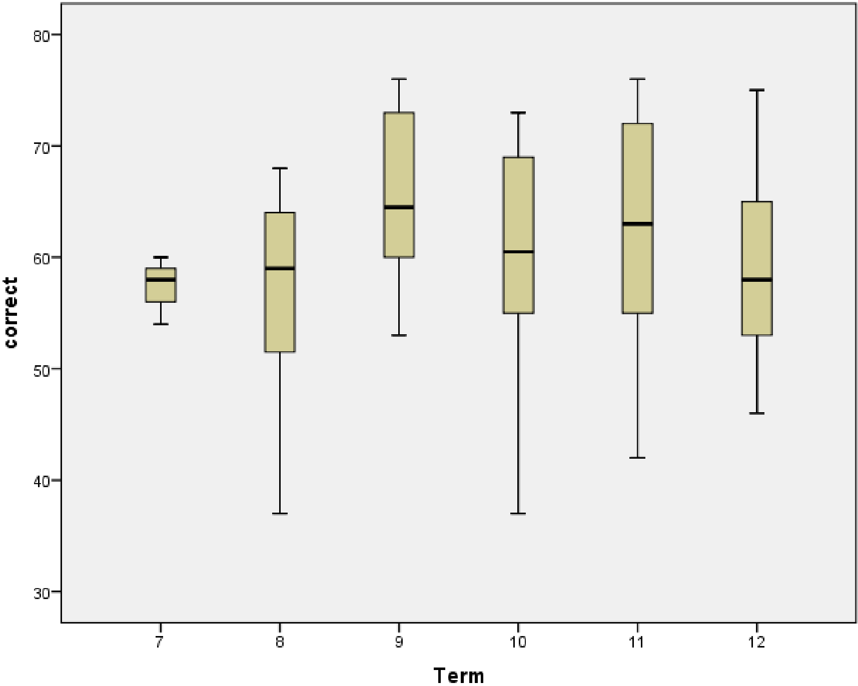


Figure 41: Test 3: Boxplots of correct responses (y-axis) distributred by terms (x-axis)

Response behavior of the don't know option done most inconsistent results with remarkable number of outliers. (Figure 42)

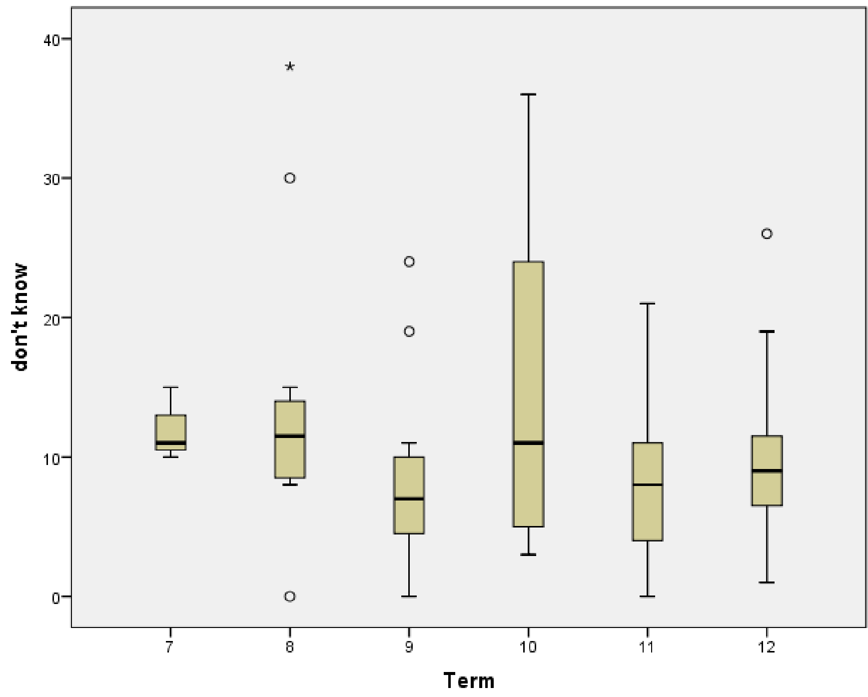


Figure 42: Test 3: Boxplots of don't know responses (y-axis) distributed by term (x-axis)

Values of false responses showed more homogenous results in the terms 7-9 than in terms 10-12 with one outlier in term 10. (Figure 43)

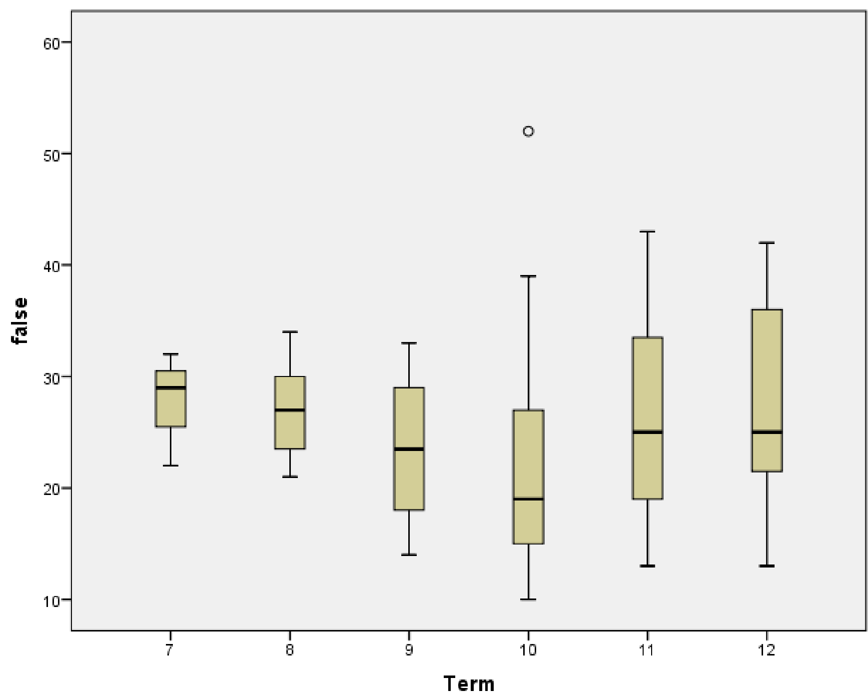


Figure 43: Test 3: Boxplots of false responses (y-axis) distributed by term (x-axis)

The tables and boxplots below (Table 19-21, Figure 44-46) show year-wise the response behavior, resulting in mean values for correct answers of 56.33, 62.82 and 60.42 from year 4 to 6. With regard to don't know responses mean values of 13.53, 10.86 and 9.32 were observed. The figures for incorrect responses were 27.13; 23.32; and 27.26 respectively.

Correct responses			
Year	4	5	6
Mean	56.33	62.82	60.42
Median	59.00	63.00	60.00
Standard deviation	9.05	9.84	10.23
Minimum	37	37	42
Maximum	68	76	76

Table 19: Test 3: Mean, median, minimum and maximum values and standard deviation of correct answers from 4th -6th year

Don't know responses			
Year	4	5	6
Mean	13.53	10.86	9.32
Median	11.00	8.00	8.00
standard deviation	9.16	9.14	6.87
Minimum	0	0	0
Maximum	38	36	26

Table 20: Test 3: Mean, median, minimum and maximum values and standard deviation of don't know answers from 4th -6th year

False responses			
Year	4	5	6
Mean	27.13	23.32	27.26
Median	28.00	20.5	25.00
Standard deviation	4.34	9.60	9.40
Minimum	21	10	13
Maximum	34	52	43

Table 21: Test 3: Mean, median, minimum and maximum values and standard deviation of false answers from 4th -6th year

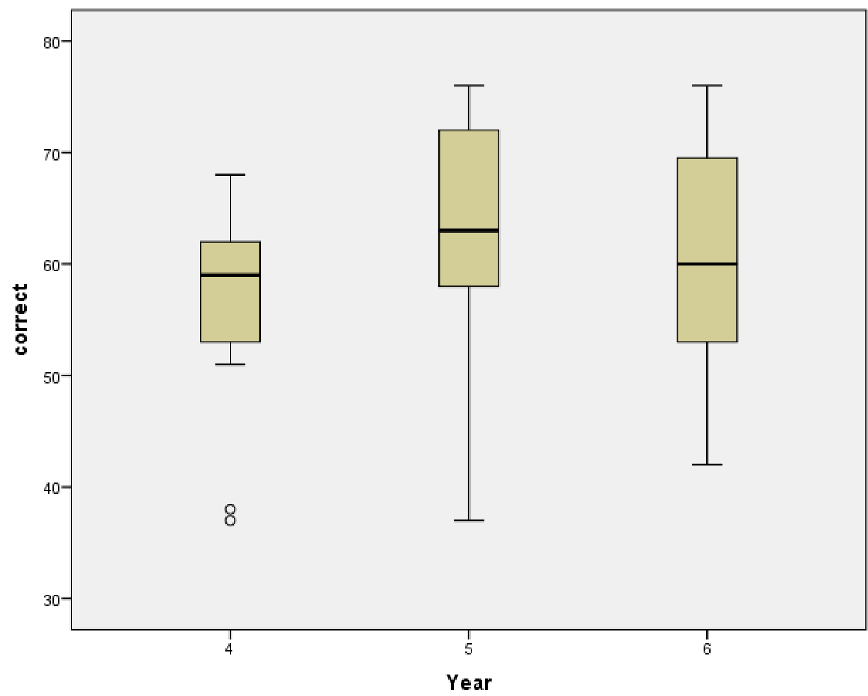


Figure 44: Test 3: Boxplots of correct responses (y-axis) distributed by years (x-axis)

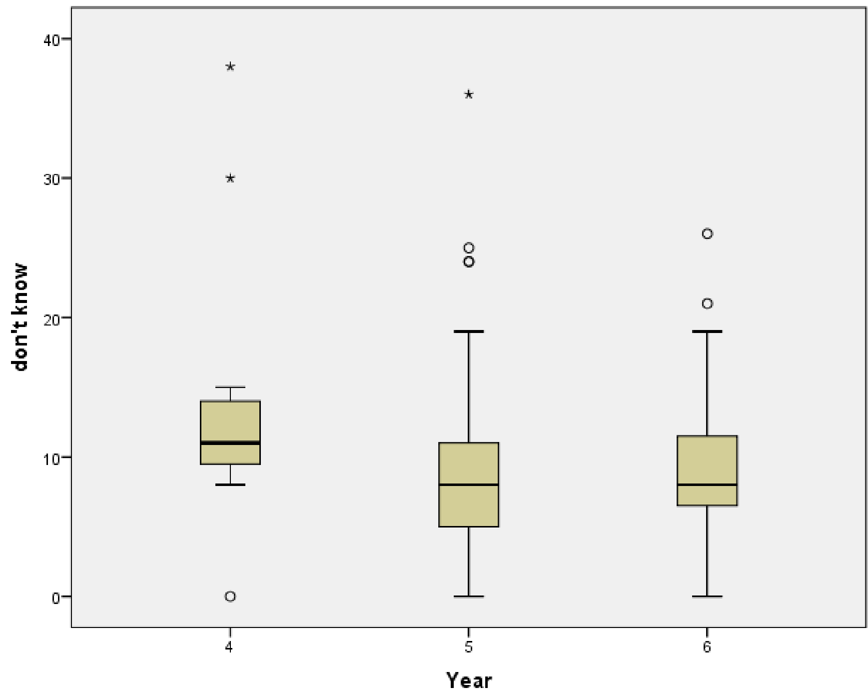


Figure 45: Test 3: Boxplots of don't know responses (y-axis) distributed by years (x-axis)

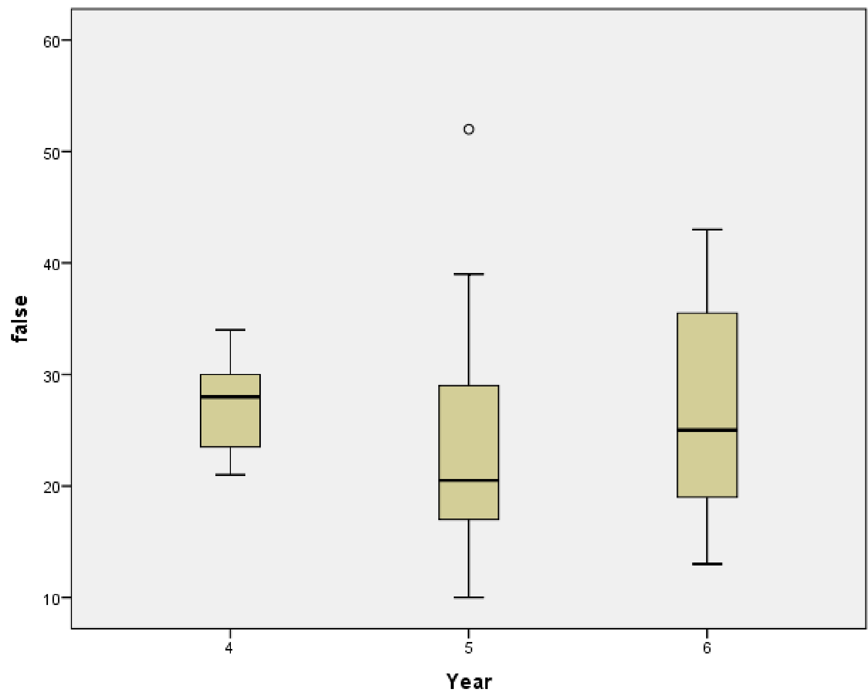


Figure 46: Test 3: Boxplots of false responses (y-axis) distributed by years (x-axis)

3.4. Results based on response categories

Test results

All three tests reflect similar results with regard to item responses with an overall calculation of 59.7% “correct”, 13.3% “don’t know” and 27.0% “false”, considering excluded items. (Table 22) (12)

“In the second assessment the number of correct answers increased from term 7/8 (4th year) to 9/10 (5th year) ($p < .001$) and 7/8 to 11/12 (6th year) ($p = .002$) (term 7/8: median number correct answers: 48, IQR: 42-55; term 9/10: 61, 55 – 69; term 11/12: 60, 51 – 67). In the other two tests, the number of correct answers did not increase. In Test 1 and Test 2 the number of “don’t know” decreased from term 7/8 to 9/10 (Test1: $p = .003$; Test2: $p < .001$) and 7/8 to 11/12 (Test 1: $p < .001$, Test2: $p < .001$) (Test 1: term 7/8: median number “don’t know” answers: 19, IQR: 10-29; term 9/10: 6, 2 – 13; term 11/12: 2, 0 – 5; Test 2: term 7/8: median number “don’t know” answers: 24, IQR: 18-32; term 9/10: 8, 5 – 15; term 11/12: 7, 2 – 12). The number of false answers increased in Test 1 from term 7/8 to 9/10 ($p = .009$) and 7/8 to 11/12 ($p = .022$) (term 7/8: median number false answers: 19, IQR: 14-25; term 9/10: 26, 22 – 38; term 11/12: 25, 20 – 34).” (12) (Table 22)

3.5. Rasch analysis

Given that all respondents had answered correctly or all had answered "false"/ "don't know", no item was excluded. However, based on sample dependency a quarter of items (25.5%, n = 75) had to be excluded. These included 1.0% (n = 3) because of too high or too low MSQ outfit statistics, none because of too high or too low MSQ infit statistics, and 0.7% (n =2) due to inappropriate response patterns within subgroups.

As a consequence, analyses resulted in 75 (Test 1), 68 (Test 2) and 72 (Test 3) items. In all three tests (test 1: χ^2= 51.071, df= 74, p = .981; test 2: χ^2= 57.044, df= 67, p = .802; test 3: χ^2= 58.443, df= 72, p = .876) the assumption of parallel ICC was met. Additionally, the person separation reliability was 0.88, 0.86 and 0.82 for test 1,2 and 3. Concerning the item difficulties for the chosen fields "oral medicine", "oral radiology" and "cases" were comparable when distributed across the latent dimensions.

While this is also accurate for the category of "oral surgery" in the first test, there were fewer difficult items for "oral surgery" in the second and fewer easy items for "oral surgery" in the last test. When using trait estimations with the application of Rasch models, in the first test no significant rise in the measured latent trait (term 7/8: 0.23±0.60; term 9/10: 0.40±0.81; term 11/12: 0.64±0.92) was observed. There was a significant gain from term 7/8 to 9/10 (p <.001) and 7/8 to 11/12 (p = .001) (term 7/8: -.12±0.77; term 9/10: 0.70±0.62; term 11/12: 0.64±0.62) in the second test and a significant increase from term 7/8 to 9/10 (p = .043) in the third test (term 7/8: 0.40±0.57; term 9/10: 0.84±0.64; term 11/12: 0.63±0.69) as depicted in the figures 47 to 49 and table 22. (12) (Table 22) (Figure 47-49)

	Overall	Test 1	Test 2	Test 3
Correct answer	59.7%	61.6%	56.0%	62.1%
False answer	27.0%	26.6%	27.8%	26.5%
Don't know	13.3%	11.8%	16.3%	11.4%
Items with all responses correct	0	0	0	0
Items with all responses false or "don't know"	0	0	0	0
Analyzed Items	294	98	99	97
Items excluded because of				
… sample dependency	75	23	30	22
… outfit MS statistics	3	0	1	2
… infit MS statistics	0	0	0	0
…inappropriate response pattern	1	0	0	2
Final number of items				
All items	215	75	68	71
Oral surgery items	62	23	20	19
Oral medicine items	47	17	15	15
Oral radiology items	62	21	19	22
Cases items	43	14	14	15
Andersen’s LR-Test (χ^2; df; P-value)		51.071; 74; 0.981	57.044; 67; 0.802	54.559; 70; 0.913

Table 22: Results of analysed items (reproduced from Kirnbauer et al.2018 (12), with permission due to License Agreement with Wiley for publishing CC-BY-NC)

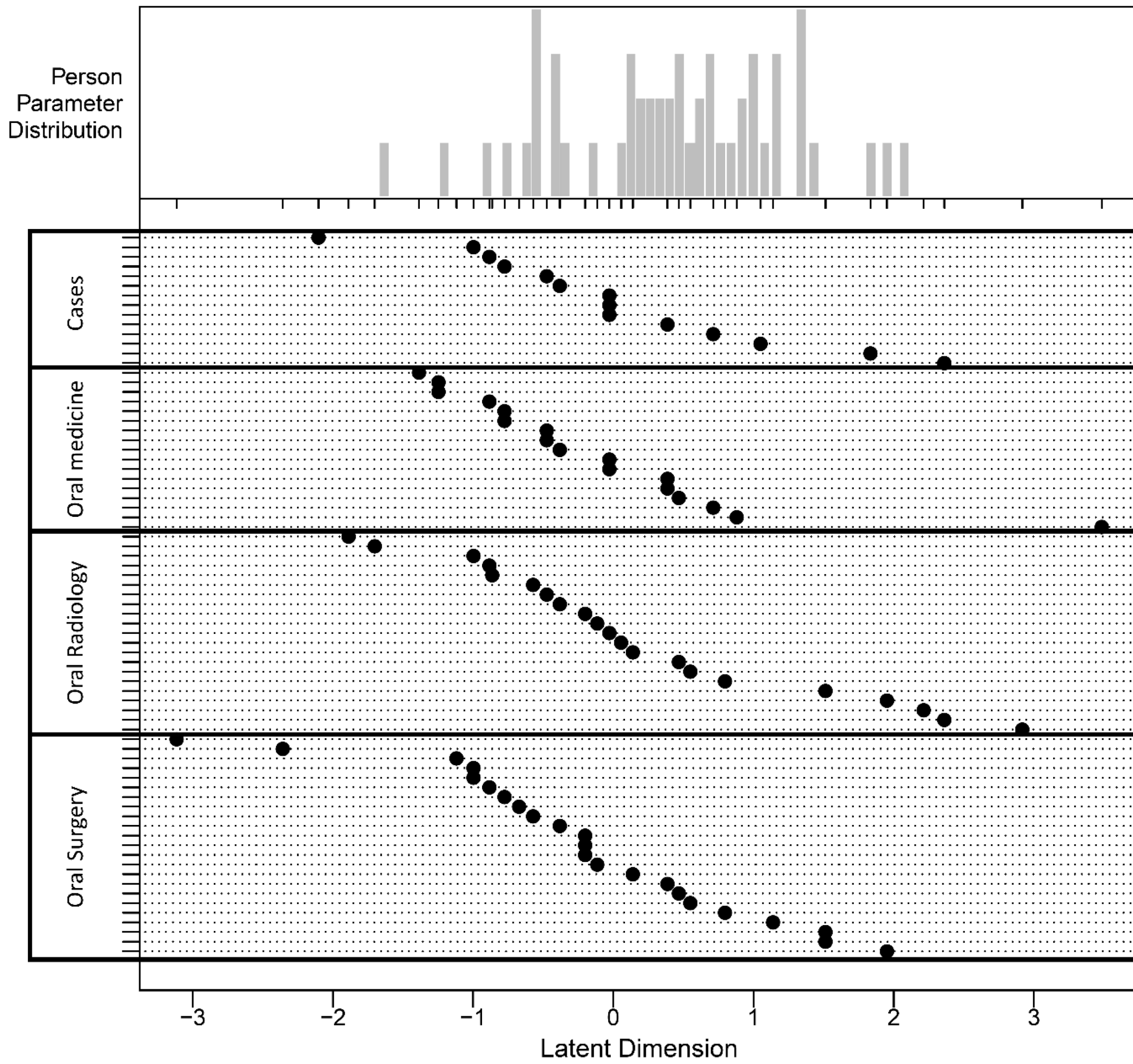


Figure 47: Person item map from Test 1 with the distribution of item difficulties at the categories Oral Surgery, Oral Radiology, Oral Medicine and Cases. The points represent the difficulty level of each item (difficult to easy from left to right). The number of students with a particular ability level is depicted with the bars. (reproduced from Kirnbauer et al.2018 (12), with permission due to License Agreement with Wiley for publishing CC-BY-NC)

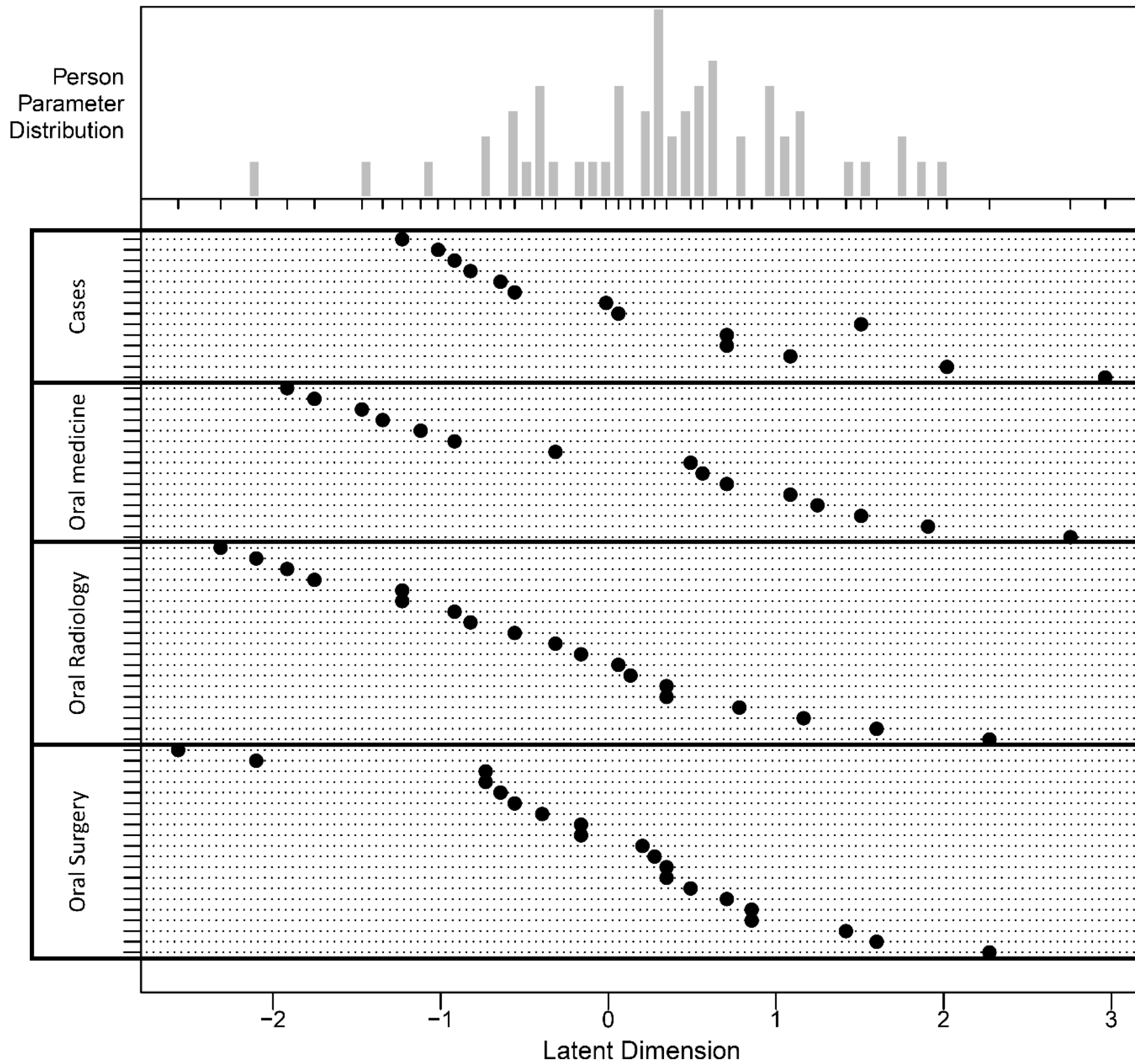


Figure 48: Person item map from Test 2 with the distribution of item difficulties at the categories Oral Surgery, Oral Radiology, Oral Medicine and Cases. The points represent the difficulty level of each item (difficult to easy from left to right). The number of students with a particular ability level is depicted with the bars. (reproduced from Kirnbauer et al.2018 (12), with permission due to License Agreement with Wiley for publishing CC-BY-NC)

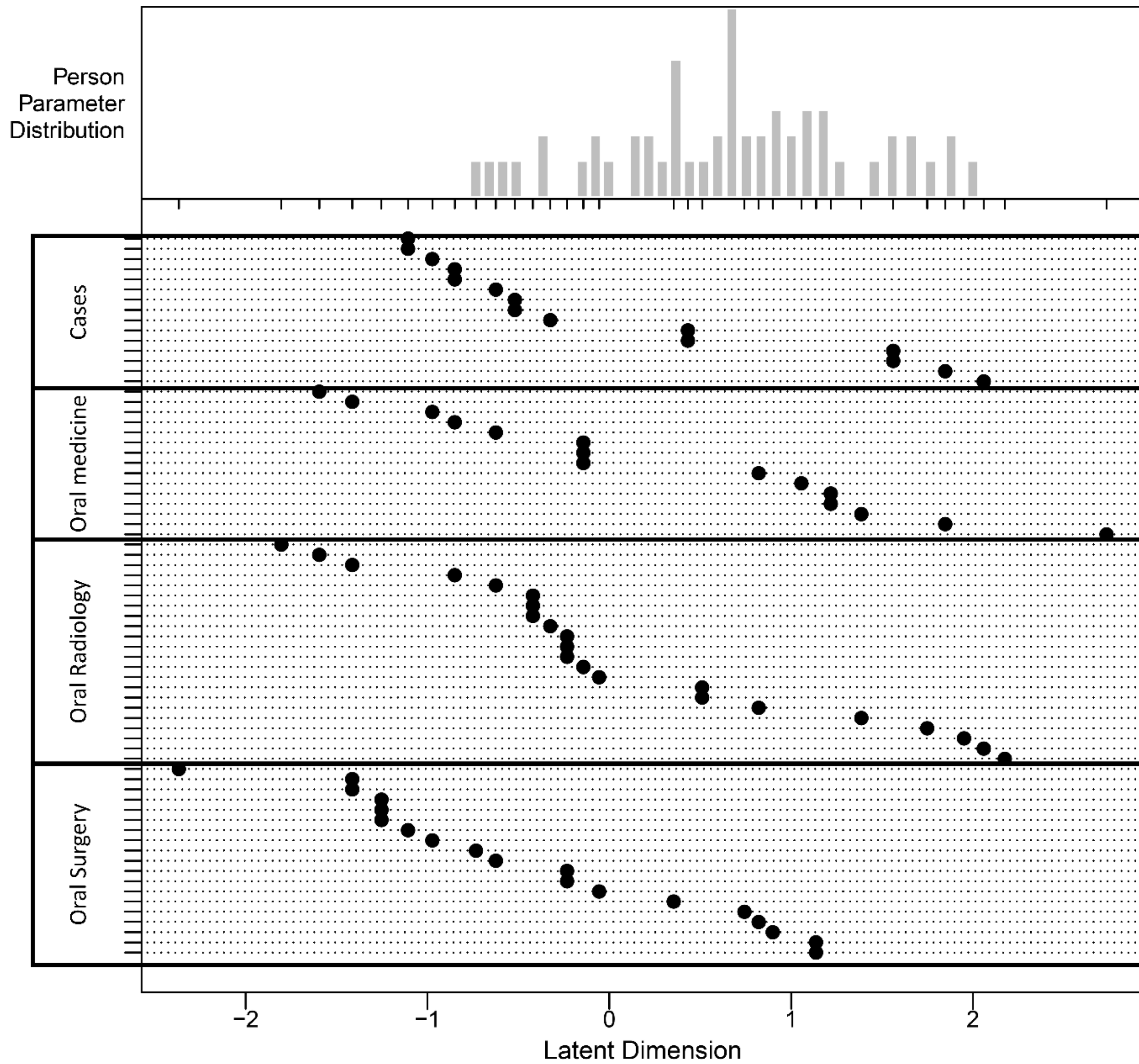


Figure 49: Person item map from Test 3 with the distribution of item difficulties at the categories Oral Surgery, Oral Radiology, Oral Medicine and Cases. The points represent the difficulty level of each item (difficult to easy from left to right). The number of students with a particular ability level is depicted with the bars. (reproduced from Kirnbauer et al.2018 (12), with permission due to License Agreement with Wiley for publishing CC-BY-NC)

4. Discussion

This new kind of DPT gives an overview about student's applied knowledge in oral surgery in an undergraduate dental curriculum at the Medical University of Graz. It also seems to be appropriate for the evaluation of dental students and is well-balanced for the targeted cohort. (12)
According to the literature this is the first study to report the implementation of a German-language based progress test in an undergraduate dental curriculum. (12) Although this test format is well established in human medical curricula in Europe and other fields, for more than 40 years, the situation in dental education is not comparable. The Dental School at the University in Plymouth (UK) is known to have first developed an English-language based DPT in two different educational programmes. (12,126,167) Wider use of PT in dental education should be promoted. Not least because it represents an essential source of information for dental educators, responsible for high-quality patient care, and for students receiving a comprehensive feedback about their performance. (12,103,109,126)
DPT developed through this research shows, that in its current form, overall numbers of "correct", "false" and "don't know" answers are in general similar to other internationally applied PTs at the academical education in medicine and dentistry. (12,103,109,125,126,159,160,172,173) Even though the cohort composition and items varied, the evaluation of all three administered tests showed similar ratings for each. However, due to the changing participants and questions an overall evaluation was not possible. (12)

"Correct" answers significantly increased in the course of the surgical education. This indicates a growth of knowledge, however significantly detectable only in one of the three tests. "Don't know" answers decreased significantly as well as fewer "false" responses occurred, however just in two out of the three tests. (12) Based on the data analysis, it can be inferred, that the results are in general comparable to reported results of other's PT. (12,125,126,159,173)

Considering mean calculations of correct response behaviour in explorative statistical analysis in more detail, we recognise a certain trend in all three tests. Thereby students started at relatively high levels. We believe that this can be explained by the fact, that we decided to carry out our DPT with more advanced students; in at least the third study section (4th year). This approach was used to achieve transparent information about student's growth of knowledge compared to their status of education, testing them during their clinical phases, would be most ideal. (12) This is different to already well-established tests as for instance described by Van der Vleuten et al. (1996, 2004) (125,129) or Ali et al. (2016, 2018) (126,167), who start with freshers in their first year. First-year students cannot be expected to have good results, because it is known that only around 20% of items reflect the knowledge acquired in the first year. However, these tests are formative for the early years. (12,125) Thus, results have to be expected to be lower than 20%, as shown in literature at former tests. (126,167)

The mean values show in general increase of correct answers from 7th over 8th to 9th term, albeit within a small range. In term 10 correct answers decreased and started to more or less increase until the 12th term again. This observation may be related to the structure of the dental curriculum and the nature of the implemented DPT itself. DPTs, only included the subjects of oral surgery, medicine and radiology. Clinical education of surgery contents started at term 7 and 8 with theory lectures, phantom-head lessons and a human cadaver course. Term nine was used for practical patient-centred education, working within the daily routine of the department, e.g. in the emergency dental setting or the surgical suites. At term 10 students left the department for other subjects of dental education, such as prosthodontics, restorative dentistry and orthodontics. At term 12 they were back at the surgical practice, in the meantime ready for all-encompassing patient care, to finalise their surgical competences before graduation. Consequently, the decrease after term 9 might be explained by the newly added learning contents; others than oral surgery, the students may have found difficult to retain. While learning to handle a patient, including all aspects of dentistry, and practicing at the surgery department, resulted in higher results in 12th term again, similar to those at term 9. Regarding these general outcomes, a more continuous increase of the correct answers before the launch of the project was expected with the highest results at the end. Instead, results seem to be closely connected to the patient centred learning period, reflecting the teaching history of the local curriculum. That means intensive contact with the subject, especially in the daily practice, leads to a deeper memorisation of assessed learning contents. So, the continuation of the surgery education shortly before graduation seems to be of utmost importance prior to signing off students as surgically fit for the professional world.

This is important due to the specifications of the European Union and second, because there is no further mandatory oral surgery education available in Austria. (4,42,95)

Based on this significant findings, parts of the curriculum have already been amended to add an extended patient care period and a reorganisation of theoretical teaching in the terms 7 to 10. (54,55) Our results are in accord with those reported in the literature which show that PTs have no higher mean-results than 60-70% correct answers at the end. (126,155) This was also reflected in our tests, while best performers, which came from the 9th and 12th term, did not reach more than around 80% correct answers. These aspects in general show a satisfying performance of the cohorts, assessed confirming our oral surgery education is at par with international institutions.
However, we need to consider that assessment measurements are first an indirect and second only one of several possible methods of quality assurance. (23) Just for explanation, the mentioned relatively low values of 60-70% correct answers are based on the argument, that PT is an assessment tool, which does not focus on learning for the test, but on promoting of student's learning from the test with reflecting their own results. (125)

The formative nature (non-relevance for grades) of DPT as used in this research and also reported in the literature, minimises interference with the curriculum, in that it is not an extra burden for students, does not influence formal evaluation of the student's progress; and provides current picture of spontaneously recalled knowledge. (12,144,163) Primarily such formats should act as a feedback instrument for students and teachers (125), as we used in the reported study. (12) However, as Albano et al. (1996) (174) reported, knowledge development curves can be more non-linear, with more ups and downs when a formative design is used, as also seen in the current work. (12) To counter the potentially negative aspect of a changing motivation (174), best performers were rewarded with prizes (free congress participation, bags from the university shop). (12)
Moreover, variations in cohort composition from test to test, including any and all from regular to Erasmus students, may influenced the results. (12,144,163,174) However, this aspect was not applicable to the research undertaken in this project. (126,144,167)

In literature formative as well as summative formats are reported. Each of these formats has benefits of use. (12,126,142,144,167) Summative means that results are relevant for student's grades and influence their pass/fail decision. Based on the nature of the PT being a longitudinal assessment, combining test results to a final pass/fail decision is common. It is widely known that results of repeated tests increase reliability of grading and the predictive value. (175) However, our tests are representative of a pilot phase/approach. Therefore, formative format decision was considered to be reasonable and fair. However, this may change and there may be opportunities to use DPT as a summative assessment in the future. Concerning student's motivation and preventing frustration at formative formats, solutions, such as the reduction of items from 250 to 200 and reduction of test time from 4 to 3.5 hours, are described. (144) Depending on these, but also influenced by other aspects, we decided to take 100 items with three hours test time per sitting. (12)

The reliability of our tests ranged from 0.82 and 0.88 (0.77-0.87) using the IRT. This indicates a good internal consistency, especially when the novelty of this approach is considered. (12) In this context, literature shows similar or slightly higher values. (12,151,176) However it has to be considered, that in contrast to our analyses, the literature mainly reports reliability calculations of Cronbach's alpha, based on CTT. (126,142,160) In our case CTT was not applicable, because of changing items and cohorts at all three test time points. Instead Rasch analysis, a more precise and accurate method, was utilised. (115) Osterberg et al. (2006) (160) show overall reliability levels of 0.96 and 0.85 for cohorts of same educational level in a formative format. Ali et al. (2016) (126), described Cronbach's alpha at an overall level of 0.753 for a combined formative/summative design in dental education, while Tio et al. (2016) (142) showed a mean reliability of 0.92 over 6 years in a well-established PT in a medical setting. As reported by Juenger et al. (2014) (99) reliability of exams should at least be at or above the level of 0.8 to meet the requirements of robustness. Further literature differentiates between values of 0.7 - 0.8, when groups have to be compared and on the other hand, the need of higher levels, such as in the range of 0.8-0.89, at important summative tests or end-of-year evaluations. Additionally, the increase of Cronbach's alpha can also be related using more items. (177-179) Therefore, the reliability statistics for the DPT conducted in this research are satisfactory and provide evidence to support its continued use in our curriculum. (12)

The congruity of our DPT question pool is supported by a similar unidimensional distribution of the 215 items ultimately selected for all three tests. The data analysis confirms that the statistics satisfy the assumptions for Rasch analysis, and a more or less harmonious alloca-

tion between the fields “oral surgery”, “oral medicine”, “oral radiology” and “cases”. (12) When linking these three tests with anchor items, an appropriate item bank for further testing may be provided. So, with the application of IRT methods, inclusion of new items and their calibration within the existing test would be achieved. (12) When considered in relation to the thought of Bologna process and to established medical PTs (145,158,164), the DPT could also be expanded locally, nationwide or internationally, acting as a comparative tool in quality control, as suggested in the literature. (125)

Generally, DPT item difficulty varied within each of the three different assessments. But they reflect the trait distribution of the tested students and are done within a preferable range. (12,180,181) The distribution of item difficulties was satisfied for three out of four categories, with deviations only in „oral surgery“. In this context there was a lack of easy items in the last test and missing difficult items in the second. (12) Nevertheless, overall difficulty of fields and tests were observed to be satisfactory. The decision to split the item pool in groups of hundreds and administer three tests was also made to achieve an acceptable test length and prevent frustration of the students. (12) The limited number of subjects covered in the DPT and the time needed to complete the test had to be considered. As a result, the difficulty parameters and the trait estimations between our DPT appointments, as already explained, are not comparable. (12,126,159,181) “*To get comparable difficulty parameters and therefore, trait estimations on the same scale, items have to be chosen from all three tests representing a wide difficulty range within each test and have to be analysed together.”* (12)
According to literature item difficulty levels in CTT should be targeted between 0.4 and 0.8, with average levels of 0.5-0.6. (182) Items lower than 0.4 are indicate of an advanced difficulty, while values more than 0.9 are reflecting very easy items. (183) Overall congruity to this fact, albeit with minor differences between the four categories, is shown within this project. In contrast to recent PT reports (126,167), IRT, allows measurement of difficulty of items and criteria of persons on a joint scale, was applied to achieve a more accurate measurement of test parameters. (115)

As already mentioned, PT has a long tradition and is a well-established tool in medical education all over the world (125,144,145,159,184), but not in undergraduate dentistry. (126,167) At the Medical University of Graz Berlin's PT has been used in the medical curriculum since 2008. (144,163,165,166) In order to get comparable longitudinal information about local student's performance, a decision was made to develop and implement a German-language DPT. (12) Resources available were limited and it was based on the initiative of a single senior staff member. The presented study had been considered to be a pilot project. Therefore, in the contrast to already described PTs (142,163), the item pool was limited to 375 questions. (12) Berlin's PT for instance falls back on an item bank of more than 2000 questions written by more than 200 authors. (160,165) As described, item writing is difficult - single development can indeed exceed one hour of time - and has to follow strict systematic procedures. (129) For that reason, reports regarding internationally sharing of item banks are described. (150,158) Furthermore, to manage the successful development of an item bank, there is a need for a close association to the learning objectives, focusing the end objectives of a programme. (125,129) For this research, item author focused on these learning objectives. However, in the context of expanding the DPT to all fields taught at the local dental school, there is still a need to define them in a precise way, as done in Switzerland or Germany (94,185) and in the document of learning objectives of the human medical curriculum at the Medical University of Graz. (45)
The review process of the DPT, robust and completed in multiple stages to assess the format and content of the test (12), as recommended by internal and external reviewers specialised in the field of oral surgery. (126,186) This process allowed for all participating staff to understand the time and resource constraints involved in such a process. (129)

It was decided to choose a single best answer as well as a true/false (K-type) MCQ format, because subjectively it seemed to be the best way to target all learning objectives. Although open-ended question formats seem to be possible, MCQs have recommended most commonly in the literature due to objectivity in marking. (125) The advantage is, that they have the highest reliability, especially when written with appropriate vignettes to provide a context to application in clinical practice. (129), compared to other test formats. (118,159) Further MCQ formats have mainly changed from true/ false to a single best format (125,126,160,167), because true/false formats may include some intrinsic flaws. (128,129) This will be considered, when item writing is continued during future work on DPT.

Focusing on the study cohort, it has to be explained that local annual group capacity is restricted to 24 available places. In comparison to other PTs, such as in the Netherlands, where more than 10 000 students sit the test (142) or the Berlin's PT (165), where more than 700 students are enrolled at the Medical University of Graz (165), the number of students in this study was indeed low, which makes it rather difficult to draw detailed conclusions, especially about student's future performance or teaching quality. Therefore, it is important to continue data acquisition with DPT in the future. (12)

As shown in the results section, performance of several students is rather low and marked as outliers in the boxplots. It might be that those students are lateral entrants, such as Erasmus students or low achievers. However, it is not possible to be certain about the precise reason for this observation as we targeted the whole cohort. Furthermore, analyses where done anonymously and blinded, but an evaluation with regard to detailed demographic data would have provided more information. It is also possible that exclusion of under-performing lateral entrants may have influenced results positively.

Discussing the "don't know" option, this is a special feature of PT, which was implemented as an additional option, to allow students to identify their learning needs. (142) This is essential, because first, PT is an assessment which students of all age groups are sitting together and second, it should be assessment drives learning. (125,184) The "don't know" allows students to avoid guessing without any penalty (142), because especially for younger age groups many questions are too difficult. (143) For this reason, we also decided to use negative marking (formula scoring) instead of number right scoring, which means calculating with the end score of correct minus false responses. (157) However, negative marking is controversial in literature. (142,150,156,157) While Muijtjens et al. (1999) (157) mentioned that negative marking can be more reliable than number right scoring, Ravesloot et al. (2005) (156) notes that the "don't know" option is affected by knowledge as well as risk taking tendencies as also shown in our study, where "don't know" is observed less frequently than the false option in higher terms. So, it is inappropriate to assume that all participants have similar intentions in choosing the "don't know". This disadvantages risk-avoiding students compared to risk-taking students with the same level of knowledge. Furthermore, the construct validity is compromised by increasing the construct-irrelevant variance. (156) Moreover, as reported by Verhoeven et al. (2005) (150), it could have also influenced our test, formative designs lead to different answering strategies. Students tend more often to guess and seldom take "don't know", as we also can interpret our data. To address this bias, as we attempted with the use of Rasch analysis, a change to formula scoring could be justified. (150)

Besides being a comparative assessment tool and as a result of this, resembling a rich source of information for teachers, curriculum planners, stakeholders and policymakers, PT is thought to be an essential feedback instrument. (142) Similar to other reports (125,144,163) we also gave information immediately after each test about results, rank in class and overall rank. Furthermore, to promote motivation, we awarded best performers. In contrast, we were not too concerned about low achievers. Nevertheless, their results helped to identify knowledge gaps, so that individually assigned tutors could help to provide remediation. To motivate participation in our formative, but mandatory test, more information about the purpose of PT has to be given to the students. (12) As soon as they understand the value of the information, reflecting the level of knowledge relative to others (184), willingness to take part should increase.

In contrast to other PTs (142), no feedback was collected from the students about questions and test composition. This is a limitation of this research. It was not possible to achieve this due to administrative overload and financial limitations, however due but should be considered at in future. (12)

With the original argument in mind; where the Bologna process and the extension of the EHEA were described as essential goals in higher education the developed DPT has relevance. First, from an economic view, there is a large benefit in cost efficiency when sharing tests between institutions (125) and second, from a didactical and scientific point of view, national and international co-operation may be promoted in a meaningful manner. (125,150) This would be a desirable aim of the DPT (12); because the test administration cannot be managed by a single staff member. To manage a national extension, different barriers will have to be overcome. National curricular differences and inconsistent learning objectives might initially prevent a quick implementation throughout Austria. (2,6,7) In this context it has to be highlighted that competencies and learning objectives for the dental degree study programme at the Medical University of Graz have been defined for all oral surgery courses in line with the Swiss catalogue of learning objectives (94,105), but there is no one uniform example that exists for the whole dental curriculum in Graz nor a national one, valid for all Austrian dental faculties. (2) This is firstly, because of national differences regarding the curricula and teaching themselves; secondly, because of a lack of a national document of learning objectives; and thirdly, because a clinical Division of Oral surgery only available in Graz and Vienna, not in Innsbruck, and existing comparability and quality control especially between Austrian Dental schools is difficult. (2,6,7) As a consequence, student mobility is rather restricted in dental medicine within Austria, despite the fact of availability of study places. Furthermore, the outcome of oral surgery education might not be the same for a graduate in Vienna, Graz, Innsbruck or Krems. This has consequences for employers when deciding

between candidates, educated in these Universities and also for patients choosing their doctor. Moreover, this actually contradicts the specifications of the Bologna process. (3) More importantly these observations may serve as an impetus to rethink Austrian dental education to develop a standardised way for evaluation and to usher in harmonisation and at least strengthen national cooperation. (99,187) Possible next steps for a Europe-wide collaboration could be like this: DPT has to be made more known among dental faculties and faculty heads have to be convinced about the benefits. Responsible employees have to be appointed for local coordination, especially concerning education in item writing and further promoting item bank creation. Further mutual item review has to be organised before assessment

However, as described by Van der Vleuten et al. (2004) (129) the issue of comparability is not easy to handle, because results between institutions consists of vulnerable information, which may not meet global expectations. Also, it is important to interpret results correctly, which is reliant on several factors. For instance, the origin of the exam items, from a single university or from all participating schools, can be a source of bias comparison. This is especially the case, when international cooperation over the boundaries of languages are negotiated. (150) Nevertheless, several authors have proved, that national and international cooperation can indeed be operationalised effectively. (125,129,150) Thereby a closer connection between the European, but at least between German-language dental faculties, should be considered for further use of DPTs and this may serve as an ideal setting for initial development and implementation of change. (12)

Possible next steps for a Europe-wide collaboration could be as follows. DPT has to be made more known among dental faculties and faculty heads have to be convinced about the benefits. Responsible employees have to be appointed for local coordination, especially concerning education in item writing and further promoting item bank creation. Mutual item review must then be organised before DPT performance and ideal conditions have to be created for a joint post-review and data analysis. Leading, and process-promoting dental schools could be the Peninsula School of Dentistry in Plymouth (UK) (126) and the Medical University of Graz (12), who have already established their local DPTs. These could be merged as a first essential step.

Overall, it needs to reiterated that PT is an appropriate assessment for longitudinal assessment. It allows students to prepare continuously over the course of a curriculum. Furthermore, it is not restricted to any particular form of university education. (12,125,162) Neverthe-

less, variations in results are not unexpected and need to interpreted cautiously. (12,129,145) The fact which speaks for the performance is, that literature, including a recently published positioning paper about the fundamental requirements of a competent dentist (103), shows the necessity and clear advantages of quality control in educational programmes. (12) One of the most positive facts is, that generates rich data on student performance which is extremely useful for feedback and identifying gaps in the curriculum. (12,142) As a consequence, individualised support can be provided for high as well as low achievers. (12,160) Moreover, this tool can be offered additionally to other exams or can be implemented as a high-value grade-relevant periodical assessment. (12,142,160) In any case, PT results in a longitudinal data collection, which allows more prediction of future competence and/or performance compared to single-point assessments. Additionally, it enables comparison of graduating dentists with the wider educational community, national or international. (12,125,150) Nevertheless disadvantages like administrative workload, faculty time efforts and significant financial resources can be challenging and impede effective implementation and feasibility and sustainability of such assessments must be considered carefully. (12,125,141,142,145,188)

5. Conclusion

Targeting the aims of the presented study, our DPT resulted in the first standardised presentation of student knowledge in undergraduate oral surgery education at the Medical University of Graz. Furthermore, it is the first performed DPT in the German-language counties of Germany, Austria and Switzerland in this form.

Currently, knowledge levels and variation of performance during the clinical educational programme could be documented. Although sample size and the duration of the study were limited, essential information was acquired concerning both learning and teaching quality in undergraduate oral surgery education.

Further, a homogeneous response behaviour, a uniform distribution of included and excluded items within the separate tests and fields, and an accurate range of difficulty of the questions could be drawn from the collected data. (12) This means sufficient and satisfactory quality of the newly created item bank, which will allow usage in the future.

The DPT provided and facilitated an innovative a comprehensive survey of students, which mandates new requirements for the educational programme at our dental school. As a result, curricular and educational changes have already been launched in the third study section. (12)

Fulfilling the thought of Bologna process, an extension at least national and as a next step to the German-speaking countries or further should be focused. As a result of this, as with the established PT for medical students, dental student cohorts could also be compared between universities. This in turn could increase comparability and competition and force institutions to focus more on high quality in education.

Accordingly, this could give rise to a positive effect in terms of harmonisation of dental education throughout Europe.

National and international collaboration to extend the item pool and sharing resources would definitely be potential options for future developments in the continued use of DPT. (12)

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7. Appendix

A: Curriculum Vitae

2000	High school degree (Matura) in Köflach (Styria, Austria) with excellent success
2000-2006	Study of Dental Medicine at the Medical University of Graz
Since 2006	Employment as research staff at the Department of Oral Surgery and Orthodontics at the Medical University of Graz

Married, 2 sons

Grants and Prizes

"8.März – (Aus)Zeit für Wissenschaft": 4-month grant, used for research fellowship at the Peninsula School of Medicine and Dentistry, Plymouth UK; 06-09 2018

"Dr. Michael Hasiba Preis" (2000 Euro); 03/2017

Poster prize: 4th Grazer Riskday – Patient Safety in Routine 09/2016 (1700 Euro)

Summer School Award Medical University of Graz 2016 (1000 Euro)

Summer School Award Medical University of Graz 2018 first and third place (3000 Euro)

B: Publication List

Kirnbauer B., Jakse N., Rugani P., Schwaiger M., Magyar M. 2018; Assessment of impacted and partially impacted lower third molars with panoramic radiography compared to MRI-a proof of principle study.47(4):20170371. doi: 10.1259/dmfr.20170371. Epub 2018 Feb 13.

Fung, P; Bedogni, G; Bedogni, A; Petrie, A; Porter, S; Campisi, G; Bagan, J; Fusco, V; Saia, G; Acham, S; Musto, P; Petrucci, MT; Diz, P; Colella, G; Mignogna, MD; Pentenero, M; Arduino, P; Lodi, G; Maiorana, C; Manfredi, M; Hallberg, P; Wadelius, M; Takaoka, K; Leung, YY; Bonacina, R; Schiødt, M; Lakatos, P; Taylor, T; De Riu, G; Favini, G; Rogers, SN; Pirmohamed, M; Nicoletti, P; GENVABO Consortium; Fedele, S, 2017

Time to onset of bisphosphonate-related osteonecrosis of the jaws: a multicentre retrospective cohort study.

Oral Dis. 2017; 23(4):477-483

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Doi:10.1111/odi.12632

Kirnbauer, B; Rugani, P, 2016

Einsatz der digitalen Volumentomographie zur Komplikationsprophylaxe in der zahnärztlichen Chirurgie

Quintessenz. 2016; 67(12): 1529-1536.

Kirnbauer, B; Rugani, P, 2016

Einsatz und Grenzen der modernen Schnittbilddiagnostik

Zahnkrone. 2016; 1/2016: 14-16.

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Prevalence of Medication-Related Osteonecrosis of the Jaw in Patients with Breast Cancer, Prostate Cancer, and Multiple Myeloma

Dentistry. 2016; 4(32):

Sorantin, E; Kirnbauer, B; Stücklschweiger, G, 2016

Strahlenschutz in der Kieferorthopädie mit besonderer Berücksichtigung von Kindern

IOK = Informationen aus Orthodontie & Kieferorthopädie. 2016; 48: 115-119.

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Sorantin,E; Kirnbauer, B; Stücklschweiger, G, 2016

Strahlenschutz in der Kieferorthopädie mit besonderer Berücksichtigung von Kindern

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Baumann, P; Widek, T; Merkens, H; Boldt, J; Petrovic, A; Urschler, M; Kirnbauer, B; Jakse, N; Scheurer, E, 2015

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Forensic Sci Int. 2015; 253: 76-80.

Listed in: [ISI:000360971500018]; [PMID:26093127] IF(2015): 1,95; IFnorm: 0,733; Citations (SCI): 9; last update: 15.01.2018

Doi:10.1016/j.forsciint.2015.06.001

Rugani, P; Acham, S; Kirnbauer, B; Truschnegg, A; Obermayer-Pietsch, B; Jakse, N, 2015

Stage-related treatment concept of medication-related osteonecrosis of the jaw-a case series.

Clin Oral Investig. 2015; 19(6): 1329-1338.

Listed in: [ISI:000356774100017]; [PMID:25511385] IF(2015): 2,207; IFnorm: 0,78; Citations (SCI): 4; last update: 15.01.2018

Doi:10.1007/s00784-014-1384-1

Rugani, P; Kirnbauer, B; Acham, S; Truschnegg, A; Jakse, N, 2015

Implant Placement Adjacent to Successfully Treated Bisphosphonate-Related Osteonecrosis of the Jaw (BRONJ).

J Oral Implantol. 2015; 41 Spec No:377-381

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Kirnbauer, B; Jakse, N; Acham, S, 2014

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Rugani, P; Luschin, G; Jakse, N; Kirnbauer, B; Lang, U; Acham, S, 2014

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Clin Oral Investig. 2014; 18(2):401-407

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Doi:10.1007/s00784-013-1012-5

Rugani, P; Truschnegg, A; Acham, S; Kirnbauer, B; Fabian, F; Jakse, N, 2014

Einsatz der photodynamischen Therapie (PDT) bei Kiefernekrosen

Zahnkrone. 2014;

Kirnbauer, B; Woelfler, A; Sill, H; Beham A; Prettenhofer, U; Jakse, N, 2013

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International Journal of Stomatology & Occlusion Medicine . 2013; 6(2): 65-69.

Rehatschek H.; Aigelsreiter A.; Regitnig P.; Kirnbauer B., 2013

Introduction of eLectures at the Medical University of Graz - Results and Experiences from a Pilot Trial

International Journal of Emerging Technologies in Learning. 2013; 8(1): 29-36.

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Use of Photodynamic Therapy in Treatment of Bisphosphonate-related Osteonecrosis of the Jaws: Literature Review and Case Series.

Journal of analytical & bioanalytical techniques. 2013; Special Issue(1): 006

Rugani, P; Kirnbauer, B; Arnetzl, GV; Jakse, N, 2009

Cone beam computerized tomography: basics for digital planning in oral surgery and implantology.

Int J Comput Dent. 2009; 12(2):131-145

Listed in: [PMID:19413269]