

Research Article

Conception of an endodontics questionnaire in undergraduate dental education

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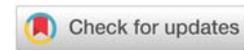
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Abstract

The purpose of this study was to create a valid assessing instrument using a set of questions to examine preclinical dental education in endodontics. For this reason, we constructed the "German Endodontology Questionnaire" (GEndoQ), which assesses preclinical dental education in endodontics. In recent years and decades, various curricula in preclinical and clinical endodontic education have been evaluated at both national and international levels and the results published. However, the conception of the questionnaires that have been used have never been discussed or published.

The GEndoQ was constructed in five phases using the Delphi technique. In the first phase, the questionnaire was generated according to former questionnaires and publications through the first Delphi round and divided into 10 categories. In phases two and three, different expert panellists, such as specialists in endodontology and attendants of a master's degree programme in endodontology, used the Delphi technique to confirm the content validity of GEndoQ. The newest literature was implemented in phase four. In phase five, GEndoQ was finally completed after multiple abbreviations were included following feedback from the expert panellists who employed the think-aloud method.

Within the five phases, GEndoQ Version 5 was created comprising 49 questions in nine categories. This was done using different answer options. The Likert scale with six possible options to choose from was used the most: 1= don't agree at all; 2= don't agree; 3= undecided; 4= agree; 5= fully agree, 6= don't know. Seven questions could be answered in a free text format, while five questions were in a single-choice format, such as yes/no answers. The GEndoQ is a valid instrument for assessing preclinical dental education in endodontics. Future research will focus on further refining and validating the instrument, for example, within a pilot test. Additionally, the questionnaire should be translated into English and validated to make comparisons among international dental faculties easier.

Introduction

On a national and international level, various curricula in preclinical and clinical endodontic education have been evaluated and published in recent years and decades [1-7]. Al Raisi et al. conducted a survey in the United Kingdom from November 2017 to January 2018 on basic endodontic education in British dental schools and compared their results with an earlier paper-based survey [1]. The study revealed a great divergence, especially in the teacher-student ratio, time management and teaching methods within British dental faculties. Endodontic education in the United Kingdom has developed positively over the last 20 years [1]. Sonntag, et al. evaluated endodontic training in Germany in 2008 [3]. They noted that preclinical endodontic training varied considerably among German universities due to differences in curricula

designs, staff and course content [3]. In 2014, Gerhardt-Szép presented a survey in the context of the 11th conference "Training for Trainers". The survey analysed the divergence in general examination projects in preclinical endodontology [8].

Nevertheless, the conception of an assessing instrument with a set of questions to examine preclinical and clinical dental education in endodontics at the national and international levels has not been presented [2-7]. A former paper-based survey by Qualtrough and Dummer from 1997 [7] was used in the studies mentioned above, where the authors stated that no modifications to the former paper-based survey had been made [1,4-6]. After 1997, various guidelines for endodontic education [9-11] and general guidelines for endodontics [12,13] have been formulated since many changes have occurred in the last decades with regard to endodontic equipment and materials



[14,15]. Furthermore, the guidelines from the European Society of Endodontology (ESE) [9] and the Association for Dental Education in Europe (ADEE) [10,11] support dental faculties in creating undergraduate endodontic curricula that promote consistent standards within Europe and enhance the quality of patient care in the community [1]. It is also known that considerable differences exist among countries in terms of curricula structure and content as well as the scope of practice generally in dental education [16].

Therefore, the use of contemporary dental assessing instruments for national and international comparison is important. Unfortunately, the current state of research indicates that no validated instrument for examining preclinical dental education in endodontics has been published, nor has the methodology of the conception and validation of such an instrument been explained [1-7]. In the most recent study about endodontic education in Great Britain, the author described that their survey “was piloted locally to check for question readability, clarity, validity and functionality and time required to complete” [1]. However, the authors did not specify the process. Reviews of literature concerning instruments for evaluating endodontics by general dental practitioners worldwide show that little to nothing has been published about the construction and validation of the questionnaires used for their studies [17-20]. However, plenty can be found for the development and validation of instruments within the dental field [21-23] and beyond the horizon of dental education [22-24]. Many publications offer general explanations for questionnaire conception and validation, such as following the “seven-step process for designing high-quality questionnaires” given in the Association for Medical Education

in Europe (AMEE) Guide: No. 87 [21, 25-27] or similar step by step methods [28]. A large number use various methods, such as the Delphi technique [29-33] and the think-aloud method [34-37], for content validation.

On that account, the main goal of this study was to create an assessing instrument comprised of a set of questions to examine preclinical dental education in endodontics. Therefore, two different methods were applied, the Delphi technique as well as the think-aloud method.

Materials and methods

Ethical approval

After consultation with the ethics committee of the Department of Medicine of the Goethe University Frankfurt am Main, it was decided that a vote by the ethics committee was not required (reference 114/2019).

General methodology

The development of the questionnaire consisted of five phases using four Delphi rounds and the think-aloud method (Figure 1).

Phase 1: Literature review and conception of a discipline-specific questionnaire

In phase one, the literature search of English articles published between 1991 and June 2019 was executed using the PubMed database. The search included combinations of keywords such as “endodontics”, “education”/“teaching”, “survey”/“questionnaire”, “preclinical”, “undergraduate”, and “root canal treatment”.

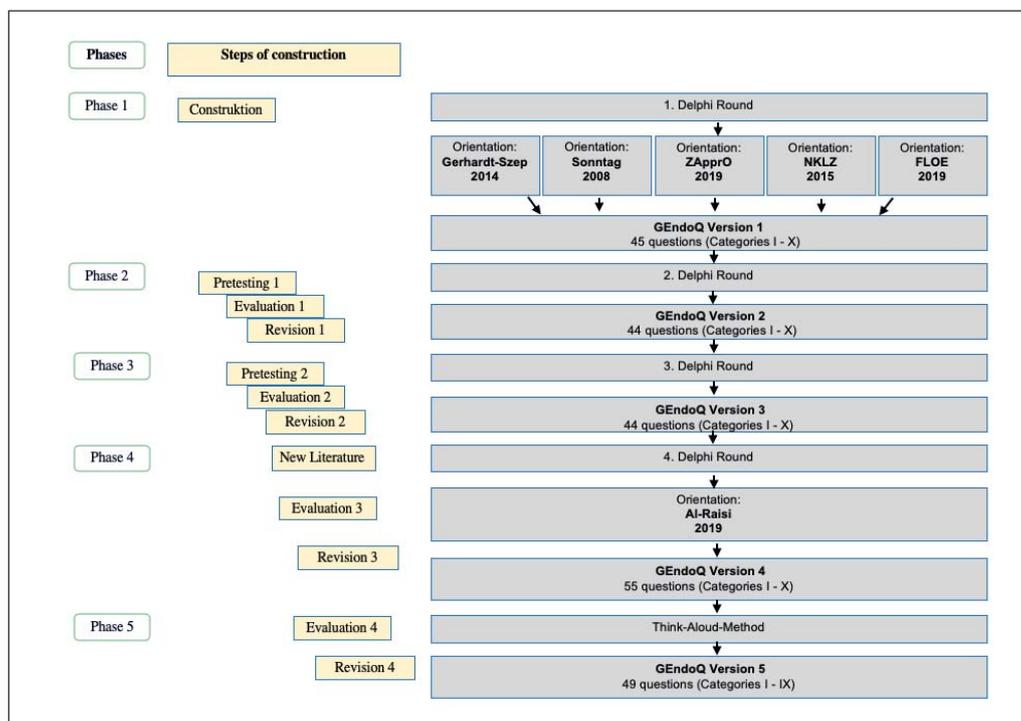


Figure 1: Methodology diagram. The questionnaire was constructed in five phases, which are illustrated in this figure. ZAppr: the new licensing regulations for dentists in Germany; NKLZ: national competencebased catalogue of learning objectives; FLOE: Frankfurt learning objectives for endodontics.



These keywords were used with the Boolean operator “AND”, although “education” and “teaching”, as well as “survey” and “questionnaire” were used as synonyms in the search. In the first step, the abstracts from the literature that was found was examined to determine the relevance of the content of each publication. Non-relevant literature was identified and excluded. For all literature references with a (possible) content reference, the full text of the publication was then searched online. The following inclusion criteria were used in the consideration of publications in order to create the questionnaire: questionnaire/survey requesting the general status quo of endodontic education in the preclinical or/and clinical undergraduate part of dental faculties nationally/internationally (Table 1).

The questionnaire was constructed by two experts (Table 2) based on the data provided in several studies and publications [1,11,14,15,38,39] and the Frankfurt learning objectives for

endodontology (FLOE) (Figure 2). The working group named the instrument the “German Endodontology Questionnaire”. In the following article, the questionnaire is titled GEndoQ.

The expert group wrote e-mails, had meetings and discussed their conceptions of the questions. Due to the dental and medical education expertise of one of the authors, the content validity was ensured. GEndoQ Version 1 was created.

Phase 2: Conception of the questionnaire

In phase two, the first pre-testing took place within the second Delphi round, which consisted of one expert from the Department of Operative Dentistry, Carolinum Dental University Institute, J.W. Goethe University, Frankfurt am Main, Germany (Table 2). In this round, the expert received the questionnaire digitally and was asked to ensure context validity and return written feedback directly on the printed questionnaire.

Table 1: Six publications about endodontic education are shown here in chronological order. The publications from De Moor et al. (2013) and the European Society of Endodontology (2006) contain guidelines for endodontic education for undergraduates and guidelines for endodontic treatment in general.

Author (Year)	Title	Database
Qualtrough et al. (1997)	Undergraduate endodontic teaching in the United Kingdom: an update.	PubMed
Qualtrough et al. (1999)	Preclinical endodontology: An international comparison.	PubMed
Cruz et al. (2000)	Endodontic teaching in Philippine dental schools.	PubMed
Petersson et al. (2002)	Undergraduate education in endodontology at two european dental schools.	PubMed
Narayanaraopeta et al. (2015)	Preclinical endodontic teaching. A survey of Saudi dental schools.	PubMed
Al Raisi et al. (2019)	How is Endodontics taught? A survey to evaluate undergraduate endodontic teaching in dental schools within the United Kingdom.	PubMed
De Moor et al. (2013)	Undergraduate Curriculum Guidelines for Endodontology	PubMed
European Society of Endodontology (2006)	Quality guidelines for endodontic treatment: Consensus report of the European Society of Endodontology.	PubMed

Table 2: Phases with their Delphi rounds and the panel expert(s) who work(s) at the Department of Operative Dentistry, Carolinum Dental University Institute, J.W. Goethe University, Frankfurt am Main, Germany.

	Phase 1+4 Delphi-round 1+4	Phase 2 Delphi-Round 2	Phase 3 Delphi-Round 3	Phase 5 Think-aloud-method
Panel Expert(s)	Expert 1: -masters education, -doctoral education Expert 2: -pre-doctoral education	Expert 3: -masters education, -doctoral education, -specialist in endodontology, author of a similar questionnaire	Panellist 1+2: - attendants master of endodontology Panellist 3: -graduate of structured advanced advanced education courses i.e. Curriculum endodontology Panellist 4: -doctoral education -specialist of endodontology	15 experts including: -Expert 1-3 -Panellist 1+2 -Panellist 4 -4 dentists with specific education -5 dentists without specific education

Frankfurt Learning Goals for Endodontics
The graduate should...
...be able to explain the etiology and pathogenesis of pulp and periradicular diseases.
...can perform diagnostics of pulp and periapical diseases.
...can explain the therapy of pulp and periapical diseases.
...can detect the presence of endodontic malformations.
...be able to explain and carry out the prevention of pulp and periradicular diseases.
...can provide the indication and contraindication for endodontic therapy.
...can provide the indication and contraindication for endodontic revision.
...describe and plan endodontic therapy.
...explain alternative treatment options (including surgical measures).
...can explain the diagnosis and treatment of endodontic emergencies.
...can educate the patient prior to endodontic treatment.
...to adequately document diagnostic findings and therapy.
...can explain incidents that require clarification.
...distinguish between complicated and non-complicated endodontic treatments and be able to justify the decision.
...can plan pre- and post-endodontic therapy.
...be able to describe the use of optical aids in endodontic therapy.
...perform non-surgical endodontic treatment on permanent uncomplicated single-root or multi-root tooth/teeth and be able to use materials, drugs and techniques within the scope of endodontic therapy.
...identify iatrogenic complications and plan the appropriate therapy.
...be able to describe and justify the therapy of the endodonts in connection with periodontal lesions.
...be able to assess the outcome of endodontic therapy and its prognosis and plan further treatment.
...characterize simple and complex dental traumas and plan interdisciplinary therapy.
...describe the causes of discolouration, the indication for bleaching of endodontically treated teeth and explain the therapeutic procedure.

Figure 2: Frankfurt learning objectives for endodontology (FLOE).

Phase 3: Conception of the questionnaire

In phase three, the second pre-testing of the updated questionnaire took place within the third Delphi round. The four-member panellist group, from the previously mentioned Department of Operative Dentistry, consisted of one specialist in endodontology, one graduate of a structured advanced training course with endodontology content and two participants of a master's degree course in endodontology (Table 2). Each of them received a printed questionnaire and was asked to improve its grammar, clarity and comprehensibility. They were also asked to ensure objectivity and provide written feedback directly on the printed questionnaire.

Phase 4: Modification of the questionnaire

In the fourth Delphi round, the expert group from the first phase modified and supplemented the third version of GEndoQ using the most recent publication from 2019 concerning undergraduate endodontic education [1].

Phase 5: Final conception of the questionnaire

In the last phase, the panellists, 15 dentists from the previously mentioned Department of Operative Dentistry (specialists in endodontology, graduates of structured further education with endodontological content and participants of a master's degree course in endodontology, participants with and without a doctorate, see Table 2), checked the fourth version of the GEndoQ for reliability, objectivity, content validity and processing time. The study and the questionnaire

were presented as a PowerPoint presentation to the panellists. In this phase, the think-aloud method was used [35].

Results

Phase 1

Using the combination of the keywords “endodontics AND education AND survey AND undergraduate” in the PubMed database, 87 results were returned. For the search “endodontics AND teaching AND survey AND undergraduate”, 81 results were returned by PubMed. Twenty-nine results were returned when asking for “endodontics AND teaching AND survey AND preclinical”. Following the criteria mentioned above, six publications were considered (Table 1). In addition, two publications of guidelines for endodontic education for undergraduates and guidelines for endodontic treatment in general were chosen (Table 1).

A total of 45 questions with 149 sub-items (sub-items are the possible answer options presented below the questions) were conceived in the first phase of the Delphi round 1. The GEndoQ was divided into ten different categories that are illustrated in Table 3. For a better overview, GEndoQ has been highlighted in different colours to show which questions and sub-items belong to which source (Figure 3). The expert group chose different answer options. The Likert scale with six possible options from which to choose was the most frequently used: 1= don't agree at all; 2= don't agree; 3= undecided; 4= agree; 5= fully agree, 6= don't know. Seven questions could be answered in a free text format, while five questions were in



single-choice formats, such as yes/no answers. The category III “Learning-teaching settings: Theoretical endodontology” and category IV “Learning-teaching materials: Theoretical endodontology” also asked for the percentage of the used settings and materials. At the end of categories III, IV, VI, VIII, IX and X, the question was asked whether something else was worth mentioning for the specific category (Table 4).

Phase 2

In the second phase, the second Delphi round, 22 changes by the panel expert were accepted and the questionnaire was adapted. For example, questions 5 and 10—the sub-item “dentist without specific education”—were complemented, while some questions had to be formulated more precisely for better comprehension (Tables 5-7). This resulted in the second

Table 3: The questionnaire was divided into 10 categories in order to provide clarity and allow for a schematic response.

Categories no.	Categories	Questions no.	Sub-Items no.
1	General information	5	11
2	Time management	3	3
3	Learning-teaching settings: Theoretical endodontology	3	18
4	Learning-teaching materials: Theoretical endodontology	3	12
5	Learning Goals: Theoretical endodontology	1	43
6	Learning-teaching settings: Practical endodontology	3	15
7	Learning Goals: Practical endodontology	1	18
8	Learning-teaching requirements: Practical endodontology	13	44
9	Examinations of theoretical and practical endodontology	7	24
10	Other	6	6
		total 45	total 194

What is the current status of student training in preclinical endodontology in the context of the phantom course in operative dentistry in Germany and German-speaking countries

I. General Information								
1.	Where is your university location (city) (please specify)? [8]	_____						
2.	How many students per semester are currently in your phantom course in operative dentistry (please specify)? [8]	n=_____ students						
3.	How many male students per semester are currently in your phantom course in operative dentistry (please specify)?	n=_____ students						
4.	How is the teacher-student ratio currently defined in the practical parts of the course (please tick)? [3]	<8:1 ①	9-12:1 ②	13-16:1 ③	17-20:1 ④	21-24:1 ⑤	25-28:1 ⑥	>29:1 ⑦
5.	Among the teachers there are (multiple answers possible):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know	
5.1.	Graduates of non-structured continuing education courses with endodontology content	①	②	③	④	⑤	⑥	
5.2.	Graduates of structured further training courses with endodontology contents (e.g. curriculum)	①	②	③	④	⑤	⑥	
5.3.	Persons working in a practice limited to endodontics	①	②	③	④	⑤	⑥	
5.4.	Persons with an endodontology specialization, not certified	①	②	③	④	⑤	⑥	
5.5.	Graduates of a master's degree course in endodontology	①	②	③	④	⑤	⑥	
5.6.	Certified specialists in endodontics	①	②	③	④	⑤	⑥	

Figure 3: GEndoQ Version 1 after phase one. For a better overview, the questionnaire was marked with references numbers to see from which sources the questions and sub-items came. Shown here is category I. General information is illustrated, consisting of 5 questions. Questions 1–3 can be answered in a free text format, question 4 has a single-choice option, and question 5 offers a Likert scale.



version of the questionnaire with 44 questions and 164 sub-items (Figures 4–5 illustrate some examples of the changes made).

Phase 3

The feedback from the expert group involved in the third Delphi round included 44 suggestions for change, 24 of which were used. The proposed amendments were changes in paragraphs and the use of other vocabulary to achieve a better understanding. One definition was added in question 16, where peer-tutoring was defined (Figures 6–7 illustrate examples of the changes made). This resulted in the third version of the questionnaire with 44 questions and 171 sub-items (Tables 8–11). The declined suggestions were due to different comprehension of definitions, and reconstructing of already

existing phrases used in the publications that formed the basis of the questionnaire.

Phase 4

The third version of the GEndoQ was modified and supplemented by 11 more questions to a total of 55 questions and 218 sub-items (Table 12). A question was added that asked for the time that dental schools dedicate to specific topics taught in preclinical endodontic classes: *root canal anatomy and pulp histology, pulp pathology and endodontic microbiology, endodontic radiology, endodontic materials, vital pulp therapies, root canal treatment on immature teeth with non-vital pulp tissues, root canal treatment, root canal re-treatment, endodontic surgery, endodontic regeneration, restoration of root-filled teeth, bleaching of endodontically treated teeth, dental trauma, endodontic emergencies.*

Table 4: The answers could be given either in a Likert scale, in single-choice format or free text format. This table shows some examples.

Answer Type	Answer Options
Likert scale	1= don't agree at all; 2= don't agree; 3= undecided; 4= agree; 5= fully agree, 6= don't know
Single choice	Yes /No Answer Choose between several options
In a free text	Quantity n (please specify) Other (please specify) Percentage (please specify) What else is worth mentioning? (please specify)

Table 5: Delphi round 2: Expert 3 was asked to ensure context validity and return written feedback directly on the printed questionnaire. He suggested 22 changes. Twenty-two changes were made. Shown here is part I with ten changes.

Original questions	Suggestions	Changed version
2. How many students are currently enrolled in your phantom course of operative dentistry (please specify)? n= _____ students	How many students per semester are currently in your phantom course in operative dentistry (please specify)? n= _____ students per semester/calendar year	How many students per semester are currently in your phantom course in operative dentistry (please specify)? n= _____ students per semester/
3. how many male students are currently in your course (please specify)? n= _____ students	How many male students per semester are currently in your course (please specify)? n= _____ students per semester as a percentage? a lot of work to fill in	How many male students per semester are currently in your course (please specify)? n= _____ students per semester
4. How is the student-teacher relationship currently defined at your location (please tick)?	How is the student-teacher relationship currently defined in the practical parts of the course (please tick)?	How is the student-teacher relationship currently defined in the practical parts of the course (please tick)?
5. -	Dentists without specific education → needs to be complemented	5.1. Dentists without specific education
6. how many hours (á 45 min) in total are available for the course (please specify)	How many hours (á 45 min) are available to you in total for the endodontology course (please specify)?	How many hours (á 45 min) are available to you in total for the endodontology course (please specify)?
9.2. Seminars...	Enter definition in the footnotes	Definitions entered behind the word Seminars = S (in-depth, mostly interdisciplinary, discussion of contents in smaller groups than in the lecture, including patient presentation)
9.3. Tutorials	Enter definition in the footnotes	Tutorials=T (are led by students with appropriate professional qualifications, supervised by members of the teaching staff and represent a possible form of regulated self-study by students)
9.4. Subject study groups...	Enter definition in the footnotes	Subject related study groups = GS (seminar and lecture contents are practiced problem-oriented).
9.4.1. ...with tutorials (problem-oriented)	Change sentence structure	Combination GS & T (problem oriented)
9.4.2. ...with tutorials (case-oriented)	Change sentence structure	Combination GS & T (case study oriented)



Table 6: Delphi round 2: Shown here is part II with seven changes shown.

Original questions	Suggestion	Changed version
10. Among the teachers, who teach the theoretical contents, are (multiple answers possible):	Grammar: multipel	Among the teachers, who teach the theoretical contents, are (multiple answers possible):
10.1. -	Dentists without specific education → needs to be complemented	10.1. Dentists without specific education
12.3. Lecture hand-outs (as Power Point/PDF)	Lecture hand-outs digital (e.g. PowerPoint/ PDF)	Lecture hand-outs digital (e.g. PowerPoint/ PDF)
12.4. Lecture hand-outs (in paper format)	Lecture hand-outs analogue (e.g. in paper format)	Lecture hand-outs analogue (e.g. in paper format)
16. The following materials are provided.	The following materials are used (multiple answers possible, please tick):	The following materials are used (multiple answers possible, please tick):
16.1. Videos (live)	Videos (live)	Videos (live)
20. the student learns in the situations listed below (multiple answers possible): 20.1. on single-root industrially manufactured simulated teeth made of plastic (up to two teeth). 20.2. on single-root 3D-printed plastic simulation teeth (up to two teeth). 20.3. single-root industrially manufactured plastic simulation teeth (more than two teeth). 20.4. on single-root 3D-printed plastic simulation teeth (more than two teeth). 20.5. multi-rooted industrially manufactured plastic simulation teeth (up to two teeth). 20.6. multi-root 3D printed plastic simulation teeth (up to two teeth). 20.7. multi-rooted industrially manufactured plastic simulation teeth (more than two teeth). 20.8. multi-rooted 3D printed plastic simulation teeth (more than two teeth). 20.9. on extracted single-rooted human teeth (up to two teeth). 20.10. on extracted single-rooted human teeth (more than two teeth). 20.11. on extracted multi-rooted human teeth (up to two teeth). 20.12. on extracted multi-rooted human teeth (more than two teeth).	Different concept for querying whether single-root, multi-root, human or simulation teeth.	Students learn in the situations listed below (multiple answers possible, please tick): <ul style="list-style-type: none"> • on human teeth • on industrially produced standardised simulation teeth made of plastic (e.g. Morita model teeth) • on patient-specific DVT-based plastic simulation teeth • on single-root teeth • on multi-root teeth • Other (please specify): • Number of single-root teeth (please specify): • Number of multi-root teeth (please specify):

Table 7: Delphi round 2: Shown here is part III and includes five changes.

Original questions	Suggestions	Changed version
26-29. Microscopes, magnifying glasses	Question about the number of microscopes and regularity of use of microscope and magnifying glasses.	28. Number of microscopes available in the course (please specify) 29. Students work with a microscope please tick as appropriate). 30. Students regularly work with magnifying glasses (please tick as appropriate)
33.1 Lateral condensation	Laterale compaction	Laterale compaction
33.2. Vertical condensation	Vertikale compaction	Vertikale compaction
36.5. on industrially manufactured plastic teeth	Question: Is the manufacturing method of the acrylic teeth important?	on industrially produced standardised simulation teeth made of plastic (e.g. Morita model teeth)
37.6. on 3D printed plastic teeth	Question: Is the manufacturing method of the acrylic teeth important?	on patient-specific DVT-based plastic simulation teeth

In addition, multiple questions addressed the materials and methods used for root canal treatment: *measurement length determination, type of NiTi instruments used, root canal irrigation, activation of the root canal irrigation, apexification and materials, type of inter-visit medicament, root canal filling pastes (sealers)*. The questions about post-endodontic restoration, the time needed to complete the endodontic treatment and whether there was a special department for endodontology were added to complement the questionnaire. Some questions were supposed to be answered in a free text format; others were in a multiple-choice format.

Phase 5

In phase five, the expert group recommended that some questions and sub-items should be abbreviated in order

to shorten the processing time. Therefore, the endodontic learning goals had to be reduced to five major ones, which combined theoretical and practical learning goals. Several questions were changed to free text answer questions instead of the Likert scale, and vocabulary was defined more precisely. All in all, 20 changes were suggested (Tables 13-14, Figures 8-9 illustrate some examples of the changes made). This step of development guaranteed the objectivity of interpretation. After this phase, GEndoQ was shortened to 49 questions with 99 sub-items (see GEndoQ Version 5 Figures 10-15).

Discussion

The aim of this study was to develop a questionnaire, using various methods, that can evaluate preclinical endodontic education.



VIII. Learning-teaching requirements: Practical endodontology						
20. The student learns in the situations listed below (multiple answers possible)	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
20.1. on single-root industrially manufactured simulated teeth made of plastic (up to two teeth).	①	②	③	④	⑤	⑥
20.2. on single-root 3D-printed plastic simulation teeth (up to two teeth).	①	②	③	④	⑤	⑥
20.3. single-root industrially manufactured plastic simulation teeth (more than two teeth).	①	②	③	④	⑤	⑥
20.4. single-root 3D-printed plastic simulation teeth (more than two teeth).	①	②	③	④	⑤	⑥
20.5. multi-rooted industrially manufactured plastic simulation teeth (up to two teeth).	①	②	③	④	⑤	⑥
20.6. multi-root 3D printed plastic simulation teeth (up to two teeth).	①	②	③	④	⑤	⑥
20.7. multi-rooted industrially manufactured plastic simulation teeth (more than two teeth).	①	②	③	④	⑤	⑥
20.8. multi-rooted 3D printed plastic simulation teeth (more than two teeth).	①	②	③	④	⑤	⑥
20.9. extracted single-rooted human teeth (up to two teeth).	①	②	③	④	⑤	⑥
20.10. on extracted single-rooted human teeth (more than two teeth).	①	②	③	④	⑤	⑥
20.11. on extracted multi-rooted human teeth (up to two teeth)	①	②	③	④	⑤	⑥
20.12. on extracted multi-rooted human teeth (more than two teeth).	①	②	③	④	⑤	⑥

Figure 4: GEndoQ Version 1 after phase one: This figure shows, as an example, category VIII, question 20 and its 12 sub-items. It is answered using a Likert scale.

VIII. Learning-teaching requirements: Practical endodontology						
20. Students learn in the situations listed below (multiple answers possible):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
20.1. on human teeth	①	②	③	④	⑤	⑥
20.2. on industrially manufactured standardised simulation teeth made of plastic (e.g. Morita model teeth)	①	②	③	④	⑤	⑥
20.3. on patient-specific DVT-based plastic simulation teeth	①	②	③	④	⑤	⑥
20.4. on single-root teeth	①	②	③	④	⑤	⑥
20.5. on multi-root teeth	①	②	③	④	⑤	⑥
20.6. Other (please specify) _____						
21. Number of single root canals (please specify):	n= ____ tooth/teeth					
22. Number of multi-rooted canals (please specify):	n= ____ tooth/teeth					

Figure 5: GEndoQ Version 2 after phase two: This figure shows questions 20–22. Expert 3 in Delphi round 2 suggested for question 20 a different concept for querying whether single-root, multi-root, human or simulation teeth. The original question was changed as illustrated above. Questions 21 and 22 ask for the specific number of teeth. This figure is one example of the changes made that were suggested in Delphi round 2 as described in Tables 5-7.

Literature review and conception of a discipline-specific questionnaire

In the first phase, the expert group conducted a literature review to ensure that the idea of the study was orientated on decisive former publications, following the AMEE Guide No. 87 and the Survey Development Guidance for Medical Education Researchers [25,40]. Its aim was to bring the reader up to date

with the literature on a specific theme and form the groundwork for future research [41]. Kossioni, et al. described in their methods for developing a questionnaire to measure the clinical learning environment for undergraduate dental students, that a literature review should be conducted [22]. Several other studies have made a similar statement [21,25,42–44]. In this current study, the publication of Sonntag, et al. [3] and the survey of Gerhardt-Szép [8], served as the basis for the questionnaire;



VI. Learning-teaching settings: Practical endodontology							
16. The following learning-teaching settings are offered to convey the practical contents (multiple answers possible, please tick and write down percentage share):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know	% share
16.1. Demonstrations (in big groups, more than 4 persons) [3]	①	②	③	④	⑤	⑥	___
16.2. Hands-on-exercises (in small groups, max. 4 persons) [3]	①	②	③	④	⑤	⑥	___
16.3. Internships with students in the patient courses	①	②	③	④	⑤	⑥	___
16.4. Internships with dentists at the university	①	②	③	④	⑤	⑥	___
16.5. clinical traineeship with dentists in private practice [38]	①	②	③	④	⑤	⑥	___
16.6. I within the framework of peer-tutored free practice periods	①	②	③	④	⑤	⑥	___
16.7. within the framework of tutored (by dental staff) free practice periods	①	②	③	④	⑤	⑥	___
16.8. within the framework of free practice periods	①	②	③	④	⑤	⑥	___
16.9. within the framework of tutored course time	①	②	③	④	⑤	⑥	___
16.10. Other (please specify) _____							___

Figure 6: GEndoQ Version 2 after phase two: Category VI. Learning-teaching settings: Practical endodontology, question 16 with its 10 sub-items and the Likert scale plus a space for the percentage share.

VI. Learning-teaching settings: Practical endodontology							
16. The following learning-teaching settings are offered to convey the practical contents (multiple answers possible, please tick and write down percentage share):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know	% share
16.1. Demonstrations [3]	①	②	③	④	⑤	⑥	__%
16.2. Hands-on-exercises [3]	①	②	③	④	⑤	⑥	__%
16.3. Internships with students in the patient courses	①	②	③	④	⑤	⑥	__%
16.4. Internships with dentists at the university	①	②	③	④	⑤	⑥	__%
16.5. clinical traineeship with dentists in private practice [38]	①	②	③	④	⑤	⑥	__%
16.6. I within the framework of peer-tutored (by students of higher semesters) free practice periods	①	②	③	④	⑤	⑥	__%
16.7. within the framework of tutored (by dental staff) free practice periods	①	②	③	④	⑤	⑥	__%
16.8. within the framework of free practice periods	①	②	③	④	⑤	⑥	__%
16.9. within the framework of tutored course time	①	②	③	④	⑤	⑥	__%
16.10. Other (please specify) _____							__%

Figure 7: GEndoQ Version 3 after phase three: Category VI. Learning-teaching settings: Practical endodontology, question 16 with its 10 sub-items and the Likert scale plus a space for the percentage share. The panellists from Delphi round 3 suggested 44 changes, including changes to question 16. It was proposed to leave out the size for "Demonstrations" and "Hands-on-exercises", as well as defining the word "peer-tutored" (see Tables 8-11). The percentage sign that was missing was added. This figure presents a portion of the changes made as an example.

both authors are experts in this study. In addition, the new licensing regulations for dentists (ZApprO) [38], the national competence-based catalogue of learning objectives (NKLZ) [39] and the Frankfurt learning objectives for endodontology (FLOE) were used. The publications using similar questionnaires that were found through the literature review [1,2,4-7] were used as orientations for developing the GEndoQ. These were the only publications between 1991 and 2020 provided by the database that included the criteria "questionnaire/survey requesting the

general status quo of endodontic education in the preclinical or/and clinical undergraduate part of dental faculties nationally/internationally". Furthermore, the guidelines for endodontic education for undergraduates and guidelines for endodontic treatment in general were added as orientation publications for the questionnaire [9,12]. The European Society of Endodontology (ESE) published undergraduate curriculum guidelines for endodontology in 1992, 2001 [45,46], the latest publication in 2013, and "[...] formed a benchmarking reference



Table 8: Delphi round 3: Four panel experts suggested 44 changes that addressed grammar, vocabulary, etc. Twenty-four changes were made. Shown here is part I and includes nine changes.

Original questions	Suggestions from the panellist 1-4	Changed version
2. How many students per semester are currently in your phantom course in operative dentistry (please specify)?	Panellist 4: Are there fluctuations in the number of participants between the semesters (summer/winter) and how big is the range of fluctuation?	How many students per semester are currently in your phantom course in operative dentistry (please specify)? Discussion: Interesting is the number of students per semester.
4. How is the teacher-student ratio currently defined in the practical parts of the course (please tick as appropriate)? <small><8:1 9-12:1 13-16:1 17-20:1 21-24:1 25-28:1 >28:1</small>	Judge 1: Why is the student-teacher ratio so defined? Assessor 4: A ratio of <8:1 is not intended, e.g. 6:1?	The definition of the student-teacher ratio is based on an earlier publication and should be left as it is.
5. Among the teachers there are (multiple answers possible):	Panellist 4: Ask for the percentage.	The question about the percentage is very difficult to answer, as it would have to be calculated by the respondent.
6. How many hours (á 45 min) are available to you in total for the endodontic course part (please specify)?	Panellist 2: How many hours (á 45 min) are available to you in total for the endodontology course part (please specify)?	How many hours (á 45 min) are available to you in total for the endodontology course part (please specify)?
7. How many hours (á 45 min) do you have available to teach the practical contents of endodontics in your course (please specify)?	Panellist 2: How many hours (á 45 min) do you have available to teach the practical contents of endodontology in your course (please specify)?	How many hours (á 45 min) do you have available to teach the practical contents of endodontology in your course (please specify)?
9.	Panellist 3+4: The percentage sign is missing on the dash for % share.	percent sign on the dash.
9.2. Seminars = S (in-depth, mostly interdisciplinary, discussion of contents in smaller groups than in the lecture, including patient presentation	Panellist 1: Comma is unnecessary	Seminars = S (in-depth, mostly interdisciplinary discussion of contents in smaller groups than in the lecture, including patient presentation
9.2.2. Combination S & Tutorials * (* see under 9.3.)	Panellist 1: Insert after 9.3. so that you can read the tutorial definition	Added after 9.3. so that you can read the tutorial definition
Answer options: Don't agree, disagree, etc.	Panellists 1-4: Put at the top of the page, for better answers	Placed at the top of the page, for better answers

Table 9: Delphi round 3: Shown here is part II and includes ten changes.

Original questions	Suggestions from the panellist 1-4	Changed version
11. Here you can, if necessary, enter in free text format whatever else comes to your mind on the subject of "Learning-teaching SETTINGS: THEORETICAL Endodontics" that seems worth mentioning.	Panellists 1-4: Here you can enter in free text format what else you think is worth mentioning on the subject of "Learning-Teaching SETTINGS: THEORETICAL Endodontics".	Here you can enter in free text format what else you think is worth mentioning on the subject of "Learning-Teaching SETTINGS: THEORETICAL Endodontics".
13.3. as a CD	Panellist 1: Would the above point to question 12 also be material	Since it also occurs in an earlier publication as a possible answer.
13.4. In the form of other data carriers	Panellist 1: Why is it important?	Since it also occurs in an earlier publication as an answer option. (e.g. USB stick)
13.5. as a Video	Panellist 1: Would the above point to question 12 also be material	Put under Materials: As Video
13.6. as a E-Learning module	Panellist 1: Would the above point to question 12 also be material	Put under Materials: As E-Learning Modul
15.	Panellist 1: In the first line, write "The graduates can..." not "They can..." repeat per learning objective.	The graduates can...
-	Panellist 1: Insert grey bars between the learning objective sub items and generally different questions to separate them	Different coloured bars inserted to distinguish the different questions
-	Panellist 4: Difference in the aim of the questions. What is meant by characterizing as opposed to explaining, possibly describing symptoms?	NKLZ learning goals: Keep in the original
15.1.3. Graduates can educate patients about the prevention of dental trauma	Panellist 4: Elucidate possible anterior tooth trauma.	NKLZ learning goals: Keep in the original
15.1.4. Graduates can perform prevention of pulp and periradicular diseases	Panellist 4: Formulation Suggestion: The graduates know strategies for the prevention of pulp and periradicular diseases and are able to implement them.	NKLZ learning goals: Keep in the original

for dental schools and regulatory bodies [...]” [9]. Therefore, the ESE guidelines were taken into account to ensure that the questions and sub-items remained relevant.

In this study, the GEndoQ was generated by a team of two individuals using the Delphi technique (explained below). The one individual, besides being a dentist, is an expert in medical education, thereby ensuring content validity.

Content validation using different methods

To evaluate the instrument's content validity, which assesses the relevance of each question and sub-item, different panel experts reviewed the questionnaire in several phases [27]. Baker, et al. stated that “[e]xperts provide an accessible source of information that can be quickly harnessed to gain opinion. They can often provide knowledge when more traditional


Table 10: Delphi round 3: Shown here is part III and includes 12 changes.

Original questions	Suggestions from the panellist 1-4	Changed version
15.1.4.10. They can describe the therapy of endodonts in connection with periodontal lesions...	Panellist 4: Formulation Suggestion: The graduates are able to recognize paro-endodontic lesions, diagnose an endodontic cause if necessary and describe an adequate therapy.	NKLZ learning goals: Keep in the original
15.1.4.10.1. ...and give reasons.	Panellist 4: Formulation Suggestion: The graduates are able to recognize paro-endodontic lesions, diagnose an endodontic cause if necessary and describe an adequate therapy.	NKLZ learning goals: Keep in the original
15.1.4.4.1... be able to justify the decision.	Panellist 3: ..justify the decision.	..justify the decision.
16.1. Demonstrations (in large groups, i.e. more than 4 people)	Panellist 1: Definition of demonstrations? Where does the number come from?	Demonstrations
16.2. hands-on (in small groups, i.e. less than 4 persons)	Panellist 1: ...definition of hands-on? Where does the number come from?	Hands-on-exercises
16.5. clinical traineeship with dentists in private practice	Panellist 1: Isn't it called observation?	ZApprO describes clinical traineeship with dentists in private practice.
16.6. within the framework of peer-tutored free practice periods	Panellist 1: What does peer tutoring mean?	in the context of peer-tutored (by students in higher semesters) free practice periods
17. the following materials are used (multiple answers possible, please tick as appropriate)	Panellist 1: Why are there no endodontology textbooks in here?	17.2 Endodontology textbooks
19.1.3.6. perform the functional restoration of endodontically treated teeth	Panellist 2: Omit "possibilities.	NKLZ learning goals, Keep in original
20. students learn in the situations listed below (multiple answers possible, please tick)	Panellist 1: "in the situations listed below" no situations	Students learn in the situations listed below (multiple answers possible, please tick):
20.4. on single-root canals	Panellist 1+2: Not canals, but teeth	on single-root teeth
20.5. on multiple-root canals	Panellist 1+2: Not canals, but teeth	on multi-root teeth

Table 11: Delphi round 3: Shown here is part IV and includes 13 changes.

Original questions	Suggestions from the panellist 1-4	Changed version
21. number of single-root canals (please specify)	Panellist 1+2: Not canals, but teeth	number of single-root teeth (please specify)
22. number of multi-root canals (please specify)	Panellist 1+2: Not canals, but teeth	number of multi-root teeth (please specify)
25.1. apical-coronal standardized	Panellist 2: What does that mean?	Common method, no definition necessary
25.4. coronal apical / step back	Panellist 4: Proposed wording: Step Down	Common formulation: coronal-apical / step back
27.2 Gold Reciproc, VDW	Panellist 2: Asks for Reciproc blue	Not relevant, as not queried in previous publication.
30. The students work with a microscope.	Panellist 1: Why not "regularly" as in question 32?	Students regularly use a microscope for root canal treatment (please tick as appropriate):
36. the theoretically imparted contents will be examined in the following settings (multiple answers possible, please tick as appropriate)	Panellist 1: Situations instead of setting	The theoretically conveyed contents are checked in the following situations (multiple answers possible, please tick as appropriate)
36.5. in a structured oral examination (OSOE= Objective structured oral examination) asked	Panellist 1: „asked“ is unnecessary	in a structured oral examination (OSOE= Objective structured oral examination)
37.2. In portfolio format	Panellist 2+4: Explain this format	Common format, no definition necessary
38.2. by one dentist	Panellist 2: Gender	by several dentists
39.2. is different than 60%	Panellist 1: 39.2 und 39.3 are duplicate questions, why not ask if the pass mark can be given?	is different than 60%. Question adopted from Gerhardt-Szep
39.3. is determined individually	Panellist 1: 39.2 and 39.3 are duplicate questions, why not ask if the pass mark can be given?	is determined individually Question adopted from Gerhardt-Szep
45. what are the endodontology material costs in the course per student in euros (please specify)?	Panellist 1+2: students?	What are the endodontology material costs in the course per student in Euro (please specify)?

research has not been undertaken” [30]. Corresponding to Skulmoski, et al., the expert panellists in the Delphi round should meet four “expertise requirements: i) knowledge and experience with the issues under investigation; ii) capacity and

willingness to participate; iii) sufficient time to participate in the Delphi technique; and iv) effective communication skills” [47]. The use of expert panels is common for assuring content validity of questionnaires [22], [24], [29], [43], [44] and is recommended by the AMEE Guide No. 87 [25].



Table 12: Delphi round 4: Based on a recent publication, the experts from the first Delphi round added 11 more questions to the GEndoQ. The questions and answer options are illustrated in this table.

Questions	Answer Options
Indicate the number of hours (4 45 min) devoted to the following subjects/topics (n= _____ h):	<ul style="list-style-type: none"> - Root canal anatomy and pulp histology Pulp - Pulp pathology and endodontic microbiology - Endodontic radiology - Endodontic materials - Vital pulp therapies - Root canal treatment on immature teeth with non-vital pulp tissues - Root canal treatment - Root canal re-treatment - Endodontic surgery Endodontic - Endodontic regeneration - Restoration of root filled teeth - Bleaching of endodontically treated teeth - Dental trauma - Endodontic emergencies
The measuring length of the root canal is determined by (please tick as appropriate):	<ul style="list-style-type: none"> - Radiograph measuring technique - Electronic working length determination (endometry) - Combination of radiograph measuring technique and endometry
Which Ni-Ti instruments do the students use for manual root canal preparation (please specify) The students use the following materials for apexification (please tick as appropriate):	<ul style="list-style-type: none"> - Calcium hydroxide (Ca(OH)2) - Mineral trioxide aggregate (MTA) - Biodentine (Septodont, NiederKassel) - Other (please specify)
The students use the following root canal irrigations (please tick as appropriate):	<ul style="list-style-type: none"> - Sodium Hypochlorite (NaOCl) - Chlorhexidine digluconate (CHX) - Hydrogen peroxide (H2O2) - Editic acid (EDTA) - Other (please specify)
The root canal irrigations are activated by (please tick as appropriate):	<ul style="list-style-type: none"> - Sound - Ultrasound - Laser (PIPS) - Ozone - Negative pressure (e.g. EndoVac) - Suction-pressure technology (e.g. RinsEndo)
The students use the following type of inter-visit medicament (no (please tick as appropriate):	<ul style="list-style-type: none"> - Calcium hydroxide (Ca(OH)2) - Corticosteroid (e.g. Ledermix) - No medicine - Other (please specify)
The students use the following root canal filling pastes (sealers) (please tick as appropriate):	<ul style="list-style-type: none"> - Zinc oxide-eugenol-based (e.g. aptal resin) - Based on epoxy resin (e.g. Ah Plus) - Based on polyketone (e.g. Diaket) - Based on glass ionomer cement (e.g. Ketac-Endo) - Other (please specify)
The students treat the tooth after completion of the root canal treatment as follows: (please mark with a cross):	<ul style="list-style-type: none"> - Temporary restoration (e.g. cement filling) - Definitive restoration (e.g. adhesive filling) - Other (please specify)
In how many treatment steps/days should the root canal treatment be completed (please specify)?:	
There is a special department/polyclinic for endodontology only (please tick)	

Table 13: Delphi round 5: Fifteen panel experts who checked for reliability, objectivity, validity and processing time suggested 20 changes. In this phase, the think-aloud method was used. Shown here is part I with 14 changes.

Original Questions/Answers	Suggestions form 15 panel experts	Changed Version
1. Where is your university location (city) (please specify)?	Anonymous survey - gets more participants	Question 1 deleted
4. How is the teacher-student ratio currently defined in the practical parts of the course (please tick as appropriate)?	Do not indicate the answer option as a Likert scale but in a free text.	Question 3: 1: _____ (Teacher : Students)
Questions 11, 14, 18, 42, 47 Here you can enter in free text format, if necessary, what else you think is worth mentioning on the topic "xxxx".	Omit, because otherwise there are too many questions, in the last category provide field for free text.	Questions 11, 14, 18, 42, 47 deleted
12.1. Endodontics textbooks	Answer in free text format is sufficient.	12.1. deleted Question 11: What literature do you recommend (multiple answers possible, please indicate: title and author)?
12.3. Lecture hand-outs digital (e.g. PowerPoint/ PDF)	digital or analog irrelevant	12.3. and 12.4. combined to 10.2. lecture hand-outs
12.4. Lecture Hand-Outs analogue (e.g. in paper format)	digital or analog irrelevant	12.3. and 12.4. combined to 10.2. lecture hand-outs
13.3. as CD	irrelevant, since no longer up to date	13.3. deleted
13.4. in the form of other data carriers (e.g. USB stick)	irrelevant, since no longer up to date	13.4. deleted
13.5. as Video	unnecessary	13.5. deleted
17.2. Endodontics textbooks	Content of question 11	17.2. deleted
23. Measuring length of the canals is determined by (please tick as appropriate):	Answer in free text format is sufficient, otherwise too much text.	19. Measuring length of the canals is determined by (multiple answers possible, please specify):
27. Students learn manual root canal preparation with hand instruments in the following technique (please tick as appropriate):	Answer in free text format is sufficient, otherwise too much text.	23. Students learn manual root canal preparation with hand instruments in the following technique (multiple answers possible, please specify):
29. Students learn how to prepare a root canal manually with the following instruments (multiple answers possible, please tick as appropriate):	Answer in free text format is sufficient, otherwise too much text.	25. Students learn how to prepare a root canal manually with the following instruments (multiple answers possible, please specify):
31. Students use the following root canal irrigations (please tick as appropriate):	Answer in free text format is sufficient, otherwise too much text.	26. Students use the following root canal irrigations (please specify):



Table 14: Delphi round 5: Fifteen panel experts who checked for reliability, objectivity, validity and processing time suggested 20 changes. In this phase, the think-aloud method was used. Part II: Six changes are shown.

Original Questions/Answers	Suggestions form 15 panel experts	Changed Version
32. Root canal irrigations are activated by (please tick as appropriate):	Answer in free text format is sufficient, otherwise too much text.	27. Root canal irrigations are activated by (please specify):
36. Students use the following type of inter-visit medication (please tick as appropriate):	Answer in free text format is sufficient, otherwise too much text.	32. Students use the following type of inter-visit medication (please specify):
37. Students use the following root canal filling pastes (sealers) (please tick as appropriate):	Answer in free text format is sufficient, otherwise too much text.	33. Students use the following root canal filling pastes (sealers) (please specify):
38. Students perform the root canal filling as follows (multiple answers possible, please tick as appropriate):	Answer in free text format is sufficient, otherwise too much text.	34. Students perform the root canal filling as follows (multiple answers possible, please specify):
41. Students shall prepare and fill at least this number of root canals, both human and simulated (please tick as appropriate):	Answer in free text format is sufficient, otherwise too much text.	37. Students shall prepare and fill at least this number of root canals, both human and simulated (please specify):
Learning objectives/goals: theoretical and practical endodontology	abbreviated and summarized, because too detailed and too time-consuming to fill in	Category VII 42. The graduates can... 42.1. explain the etiology and pathogenesis of pulp and periradicular diseases. 42.2. diagnose pulp and periapical diseases. 42.3. carry out the prevention of pulp and periradicular diseases. 42.4. plan the endodontic treatment and carry it out. 42.5. use primary and secondary evidence, in particular, to make decisions on medical/dental issues in everyday dental practice.

V. Learning Goals: Theoretical endodontology						
16. The following learning objectives* are taught in your curriculum (multiple answers possible, please tick)	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
The graduate can...						
1.1. explain the etiology and pathogenesis of pulp and periradicular diseases.	①	②	③	④	⑤	⑥
1.1.1. characterise the etiology and pathogenesis of diseases of the pulp-dentine complex and periradicular tissue	①	②	③	④	⑤	⑥
1.1.2. explain their epidemiology	①	②	③	④	⑤	⑥

Figure 8: GEndoQ Version 4 after phase four: This figure shows how the theoretical learning goals were questioned. As an example, the first three sub-items out of 54 sub-items of the learning goals are illustrated. There is also a part of practical learning goals questioned in GEndoQ Version 4, consisting of 18 sub-items.

VIII. Learning Goals						
42. The following learning objectives/goals are taught in your curriculum (multiple answers possible, please tick as appropriate):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
The graduates can...						
42.1. explain the etiology and pathogenesis of pulmonary and periradicular diseases.	①	②	③	④	⑤	⑥
42.2. diagnose pulp and periapical diseases.	①	②	③	④	⑤	⑥
42.3. carry out the prevention of pulp and periradicular diseases.	①	②	③	④	⑤	⑥
42.4. plan the endodontic treatment and carry it out.	①	②	③	④	⑤	⑥
42.5. in particular, use primary, but also secondary evidence collected and critically evaluated to make decisions on a medical/dental issue in everyday dental practice.	①	②	③	④	⑤	⑥

Figure 9: GEndoQ Version 5 after phase five: This figure shows the changed version of the learning goals after the Delphi round 5. In order to abbreviate and summarize the learning goals, because they were too detailed and too time-consuming to fill out, they were consolidated to just five learning goals with five sub-items. The suggested changes can be seen in Tables 13–14.



What is the current status of student training in preclinical endodontology in the context of the phantom course in operative dentistry in Germany and German-speaking countries?

I. General Information							
1.	How many students per semester are currently in your phantom course in operative dentistry (please specify)?	n= _____ Students per semester					
2.	How many male students per semester are currently in your phantom course in operative dentistry (please specify)?	n= _____ Students per semester					
3.	How is the teacher-student ratio currently defined in the practical parts of the course (please specify)?	1: _____ (Teacher : Student)					
4.	Among the teachers there are (multiple answers possible):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
4.1.	Dentists without specific education	①	②	③	④	⑤	⑥
4.2.	Graduates of non-structured continuing education courses with endodontology content	①	②	③	④	⑤	⑥
4.3.	Graduates of structured further training courses with endodontology contents (e.g. curriculum)	①	②	③	④	⑤	⑥
4.4.	Persons working in a practice limited to endodontics	①	②	③	④	⑤	⑥
4.5.	Persons with an endodontology specialization, not certified	①	②	③	④	⑤	⑥
4.6.	Graduates of a master's degree course in endodontology	①	②	③	④	⑤	⑥
4.7.	Certified specialists in endodontics	①	②	③	④	⑤	⑥
II. Time Management							
5.	How many hours (á 45 min) are available to you in total for the endodontology course part (please specify)?	n= _____ hours					
6.	How many hours (á 45 min) do you have available to teach the practical contents of endodontology in your course (please specify)?	n= _____ hours					
7.	How many hours (á 45 min) do you have available to teach the theoretical contents of endodontology in your course (please specify)?	n= _____ hours					
III. Learning-teaching settings: Theoretical Endodontology							
8.	The following learning-teaching-settings are offered to convey the theoretical contents (multiple answers possible):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
8.1.	Lectures	①	②	③	④	⑤	⑥
8.2.	Seminars = S (in-depth, mostly interdisciplinary discussion of contents in smaller groups than in the lecture, including patient presentation)	①	②	③	④	⑤	⑥
8.2.1.	... whereby the number of seminar participants is not more than 20 students	①	②	③	④	⑤	⑥
8.3.	Combination S & Tutorials * (* see under 8.4)	①	②	③	④	⑤	⑥
8.4.	Tutorials=T (are led by students with appropriate professional qualifications, supervised by members of the teaching staff and represent a possible form of regulated self-study by students)	①	②	③	④	⑤	⑥
8.5.	Subject related study groups = GS (seminar and lecture contents are practiced problem-oriented).	①	②	③	④	⑤	⑥
8.5.1.	Combination GS & T (problem oriented)	①	②	③	④	⑤	⑥
8.5.2.	Combination GS & T (case study oriented)	①	②	③	④	⑤	⑥
8.6.	Blended learning (combination of a. face-to-face teaching and then b. e-learning)	①	②	③	④	⑤	⑥
8.7.	Inverted classroom (combination of a. e-learning followed by b. classroom teaching)	①	②	③	④	⑤	⑥
8.8.	Other (please specify): _____						

Figure 10: GEndoQ Version 5: The final version of the questionnaire has 49 questions with 99 sub-items. Page 1 includes three categories.



9.	Among the teachers, who teach the theoretical contents , are (multiple answers possible):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
9.1.	Dentists without specific education	①	②	③	④	⑤	⑥
9.2.	Graduates of non-structured continuing education courses with endodontology content	①	②	③	④	⑤	⑥
9.3.	Graduates of structured further training courses with endodontology contents (e.g. curriculum)	①	②	③	④	⑤	⑥
9.4.	Persons working in a practice limited to endodontics	①	②	③	④	⑤	⑥
9.5.	Persons with an endodontology specialization, not certified	①	②	③	④	⑤	⑥
9.6.	Graduates of a master's degree course in endodontology	①	②	③	④	⑤	⑥
9.7.	Certified specialists in endodontics	①	②	③	④	⑤	⑥
IV. Learning-teaching materials: Theoretical Endodontology							
10.	The following learning-teaching materials are offered for teaching the theoretical contents (multiple answers possible):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
10.1.	Endodontology-scripts	①	②	③	④	⑤	⑥
10.2.	Lecture-hand-outs	①	②	③	④	⑤	⑥
10.3.	E-learning-modules	①	②	③	④	⑤	⑥
10.4.	Other (please specify): _____						
11.	What literature do you recommend (multiple answers possible, please indicate: title and author)?	_____					
12.	The materials are made available (multiple answers possible):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
12.1.	in the internet	①	②	③	④	⑤	⑥
12.2.	in the intranet	①	②	③	④	⑤	⑥
12.3.	Other (please specify): _____						
13.	Indicate the number of hours (á 45 min) devoted to the following subjects/topics :						
13.1.	Root canal anatomy and pulp histology Pulp	n= ___ hours					
13.2.	Pulp pathology and endodontic microbiology	n= ___ hours					
13.3.	Endodontic radiology	n= ___ hours					
13.4.	Endodontic materials	n= ___ hours					
13.5.	Vital pulp therapies	n= ___ hours					
13.6.	Root canal treatment on immature teeth with non-vital pulp tissues	n= ___ hours					
13.7.	Root canal treatment	n= ___ hours					
13.8.	Root canal re-treatment	n= ___ hours					
13.9.	Endodontic surgery Endodontic	n= ___ hours					
13.10.	Endodontic regeneration	n= ___ hours					
13.11.	Restoration of root filled teeth	n= ___ hours					
13.12.	Bleaching of endodontically treated teeth	n= ___ hours					
13.13.	Dental trauma	n= ___ hours					
13.14.	Endodontic emergencies	n= ___ hours					

Figure 11: GEndoQ Version 5: Page 2/6.



V. Learning- teaching settings: Practical Endodontology						
	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
14. The following learning-teaching settings are offered to convey the practical contents (multiple answers possible):						
14.1. Demonstrations	①	②	③	④	⑤	⑥
14.2. Hands-on exercises	①	②	③	④	⑤	⑥
14.3. Internships with students in the patient courses	①	②	③	④	⑤	⑥
14.4. Internships with dentists at the university	①	②	③	④	⑤	⑥
14.5. clinical traineeship with dentists in private practice	①	②	③	④	⑤	⑥
14.6. within the framework of peer-tutored (by students in higher semesters) free practice periods	①	②	③	④	⑤	⑥
14.7. within the framework of tutored (by dental staff) free practice periods	①	②	③	④	⑤	⑥
14.8. within the framework of free practice periods	①	②	③	④	⑤	⑥
14.9. within the framework of tutored course time	①	②	③	④	⑤	⑥
14.10. Other (please specify): _____						
15. The following materials are used (multiple answers possible):						
15.1. Videos (recorded)	①	②	③	④	⑤	⑥
15.2. Endodontology scripts (e.g. step by step)	①	②	③	④	⑤	⑥
15.3. Other (please specify): _____						
VI. Learning-teaching requirements: Practical Endodontology						
	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
16. Students learn in the situations listed below (multiple answers possible):						
16.1. on human teeth	①	②	③	④	⑤	⑥
16.2. on industrially manufactured standardised simulation teeth made of plastic (e.g. Morita model teeth)	①	②	③	④	⑤	⑥
16.3. on patient-specific DVT-based plastic simulation teeth	①	②	③	④	⑤	⑥
16.4. on single-root teeth	①	②	③	④	⑤	⑥
16.5. on multi-root teeth	①	②	③	④	⑤	⑥
16.6. Other (please specify): _____						
17. Number of single root teeth (please specify):	n= _____ tooth/teeth					
18. Number of multi-rooted teeth (please specify):	n= _____ tooth/teeth					
19. The measuring of the working length of the root canal is determined by (multiple answers possible, please specify):	_____ _____ _____					
20. Students learn manual root canal preparation with hand instruments (please tick as appropriate)	①	②	③	④	⑤	⑥
21. Ni-Ti instruments are used for manual root canal preparation (please tick as appropriate):	①	②	③	④	⑤	⑥
22. Which Ni-Ti instruments do the students use for manual root canal preparation (multiple answers possible, please specify)?	_____ _____ _____					
23. Students learn manual root canal preparation with hand instruments in the following technique (multiple answers possible, please specify):	_____ _____					

Figure 12: GEndoQ Version 5: Page 3/6.



	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
24. Students learn mechanical root canal preparation with rotary/reciprocal instruments (please tick as appropriate):	①	②	③	④	⑤	⑥
25. Students will learn how to prepare root canals mechanically with the following instruments (please specify):	_____					
26. Students use the following root canal irrigations (please specify):	_____					
27. The root canal irrigations are activated by (please specify):	_____					
28. Number of microscopes available in the course (please specify):	n= _____ mikroskope(s)					
	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
29. Students regularly use a microscope for root canal treatment (please tick as appropriate):	①	②	③	④	⑤	⑥
30. Students regularly use magnifying glasses for root canal treatment (please tick as appropriate):	①	②	③	④	⑤	⑥
31. Students regularly use a microscope for root canal treatment (please tick as appropriate):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
31.1. Calcium hydroxide (Ca(OH) ₂)	①	②	③	④	⑤	⑥
31.2. Mineral trioxide aggregate (MTA)	①	②	③	④	⑤	⑥
31.3. Biodentine (Septodont, Niederkassel)	①	②	③	④	⑤	⑥
31.4. Other (please specify):	_____					
32. Students use the following type of inter-visit medication (please specify):	_____					
33. Students use the following root canal filling pastes (sealer) (please specify)	_____					
34. Students perform the root canal filling as follows (multiple answers possible, please specify):	_____					
35. students treat the tooth after completion of the root canal treatment as follows (please tick as appropriate):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
35.1. Temporary restoration (e.g. cement filling)	①	②	③	④	⑤	⑥
35.2. Definitive restoration (e.g. adhesive filling)	①	②	③	④	⑤	⑥
35.3. Other (please specify):	_____					
36. In how many treatment steps/days should the root canal treatment be completed (please specify)?:	n= _____ Treatment steps/days					
37. Students prepare and fill at least this number of teeth, both human and simulated (please specify):	n= _____ tooth/teeth					

Figure 13: GEndoQ Version 5: Page 4/6.



VII. Examinations in THEORETICAL and PRACTICAL Endodontology							
38.	The theoretically conveyed contents are checked in the following situations (multiple answers possible, please tick as appropriate):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
38.1.	in a written examination with free text	①	②	③	④	⑤	⑥
38.2.	in a written examination in e.g. multiple choice format, with a correct answers	①	②	③	④	⑤	⑥
38.3.	in a written examination in e.g. multiple choice format, with several correct answers	①	②	③	④	⑤	⑥
38.4.	in an oral examination	①	②	③	④	⑤	⑥
38.5.	in a structured oral examination (OSOE = Objective structured oral examination)	①	②	③	④	⑤	⑥
38.6.	other (please specify): _____						
39.	The practically mediated contents are checked in the following settings (multiple answers possible, please tick as appropriate):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
39.1.	as OSCE= Objective structured clinical examination format	①	②	③	④	⑤	⑥
39.2.	in portfolio format	①	②	③	④	⑤	⑥
39.3.	in alternative format (e.g. Mini-CEX= Mini-Clinical Evaluation Exercise, DOPS= Direct Observation of Procedural Skills)	①	②	③	④	⑤	⑥
39.4.	on human extracted teeth	①	②	③	④	⑤	⑥
39.5.	on industrially produced standardised simulation teeth made of plastic (e.g. Morita model teeth)	①	②	③	④	⑤	⑥
39.6.	on patient-specific DVT-based plastic simulation teeth	①	②	③	④	⑤	⑥
39.7.	The test teeth are installed in endodontic models (please tick as appropriate).	①	②	③	④	⑤	⑥
39.8.	The test teeth are measured endometrically (please tick as appropriate).	①	②	③	④	⑤	⑥
39.9.	other (please specify): _____						
40.	The evaluation of the theoretical/practical tests is carried out (multiple answers possible, please tick as appropriate):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
40.1.	via a central office	①	②	③	④	⑤	⑥
40.2.	by one dentists	①	②	③	④	⑤	⑥
40.3.	by several dentists	①	②	③	④	⑤	⑥
40.4.	other (please specify): _____						
41.	The pass mark (please tick as appropriate)...	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
41.1.	is 60%.	①	②	③	④	⑤	⑥
41.2.	is different from 60%	①	②	③	④	⑤	⑥
41.3.	other (please specify): _____						

Figure 14: GEndoQ Version 5: Page 5/6.



VIII. Learning Goals						
42. The following learning objectives/goals are taught in your curriculum (multiple answers possible, please tick as appropriate):	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
The graduates can...						
42.1. explain the etiology and pathogenesis of pulmonary and periradicular diseases.	①	②	③	④	⑤	⑥
42.2. diagnose pulp and periapical diseases.	①	②	③	④	⑤	⑥
42.3. carry out the prevention of pulp and periradicular diseases.	①	②	③	④	⑤	⑥
42.4. plan the endodontic treatment and carry it out.	①	②	③	④	⑤	⑥
42.5. in particular, use primary, but also secondary evidence collected and critically evaluated to make decisions on a medical/dental issue in everyday dental practice.	①	②	③	④	⑤	⑥
IX. Others						
	Do not agree at all	Do not agree	Un-decided	Agree	Strongly agree	Do not know
43. The teaching events are regularly evaluated for their success (please tick as appropriate).	①	②	③	④	⑤	⑥
44. I consider an exchange with other universities regarding the examination formats for the subject of endodontology to be useful (please tick as appropriate).	①	②	③	④	⑤	⑥
45. There is already an exchange with other universities in Germany (please tick as appropriate). Exchange with (please specify): _____	①	②	③	④	⑤	⑥
46. There is already an exchange with other international university locations (please tick as appropriate). Exchange with (please specify): _____	①	②	③	④	⑤	⑥
47. There is a special department/polyclinic for endodontology only (please tick as appropriate).	①	②	③	④	⑤	⑥
48. What are the endodontology material costs in the course per student in Euro (please specify)?	_____ € per Student					
49. Here you can enter in free text format, if necessary, what else you think is worth mentioning on the subject of student training in preclinical endodontology in the context of the Phantom Course in operative dentistry.	_____ _____ _____ _____					

Thank you for your cooperation

Figure 15: GEndoQ Version 5: Page 6/6.



In the current publication, the experts used the Delphi technique in different phases. The so-called Delphi technique is a systematic, multi-stage decision-making process with resonance, in which experts or groups of experts assess the questionnaire and provide feedback [48-51]. According to Buckley, et al., the Delphi technique is used when the topic under investigation is not suitable for precise analytical techniques but can benefit greatly from subjective judgements on a collective basis [52]. He also refers to the possibility of variations in a true Delphi study [53]. In general, the Delphi technique results in multiple iterations to create a consensus of opinions concerning a specific topic, using a controlled feedback process [47,54,55].

For the second and third Delphi rounds in the development of the GEndoQ, the experts were selected according to their professional competence [56]. Therefore, the second Delphi round consisted of one expert. This expert, among other qualifications, was a specialist in endodontology and an author of an already existing publication on the same topic [3]. According to Powell, et al. representation is assessed by the qualities of the expert panel rather than its numbers [57]. A similar approach was made for the third phase within the third Delphi round evaluating GEndoQ Version 3. Four panel experts were chosen: one specialist in endodontology, one graduate of a structured advanced training course with endodontology content and two participants of a master's degree programme in endodontology. From today's point of view, no standardized number of experts has been recommended for the Delphi technique. The literature has indicated that panel size has ranged from two experts to hundreds of experts [47,56,58,59].

Comparing studies that have evaluated preclinical and clinical education in endodontics, only Al Raisi, et al. [1] stated that they validated their questionnaire, which was a former paper-based survey that had been developed by Qualtrough and Dummer in 1997 [7]. Unfortunately, the validation process of the questionnaire was not part of the publication since no modification had to be made to the almost two-decades-old instrument. Therefore, it is unknown through which method the instrument used by Al Raisi, et al. was validated and why it was decided not to change anything. One might think that modifications would have been necessary because various guidelines for endodontic education were formulated after 1997 [9-11]. In addition, many changes have occurred with regard to endodontic equipment and materials in the last decades [14,15].

After generating GEndoQ Version 3, the instrument was complemented by 11 questions from the publication of Al Raisi, et al. Part of the questionnaire that Al Raisi, et al. used in their study was illustrated in their publication [1]. Their questionnaire was based on a former paper survey [7]. The expert group of the first phase could, therefore, approximate the questions to the questionnaire of Qualtrough and Dummer from 1997 [7]. This has made it more comparable to the studies mentioned above [2], [4], [5] since those studies were based on the same questionnaire. In addition, the questions and sub-items used by Al Raisi, et al. considering preclinical education in endodontics, completed GEndoQ Version 4 after the additional literature review [25,40].

In the last phase, GEndoQ Version 4 and the study was presented in a PowerPoint presentation to an expert group consisting of 15 dentist expert panellists with different qualifications (Table 2). After the presentation, the panellists were asked to provide their feedback on GEndoQ version 4 using the think-aloud method, and the verbal feedback was transcribed (Tables 13-14). This method asks the experts to verbalise their thinking during the thought process [60]. The think-aloud method is a scientific method that has been used in various disciplines [61]. For example, Zahiri Esfahani, et al. used the think-aloud method to measure effectiveness, learnability, errors and efficiency characteristics of a picture archiving and communication system [35]. In contrast, Adams, et al. explained the use of the think-aloud interview in order to create and validate a test [34]. Field et al. described that their questionnaire-which assessed the "pan-European practice in relation to curriculum content, teaching and learning strategies and assessment of preclinical dental skills"-had been originally piloted through think-aloud testing [62]. Therefore, the think-aloud method was an adequate method to gather feedback and make modifications to GEndoQ Version 4.

Transferability to national and international levels

The GEndoQ questions and sub-items were based on recent publications in order to make the results more comparable [1,2], [4,7]. It is important to see how and whether dental faculties have developed in the last years and whether they have adapted their endodontic curriculum to the contemporary guidelines of the ESE [9]. Standardisation and quality assurance in both endodontic training and general dentistry are necessary because since 1981, qualifications for various health professions, including dentistry, have been mutually recognised throughout the European Union in accordance with EU Directive 81/1057/EEC [63].

Limitations

Concerning the literature review in the first phase, it has to be mentioned that a single database was used for the search. Perhaps more matching publications could have been found if more databases had been used. However, this would have exceeded the time allowed for this project.

The GEndoQ is an instrument for evaluating preclinical education in endodontics for German-speaking dental faculties. The questions have been formulated in the German language. Therefore, the English version of the questionnaire would need to be validated after translating as well.

Finally, as the validation process is not yet complete, the final instrument should be field-tested. Therefore, in future research, the GEndoQ will be tested and applied in real dental faculty environments in order to refine further and eliminate any weaknesses that the questionnaire might have.

While this questionnaire has been generated as a paper-based survey, a web-based or mail survey would "offer anonymity and [...] afford respondents time to complete the questionnaire at their own pace", according to Cavana et al. [64]. Hence, implantation into an online survey software could be the next step.



Conclusion

GEndoQ is an instrument to assess preclinical education in endodontics, but the complete validity and reliability has not been assessed. It should be part of further research after field-testing this instrument. This study emphasises the significance of an instrument to assess preclinical education in endodontics. The goal is to make endodontic curricula comparable with each other on a national or international basis. The five phases show the effort of the conception of our questionnaire. In general, the methodology of such an instrument should not be underrated.

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