A Scoping Study of Undergraduate Dental Basic Research Education

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Abstract

Background: One of the essential ways to develop the potential for scientific research is through undergraduate dental basic research education. These abilities are essential for addressing challenges in basic science and advancing scholarly discoveries.

Objective: The current state of Undergraduate Dental Basic Research Education(UDBRE), including training results, educational goals, teaching program and material, assessment system, obstacles, and reflections, is intended to be summed up in this scoping study.

Methods: The peer-reviewed articles were authored in English from its start till January 29, 2021, the authors conducted a thorough literature search in PubMed, Web of Science, and the Education Resources Information Center (ERIC). By the inclusion and exclusion criteria, articles were examined and filtered. Subsequently, pertinent information was gathered and condensed from the included sources.

Results: The authors searched 646 articles for the study and selected 16 pieces. Fostering interest in basic research (n = 2, 12.5%) and the development of five main dental basic research competencies (n = 10, 62.5%) were two of the educational goals. Regarding the curriculum, the student research project guided by a mentor was the most popular assignment (n =11, 68.8%). After that came training in experimental skills (n =1, 6.3%), didactic courses (n =5, 31.3%), and a mix of these (n =3, 18.8%). However, there were differences between the evaluation technique and the training outcome. According to the evidence at hand, UDBRE yielded good learning outcomes. Insufficient funds (n = 5, 31.3%), a heavy workload (n = 2, 12.5%), a shortage of instructors (n = 3, 18.8%), inadequate research abilities, and insufficient research skills and knowledge (n=5, 31.3%) were among the obstacles.

Conclusion: Despite the attempts, UDBRE's immature condition was exposed by the variance among trials. A workable model for the UDBRE education system was proposed. In the meantime, further study is needed to maximize a strong UDBRE system with distinct learning objectives, attractive teaching materials, and persuasive evaluation procedures.

Keywords: *Dental education, basic research, education, systematic review.*

BACKGROUND

According to the director of the US Office of Scientific Development and Research, "basic research" is the growth of scientific knowledge and understanding of a topic or particular natural occurrence, primarily in natural science [1]. Since fundamental research is theoretical, concentrates on large concepts, and examines hypotheses, it is obvious that it is essential for the evolution of dentistry. Improvements in fundamental dental research have led to new ideas, theories, and principles that have broadened our basic understanding of dentistry and greatly enhanced dental diagnosis and treatment [1-4]. Put succinctly, fundamental dental research plays a significant role in the development of dentistry. Unfortunately, there is a scarcity of dental scientists in the workforce today, and dental talent is becoming less competitive [5-7]. Furthermore, there appears to have been a general downturn in the number of grant applications and grants given to scientists between 1999 and 2012 [8]. The majority of dentists are clinically skilled, but their research talents are rather weak [8]. The success of present dentistry education in developing talent for dental research is called into question by this tendency. Dental education should support and give dental students research opportunities as part of the optional dentistry curriculum, according to the Gies Report, which was published in 1926 [9]. Crucially "basic research" is the focus of "Undergraduate Dental Basic Research Education (UDBRE)," which is a crucial component and addition to undergraduate dentistry education [10, 11]. Aside from instruction about the laboratory (RCR, western blot, *etc.*), it also covers the fundamentals of research commonalities, such as understanding what is a problem and how to pose a scientific dispute [12]. The UDBRE [13] enhances undergraduate dentistry students' access to, acceptance of, and application of basic science in a variety of ways, including didactic lectures [13, 17], laboratory-based experimental courses [16], student research programs [13, 15, 18-23], *etc.*

The UDBRE technique is widely recognized as a crucial tool for developing creative dental researchers [23]. As a whole, UDBRE gives undergraduates the ability to do "basic research" [10, 14, 15, 17, 22, 23]. These abilities are essential for addressing challenges in basic science and advancing scholarly discoveries. Furthermore, UDBRE awakens scientific curiosity [15, 23], encourages active learning and critical thinking [10], and leads dental students to reflect on and identify fundamental

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science problems in their routine clinical practice—all of which enhance the field of dentistry. As a result of their training, which equips them with both clinical expertise and proficient "basic research" abilities, students become more qualified over time and demonstrate a greater desire to pursue academic careers in addition to teaching. This increases the number of college staff members and alleviates the brain drain that is currently occurring [13]. UDBRE has emerged as a new hotspot in dentistry education, backed by government support in both policy and funding [24].

Dental clinical education has developed into a well-developed training system that includes didactic courses at the beginning, followed by internships, general training, probation, and professional training to meet various learning objectives at various phases [25, 26]. However, UDBRE remains in its primary, infancy stage. Due to different restrictions, the majority of dental schools have either not launched student research programs or just offered insufficient programs [15]. The ambiguous nature of the current UDBRE education objectives might lead to incorrect decisions on how best to design certain curricula. Because of this, the existing curriculum forms are varied, and a UDBREE system that is optimized based on students' step-by-step learning process has not yet been developed [10, 11, 13-23, 27]. The evaluation techniques also differ. A well-established, optimal assessment mechanism is still lacking, which has further complicated curriculum design, and it is unclear which indicators can accurately capture the real impacts of UDBRE [13, 18, 19, 23]. The content, instructional methodology, and assessment techniques of the UDBRE vary depending on the location. Confusing issues include the training results and the difficulties in implementing them. Moreover, large-scale data gathering is necessary due to the UDBRE's embryonic development stage and the paucity of relevant research.

To establish the present state of the UDBRE programs in terms of aims, content and teaching style, assessment, results, impediments, and problems, a scoping study was carried out to methodically gather information in the field and identify any gaps in knowledge that could exist. UDBRE advanced education model establishment and scientific analysis are necessary.

MATERIALS AND METHODS

Following the PRISMA Guidelines [28], this scoping review was carried out. A thorough search of the PubMed, Web of Science, and Education Resources Information Center (ERIC) databases was carried out by three experienced researchers. Keywords such as "basic research," "undergraduate," and "dental education" were utilized.

Eligibility Criteria

The following criteria were used for inclusion: (1) All studies about undergraduate, graduate, and basic research in dentistry, regardless of curricular types; (2) English-language papers; and (3) articles published between the date of initiation and January 29, 2021.

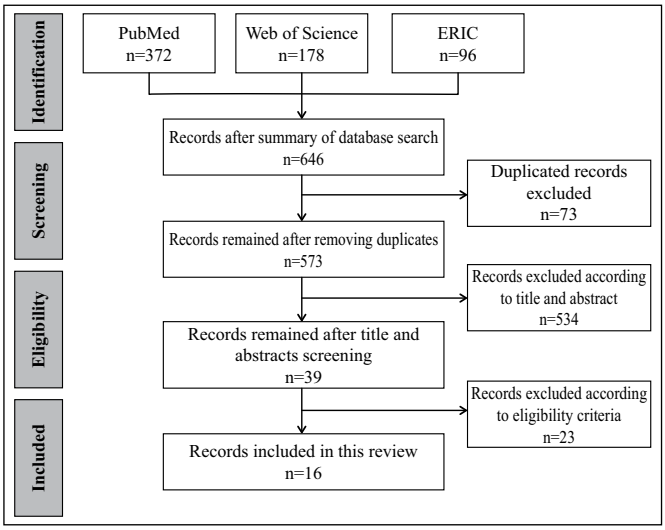

Fig. (1): The picture of undergraduate dental basic research education: a scoping review.

The following were the criteria for exclusion: Exclusion criteria were (1) studies not concentrating on "dental education," "undergraduate," or "basic research," (2) studies about "dental technology" or "dental hygiene," as these disciplines differed from "dentistry" in the curriculum, and (3) non-English authored papers.

Selection of Sources of Evidence

Once duplicate documents were eliminated, three reviewers independently assessed the publications based on their titles and abstracts by searching the databases of PubMed, Web of Science, and Education Resources Information Center (ERIC). Each piece was then subjected to two reviews, with each of the three reviewers going over the complete texts of two-thirds of the preserved articles. To resolve disagreements and come to a consensus on the final included articles, reviewers met throughout the whole process. A flow diagram (**Fig. 1**) provides an overview of the literature screening procedure.

Diagram of the PRISMA Process

The flow diagram for PRISMA illustrates the thorough procedure for finding information and screening literature.

Data Charting Process and Synthesis of Results

Basic information, educational objectives, instructional strategies, evaluation techniques and metrics, educational results, obstacles, and primary findings are among the details the writers took out of the included papers.

RESULTS AND DISCUSSION

Sixty-six publications were collected in total, of which sixteen were included based on the inclusion and exclusion criteria (**Fig. 1**). The featured papers were

Table 1: Summary of basic information, characteristics, and main conclusions of included literature.

Author, Year	Type of Articles	Type	Location Reported	Education Goals	Curriculum Forms	Teaching Program	Assessment Method	Assessment Indicators	Educational Outcome	Barriers	Main Conclusions
Divaris, 2008 [10]	Working group report	EGC, DP, IB	International	Overall competences	ECA	MgSRP	/	/	/	ECB, LFS	The committee gathered opinions from students on the academic setting and suggested using research projects to include research elements in the curriculum.
Rushton, 2008 [6]	Review	IB	Britain	/	/	/	/	/	/	TS	The evaluation brought attention to issues regarding academic staffing levels in the UK and dentistry.
Scott and de Vries, 2008 [13]	Quantitative research	DP, AS, SO	Canada	/	ECA	MgSRP	Oral presentation, thesis	Participant count, profession preference, and GPA	More awards were awarded, participants performed better academically, and they demonstrated greater recall and motivation to learn more.	/	The ultimate outcomes of laboratory research undertaken by undergraduate dental students in the BSc Dent program were papers and presentations. No specific courses are required; the scheduling is open.
Scott, 2008 [27]	Report	EGC, DP, AS, SO	Canada	SRW, PSI	ECA	MgSRP	Competitions	Research competition awards	Some students' exceptional efforts resulted in awards from scientific research contests.	/	The instances and experiences of notable BSc Dent program alumni are displayed in this article.
Grossman, 2009 [18]	Quantitative research	DP, AS, SO, IB	South Africa	/	CC, EC	TC, MgSRP	Questionnaire, competitions, presentations, thesis	Self-assessment	Most agreed they would do research in the future and 1/3 of students were satisfied with the research experience.	TS, LFS	South Africa incorporated lectures, experiments, written assignments, and presentations along with research components into the undergraduate dentistry curriculum. Students work independently or collaborate on ongoing projects.
Guven, 2011 [11]	Quantitative research	EGC, DP, AS, SO	Turkey	RD, SRW	ECA	MgSRP	Questionnaire	Self-assessment, number of funds, future career choices, GPA	With higher GPAs, greater retention rates, and an increase in funded projects, club members demonstrated increased skills in research design, experiment management, and scientific report writing.	/	193 research projects were presented by 409 different students in the Student Research Club. Students actively apply for research projects and give presentations lasting between ten and fifteen minutes to discuss their findings. Every department contributed financially. The group has been shown to help students' academic careers.
Franzén, 2013 [19]	Qualitative research	EGC, DP, AS	Sweden	BRPD, LR, SRW	CC	MgSRP	Thesis	/	/	/	Under the direction of the lecturers, undergraduate research projects in Swedish dentistry schools involve conducting experiments and composing articles. The Swedish dentistry curriculum system now includes this initiative.
Jeelani, 2014 [14]	Quantitative research	DP, AS, SO, IB	Pakistan	/	ECA	TC	Questionnaire	Self-assessment, attendance rate	Of the students, 68.7% had conducted research, 46.7% could write an article, and 59.2% could organize a study.	ECB, LFS	Third-year undergraduate dentistry students now take a research techniques course offered by the dental school. The majority of the students voiced complaints about their academic workload and lack of funding.

Author, Year	Type of Articles	Type	Location Reported	Education Goals	Curriculum Forms	Teaching Program	Assessment Method	Assessment Indicators	Educational Outcome	Barriers	Main Conclusions
Franzén, 2014 [20]	Qualitative research	EGC, DP, AS, SO	Sweden	SRW	CC,	MgSRP	Thesis	/	Students didn't reflect enough on how research and clinics are related, instead focusing on other subjects.	/	This study looked at the research methodology, topic selection, and students' understanding of the therapeutic relevance of the findings.
Ping, 2015 [15]	Quantitative research	DP, AS, SO, IB	China	/	ECA	TC, MgSRP	Questionnaire	Self-assessment	Particularly among older students, half of the non-participating pupils said they had little interest in scientific research.	SK, IG	Undergraduate Chinese dentistry students applied for student research programs or took part in faculty research programs.
Habib, 2018 [29]	Quantitative research	AS, SO, IB	Saudi Arabia	/	/	/	Questionnaire	Self-assessment	The attitudes of students toward scientific research were average.	ECB, TS, ISK	According to the poll, students confront obstacles including a heavy curriculum, a lack of enthusiasm for and understanding of science, and a paucity of faculty members.
Costa-Silva, 2018 [16]	Qualitative research	EGC, DP, AS, SO	Brazil	ET	CC	TC, EST	Questionnaire, oral presentations, test, and experiment report	Self-evaluation, experimental reports, and experiment lesson scores	Students who attended the experimental course had higher marks, and their experimental reports contained more details on the methodology and literature that supported it.	/	Both theoretical and experimental components are covered in the Cell Biology course. Students read up on dental biomaterials' biocompatibility assessment, conducted experiments, gathered information, and completed experimental reports.,

first released in phases starting in 2008. Each report described a different length of time for the educational initiative, which might have lasted up to 25 years.

1. Abbreviations for reported types: agreement on EGC Education objectives, DP AS Assessment system, SO, Description program study results, IB Barriers to implementation
2. Educational objectives abbreviations: BRPD Fundamental inquiry-finding skills, LR Ability to retrieve literature, RD Research design proficiency, ET methods of experimentation, SRW Ability to write scientific reports, PSI stimulating interest in science
3. Curriculum form acronyms include CC. Curriculum that is required, EC Curriculum elective, ECA Aside from the classroom
4. The instructional program's acronyms are TC theoretical instruction, EST MgSRP, experimental skills training mentor-led research projects for students.
5. Shorthand for obstacles: Central Bank Overwhelming course load, TS Insufficient tutors, IG inadequate instructions, LFS Insufficient financial backing, ISK Insufficient foundational knowledge and research abilities

Goals

The overarching objective of UDBRE, which is to "cultivate dental research talent with basic research capabilities and strong scientific interest," has given rise to specific aims [10, 11, 16, 17, 19, 20]. (**Table 1**). The suggested goal competencies are broken down into five categories based on the methodology of scientific research:

1. Basic aptitude for identifying research questions: It is recommended that students formulate novel scientific inquiries based on the challenges encountered in dental clinical practice [19, 21, 23]. Another significant factor is creativity [19].
2. Ability to retrieve literary works. It is expected for undergraduates to be able to retrieve literature, evaluate the question's development, critically analyze prior research, and formulate a hypothesis [17, 19, 21].
3. Research design proficiency. Students must be able to locate literature, exercise critical thought, use theoretical knowledge, define specific goals, develop procedures, integrate creative ideas, weigh ethical principles, do preliminary experiments, and formulate clear goals [11, 19, 23, 23]. Many student research programs also aim to enhance the competence to seek financial help (funding for research, scholarships, *etc.*) through written applications or oral presentations on research projects [11, 23].

4. Methodology experiments Students must be able to gather reliable data, analyze experimental results, and perform fundamental laboratory procedures [16, 23]. Students must be able to gather reliable data, analyze experimental results, and perform fundamental laboratory procedures [16, 23].

5. The capacity to write reports that are grounded in science. In addition to data analysis [23], graph plotting, and critical thinking [11, 19, 20, 21, 22, 27], it entails producing scientific publications (theses, papers, *etc.*). Academic communication is one more goal. After completing the UDBRE program, students should be able to exhibit their problem-solving and collaboration abilities [10], as well as increase their understanding of professional theory practice and science. Developing scientific curiosity is one of UDBRE's main goals, which is ignored by many criteria in addition to developing competencies [23, 27]. Although studies have differing objectives, certain UDBRE program goals have been suggested. The ideal goals of UDBRE are to foster scientific interest and the development of the five key competencies mentioned above. Dental schools can create targeted teaching strategies to meet their objectives by making the education focus clear.

Content and Mode of Instruction

Despite differences in the purported content and teaching method, UDBRE shares a common aspect. Table **1** presents the four primary categories that the authors identified: The four main kinds of student research projects are as follows: (1) student research projects directed by mentors [10, 11, 13, 15, 18-23, 27]; (2) experimental skills training [16, 23]; (3) theoretical courses or lectures [14-18]; and (4) mixtures of the aforementioned forms [15, 16, 18].

Theoretical Seminars on Dental Fundamental Research

A Brazilian dental school reported offering theoretical classes before the experiential course. Compared to individuals who attended a single laboratory class, participants in the final reports showed a higher knowledge of important science themes and more discussion [16]. Similar lessons have been reported in [14, 15, 17, 18]. It may be helpful to attend the theoretical courses on dentistry basic research before the experimental lessons to build scientific thinking, gain scientific knowledge, and contextualize basic research in dentistry courses.

The training materials for each study included several themes, such as scientific research procedures, literature retrieval, data analysis, paper writing, laboratory safety, and basic research thinking training [14, 17, 18]. Sadly, no documentation about the textbooks or reference materials utilized could be found. Furthermore, the particular teaching approaches have advantages of their own.

While some adopted innovative methods like problem- and project-based learning [16, 10], others stuck to traditional didactic curricula [18]. Despite its significance in methodical research knowledge illumination, theory courses in UDBRE have only been detailed in a small number of studies [14-18], the teaching methodology and substance of the didactic courses were confusing, necessitating further efforts to boost profitability.

The training material should also include the fundamentals of dental basic research, including the basic research method, academic standards, and key competencies.

Training in Experimental Skills in UDBRE

Experimental skills training is not a stand-alone educational project; it is often integrated into UDBRE alongside other programs [11, 13, 16, 18, 20, 23]. To learn the experiment that is a part of their projects, undergraduates most usually obtain mentoring [23]. Combining theoretical and experimental classes is an alternative [16]. The current strategy is feasible, but students may not receive systematic teaching and may only sometimes and irregularly acquire experimental abilities. It's time to transform this haphazard, unusual learning into a logical, carefully thought-out course.

Student Research Project Supervised by a Mentor

The majority of the included publications [10, 11, 13, 15, 18, 19, 20] involve a student conducting research under the guidance of a mentor. Dental students work under mentorship on various projects while they do research. When starting their scientific research projects, undergraduates usually start by posing scientific questions regarding dentistry and then do preliminary work (literature study, protocol design, *etc.*) [21-25]. After that, they apply for funding for research, scholarships, and student research projects. After their application is accepted, students are required to conduct lab work, evaluate information, exercise critical thought, write articles or reports, and, with the assistance of their tutors, finish their student research project [11, 13, 15, 18, 19, 22, 23]. Regarding specialties, the most sought-after areas in clinical departments have been orthodontics, oral and maxillofacial surgery, periodontology, and restorative dentistry. Microbiology, biochemistry, and pathology are the most alluring disciplines of fundamental science [11]. While multidisciplinary mentorship is feasible, the study subject needs to be related to dentistry because of its special qualities. However because there were not enough dental supervisors, many institutions were unable to guide student research projects popular. Given the commonality in scientific study, interdisciplinary research is allowed in this context.

Summary

Dentistry schools are now aware of the significance of UDBRE, even though it has not yet received general recognition, as the results demonstrate. A few academic institutions have tried and been somewhat successful

at first. There are several recognized forms of UDBRE, including theoretical classes, student research projects with mentors, and training in experimental techniques.

The current clinical training paradigm is not structured similarly to dental basic research education. These kinds of integrated projects are uncommon [15, 16, 18]. Most of them are limited to a maximum of two years [18, 23]. There aren't any long-term training programs in place right now. Taking everything into account, the next goal of UDBRE is to create a modern and scientific education system. The many types of education are not the same. Additionally, it's uncertain whether tactics are better. To optimize learning results, further study is required to ascertain the most effective way to integrate different teaching forms organically. The differing emphasis on teaching approaches may also be a result of differences in policies, procedures, and educational contexts [19].

ASSESSMENT

Assessment Methods

Table **1** relates the techniques of evaluation to the modes of education. Teachers used the following for theoretical courses: (1) conceptual test [16, 17]: students in a Brazilian dental school are required to take an exam covering the fundamentals of dental biomaterial after their classes [16]; (2) article presentation [16]: students are required to conduct a literature search on the assigned topic and present the articles, along with their opinions on search techniques, result translation, and critical reading abilities, in a seminar [16]; and (3) questionnaire [14-19]. The following were the strategies used for evaluating experimental skills training: (3) questionnaire [16], (2) experimental report [16], and (1) exam [16]. The evaluation was typically scheduled for the end of the research project and included one of the following: (1) Oral presentations or meetings [11, 13, 18]. Students presented their study for 10 to 15 minutes during Istanbul University's annual meetings of the Student Study Club (SRC). To stimulate academic discourse, each participant was given a booklet containing the abstracts of all the projects [11]; (2) competitions [18, 27] (South African undergraduates [18] won prizes in the Colgate Undergraduate Competition based on the caliber of their projects and the insights they demonstrated in the questioning section); (3) surveys [11, 15, 18, 21, 22, 23]; and (4) a combination of the previously mentioned methods [13, 18, 22, 23].

Assessment Indicators

Specific indicators were selected based on the feasibility of indicator collection and assessment methods to fulfill the learning objectives (1) The capacity to identify problems can be assessed independently [11, 14, 22, 23] or in combination with other research skills. One way to assess a project's design and problem-solving abilities is to look at how many supported projects it has [11, 23]. (2) One can evaluate their ability to retrieve literature by self-evaluating [11, 17, 21]. (3) Research design competency may be shown by the amount of funds allocated to applied research [11, 23] and by self-evaluation [11]. (4) An experimenter's competency may be determined by examining their experimental reports [16], experiment course scores [16, 23], and self-evaluation [11, 14, 23]. (5) The number of published articles [23], research competition wins [27], and self-evaluation [11, 14] are a few indicators that may be used to determine someone's suitability for writing scientific reports. (6) Useful information, such as the number of participants and the attendance rate, may be utilized to (a) determine how enthusiastic students are about scientific research [13, 23]. (b) long-term effects, which include future career choices and skill maintenance [11, 13, 18, 23, 29].

Summary

Studies are conducted using several assessment methods. Sadly, there is a problem with the current evaluation since it is not methodical and is not clear. A failure to assess the overall objectives is indicated by ignorance of one or more of the educational objectives. Moreover, mid-term evaluations were often not conducted in the included research. This makes evaluating overall achievement and comparing the effectiveness of different studies and efforts difficult. To oversee the outcomes of UDBRE and provide prompt modifications and extended monitoring, a full and all-encompassing assessment framework based on educational objectives has to be put into place.

Outcomes

Extant literature reveals the educational accomplishments of UDBRE, encompassing the cultivation of target research abilities and the advancement of scientific interest.

1. Shorthand: GPA VAS and grade point average Analog scale in visual form
2. The aVAS score indicates the level of contentment. It has a range of 0 to 100.

Growth of the Intended Research Skills

The ability to identify problems: 45.2% of students in Nigeria choose their course of study, according to research [22]. Participants highly agreed [11] that the program improved their experience searching archives and retrieving material. Nieminen also discovered that more than 80% of undergraduates believed they had good or appropriate literature retrieval skills following mandatory information retrieval training [17]. (3) Research design capability: Yu's investigation revealed that during the preceding 11 years, funded research projects have increased, from 1-2 annually (2007-2011) to 7 annually (2017) [23]. According to Guven's research, funding is also trending upward, and participants said the study improved their ability to do independent research and organize studies [11]. Fourth, the capacity to conduct experiments successfully was demonstrated

Table 2: Summary of dental basic research education outcomes of included literature.

Publication	Dental Basic Research Education Outcome						
	Basic Research Question Discovery Ability	Literature Retrieval Ability	Research Design Capability	Experimental Techniques	Scientific Report Writing Ability	Promoting Scientific Interest	Other Aspects
Scott, 2008 [27]	/	/	/	/	/	1. As compared to 1 in 1980, there were 11 in 2005. 2. Of the graduates, 14% remained as faculty members and 31.5% pursued careers in higher education.	The mean GPA for individuals who took part and those who did not was 3.14 and 3.42, respectively.
Grossman, 2009 [18]	/	/	/	/	/	1. The research experience was deemed satisfactory by 44% of those surveyed. 2. 92% of respondents felt research was crucial.	In three out of four surveyed schools, over half of the students were unlikely to do research in the future.
Guven, 2011 [11]	The funded projects number increased from 16 (1993) to 25 (2008).	1. The great majority of club participants concurred that they improved their book retrieval skills. 2. They both acknowledged talking about how science was advancing.	1. There were 25 funded projects in 2008, up from 16 in 1993.	All of the club members said they had worked in laboratories.	Everyone in the club agreed that their capacity for data analysis and presentation had improved.	1. Every club member said they would be open to pursuing graduate studies. 2. During the five years prior, Istanbul University served as the educational destination for seventy-four members of the SRC.	1. Following their membership in the club, the student's GPA increased (3.22 ± 0.33 V.S. 2.90 ± 0.36). 2. With a GPA of 3.05 ± 0.44 v.S. 2.55 ± 0.42, members scored higher than non-members.
Jeelani, 2014 [14]	59.2% of the students studying medicine and dentistry could plan and execute a study.	/	/	/	1. Of the students, 46.7% could write an essay. 2. Of the students, 17.7% knew what the publication process entailed.	Out of the medical and dentistry students polled, 68.7% had taken part in the study.	/
Ping, 2015 [15]	/	/	/	/	/	1. Of those asked, 54% of dentistry students said they had taken part in the study. 2. While 73% of students said they were interested in research, senior students were less so.	Half of the non-participants admitted that they had no interest in scientific research.
Nieminen, 2020 [17]	/	80% of students were able to retrieve texts with a reasonable or high level of skill.	/	/	/	/	/

Publication	Dental Basic Research Education Outcome					
	Basic Research Question Discovery Ability	Literature Retrieval Ability	Research Design Capability	Experimental Techniques	Scientific Report Writing Ability	Promoting Scientific Interest	Other Aspects
Otuyemi, 2020 [22]	While 20.4% of respondents said their supervisors modified the research project topic, 45.2% of respondents selected it on their own.	/	/	/	/	The majority of students said they were happy with the topic they had picked. Of the students, 26.6% felt more comfortable doing research after the study project.	/
Yu, 2020 [23]	1. Every year, two fundamental research projects were carried out from 2007 to 2017.	/	There were 3.33 (2017) instead of 6.25 (2007) students for every funded project.	Students strongly agreed they obtained experimental skills (4.00 ± 0.80).	The participants wrote more papers (1.62 ± 1.41 V.S. 1.31 ± 0.75) during the post-graduate phase (P = 0.025).	. From 36.84 to 90%, more people attended the research program.	Participants' GPAs were higher than non-participants' (3.41 ± 0.02 V.S. 3.21 ± 0.04, P < 0.001).
Scott and de Vries, 2008 [13]	/	/	/	/	In research contests, a few students took home awards.	/	/
Kyaw, 2018 [21]	/	51.2% of students said they could evaluate literature to some extent.	/	/	/	83.3% of medical and dental students polled had moderate views toward scientific research.	/

by Brazilian research, which found that PBL participants' average course scores were somewhat higher (7.8 ± 1.2 and 7.2 ± 1.6, respectively) than those of students who completed theoretical courses only. The experimental reports from PBL participants had significantly more methods and support from scientific literature [16]. According to student opinions, UDBRE made it easier to gain experimental methods for Yu and Guven's work [11, 23] (**Table 2**).

Students' Interest in Scientific Research

UDBRE has both short-term and long-term effects on students' interest in scientific research. Scott discovered that the number of UDBRE participants increased from one in 1980 to eleven in 2005 just after the research [13]. Yu's study found that the UDBRE attendance rate increased from 36.84 to 90% [23] and that student satisfaction was good (VAS score = 72.36 ± 20.37). In a poll conducted in South Africa, 92% of students stated they knew the importance of basic research, and 34% indicated they would be delighted to participate in research projects once more [18]. Several dental schools in Sweden have satisfaction levels ranging from 26 to 50 percent [19]. Based on three studies, 75% of students who had conducted research did not feel more confident about their research abilities, and they had a negative attitude toward it [21, 22, 29]. Impact throughout time: SRC members have expressed a significant desire to earn a Ph.D. Furthermore, 74 SRC members finished their degrees at Istanbul University between 2005 and 2009, and 31 percent of the teaching assistants who work there now were SRC members at one point [11]. In contrast, 17% of the University of Manitoba UDBRE graduates continued postgraduate courses, and 31.5 percent of those graduates went on to earn advanced degrees [13]. However, Grossman found that at three of the four universities he looked at, over half of the students said they were not interested in doing research in the future [18] as seen in Table **2**.

Summary

According to available data, the UDBRE has achieved several educational goals. UDBRE participants demonstrated positive progress in their focused scientific research skills. A greater propensity to pursue postgraduate education and academic jobs was shown by undergraduates, who also showed a high level of satisfaction with UDBRE and interest in scientific research. Only a small percentage of students had unfavorable views [15, 18], which might lead to challenges (difficulty with clinical learning, experiment failure, inadequate direction, *etc.*). This prompts educators to be concerned about obstacles to UDBRE and to remind them to provide timely advice and support to strengthen the UDBRE program.

Challenges

Aside from the subjective design reasons for the current UDBRE deficiency, objective barriers such as

the overburdensome curriculum [10, 14, 29], lack of academic faculty and mentorship [6, 15, 18, 23, 29], inadequate financial support [10, 14, 18, 21, 23], and deficiencies in research methodology and background knowledge [15, 17, 21, 23, 29] cannot be disregarded. Several papers [10, 14, 15, 18, 23] offer reflections and potential remedies.

Excessive Curriculum Burden?

UDBRE may make the demanding dentistry clinical course load worse. 91.9% of undergraduates in Pakistan's medical and dentistry schools voiced complaints about the demanding coursework [14]. In South Africa (18%) and China (12%), students acknowledged that their academic and research schedules conflicted. Because dental clinical curricula are time- and energy-consuming, several studies have found that students are less inclined to take initiative and show interest in scientific research [10, 29]. Only 34% of respondents to a study said they would attend research, even if it was optional [18]. It was shown that UDBRE had a beneficial influence on the dental clinical study rather than a negative one in follow-up studies on grade point average (GPA) [11, 13, 23] and scholarship [13, 23]. Participants in the UDBRE program in Canada had baseline GPAs that were comparable to those of non-participants, but by graduation, their total GPAs increased considerably (3.42 ± 0.41 and 3.14 ± 0.44, respectively) [13]. Comparative GPA comparison results were similar for Yu (3.41 ± 0.02 and 3.21 ± 0.04, respectively, $P < .001$) and Guven (3.05 ± 0.44 and 2.55 ± 0.42, respectively, $P < .001$) [11, 23] as seen in Table **2**.

These results show that children can tolerate this level of pressure and that it won't affect their academic achievement. Education professionals should thus offer psychological counseling and optimize curriculum design to reduce stress and control students' time consumption. This allows educational institutions to do the following: integrate the UDBRE into the undergraduate curriculum, condense it into a more manageable undergraduate curriculum structure, simplify and optimize all already provided undergraduate courses, and include recurrent lessons. Defining primary and intermediate educational goals flexibly, merging core and extracurricular curricula to create flexible teaching methodologies, and exposing students to UDBRE early on are some alternatives to avoid scheduling issues.

Lack of Tutors and Inadequate Direction?

Most of the literature on UDBRE [6, 18, 29] addresses the shortage of academic faculty. In the United States, there were 250 available positions as professors at dental schools in 2004 and 2005 [30]. The UK [6] and South Africa [18] are two other countries where this is valid.

Additionally, several studies demonstrate that teacher mentorship was insufficient [15, 18, 23]. A study by Grossman [18] found that more than 25% of students felt their supervisors weren't giving them adequate help. When most junior associate professors started their jobs, they lacked these educational skills [23]. This might be a serious issue. Students' research experiences were severely harmed by supervisors' inadequate mentoring [31].

A potential solution to address the deficit is to increase the pay of research professors. Other tactics are as follows: (2) increasing the size of the faculty troop by employing young doctors, postdoctoral fellows, and even academic tutors from other fields; (3) integrating student projects into instructors' research areas to promote more in-depth and professional tutor guidance and address understaffed tutor situations with undergraduate assistance; and (4) offering mentor training courses to junior tutors.

Lack of Financial Support?

Funds and financial assistance were identified as being crucial for undergraduate research initiatives by both teachers and students [23]. However, in Pakistan, 86.9% and 92.6% of dentistry and medical students, respectively, reported financial difficulties [14]. The UDBRE cannot function sustainably without the financial assistance and academic atmosphere that the government, colleges, and dentistry schools provide [23].

Inadequate Prior Knowledge and Fundamental Research Abilities?

Insufficient foundational knowledge and research skills resulted in difficulty initiating and decreased initiative [15, 29]. First-year undergraduates in particular spend more time learning about the background information and scientific research techniques [15]. Even fourth-year dentistry students showed inadequate information retrieval skills and a lack of research expertise [17].

Even though interdisciplinary research is a relatively new trend in fundamental research, the majority of students only have a general understanding of a certain field. From 0 (2007) to a maximum of 55.56% (2015), Yu documented a rising percentage of multifunctional initiatives. Furthermore, the interviewers, comprising 8.22% of the sample, expressed awareness that cross-departmental training was important to accomplish the study project, as did the dental professors and students [23]. To master fundamental research skills before starting a research project, undergraduates should take theoretical and experimental courses. However, teaching is challenging, and incorporating fundamental research experiment training into the curriculum system might be an answer. For instance, dental microbiology courses might incorporate experimentation instruction about microbes. Opportunities for additional study might also be provided through supplemental education.

The authors suggested a new UDBRE component—a rotation in several research departments—as a reaction to the dearth of prior knowledge and the trend of

interdisciplinary research. This would allow students to hone their fundamental research abilities and acquire background information in a variety of research areas.

Summary

There are still several challenges and related fixes in the UDBRE implementation. The UDBRE system must be improved to facilitate students' research project initiation and prevent obstacles and disinterest. Additionally, actions are required to increase teachers' accountability and enthusiasm.

Implications for Undergraduate Dental Basic Research Education

While UDBRE is still relatively unknown globally, several nations have investigated its formation, and the number of UDBRE initiatives has lately expanded. Several insightful conclusions were drawn from the methodical examination of these beneficial investigations and encounters as seen in Table **2**.

Implications for Dentistry School Objectives

Compound talent with both clinical abilities and fundamental research capacity is desperately needed. Evidence-based medicine and critical thinking are useful even for practicing dentists. Research question formulation, literature retrieval, research design, and report writing are examples of typical research essentials taught in UDBRE that might help dentists in their future clinical employment. It is crucial for education that students be equipped with both basic and comprehensive scientific research skills for them to create evidence-based opinions and engage in critical thinking. The phrase "cultivating dental research talent with basic research capabilities and strong scientific interests" sums up these particular objectives. In light of this, encouraging scientific curiosity and developing the five main research skills—identifying fundamental research questions, finding relevant literature, designing experiments, conducting research, and producing scientific reports—might be the perfect goals of UDBRE.

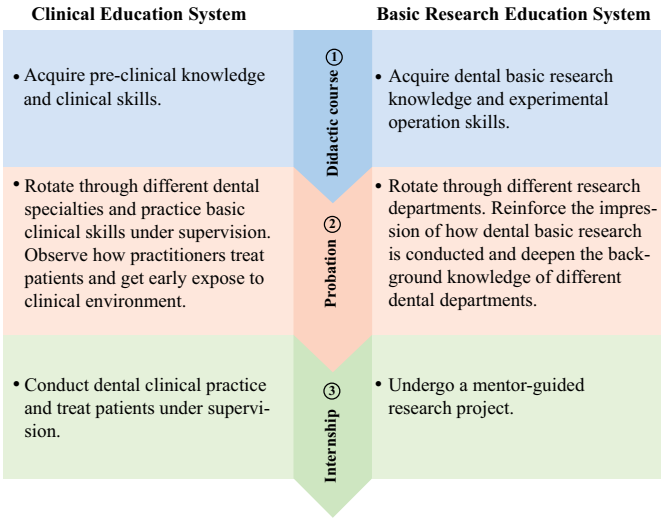

Fig. (2): The three-phase UDBRE approach that imitates the clinical training method for dentists. Given that the dentistry clinical training system is relatively developed and the UDBRE education model is still being explored, we have made an effort to organize and categorize the program's training contents into three stages that correspond to the current clinical training system: didactic course, probation, and internship.

Consequences for the Dental Curriculum

The dental basic research education is a more skill-based course and has the potential to improve workload and clinical study findings, there may be some concerns. Students frequently had higher GPAs in clinically related courses, according to evaluation findings and my experience teaching this course; this suggests that UDBRE had a positive, rather than a detrimental, impact on dental clinical studies. This offers additional proof of the system's necessity and feasibility when integrated vertically. Dental basic research education is a deliberate endeavor, and early, frequent, and prolonged usage of the UDBRE system is permissible. It can also be carried out concurrently and vertically connected to clinical education [32]. Classifying and organizing the UDBRE training materials into three levels is an attempt made in this study to mirror the developed dental clinical training system (**Figs. 2** and **3**).To start the research practice and get beyond the obstacle of having insufficient

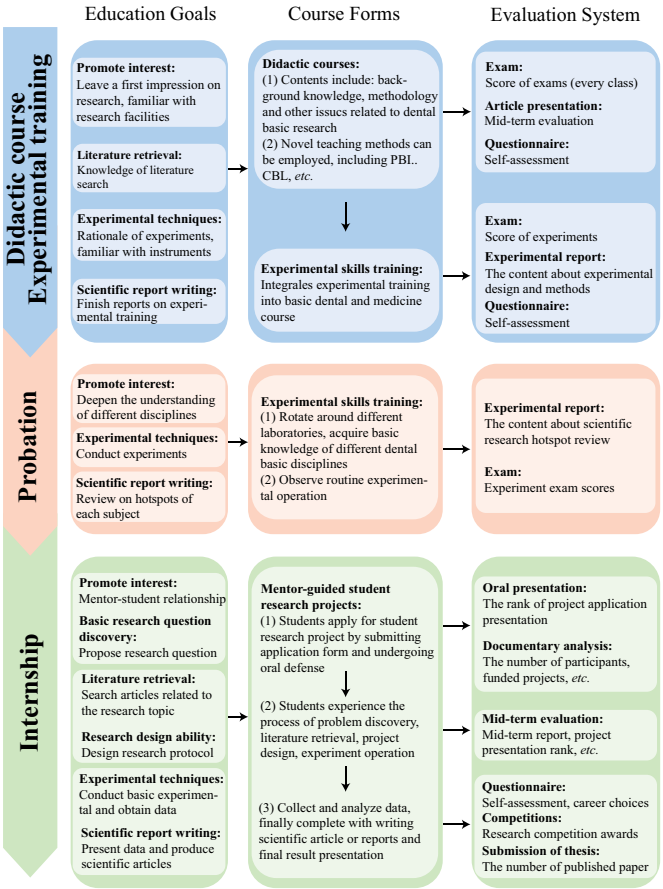

Fig. (3): Comprehensive details on a three-stage UDBRE system example. The course styles, assessment procedures, and expected learning objectives of the undergraduate dental basic research education (UDBRE) program are all thoroughly described along the timeline.

fundamental research abilities, students must first grasp the essential foundational research theory and skills (**Fig. 3**).

CONCLUSION

The inconsistent results across studies revealed the immaturity of UDBRE despite efforts. A feasible concept for a UDBRE education program was put forth. Maximizing a robust UDBRE system with compelling assessment instruments, clear learning objectives, and well-designed instructional formats would require more research.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORS' CONTRIBUTION

GMS: Abstract, Methodology, Results

MS: Introduction, literature search, discussion, conclusion, references.

REFERENCES

1. Bush V. Science: The Endless Frontier A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development. United States Government Printing Office. Available from: https://www.nsf.gov/about/history/nsf50/vbush1945_content.jsp
2. Slavkin HC. The impact of research on the future of dental education: How research and innovation shape dental education and the dental profession. J Dent Educ 2017; 81(9): eS108-27. DOI: https://doi.org/10.3109/0142159X.2014.970998
3. Selwitz RH, Ismail AI, Pitts NB. Dental caries. Lancet 2007; 369(9555): 51-9. DOI: https://doi.org/10.1016/S0140-6736(07)60031-2
4. Sandy JR, Farndale RW, Meikle MC. Recent advances in understanding mechanically induced bone remodeling and their relevance to orthodontic theory and practice. Am J Orthod Dentofac Orthop 1993; 103(3): 212-22. DOI: https://doi.org/10.1016/0889-5406(93)70002-6
5. Iacopino AM, Lynch DP, Taft T. Preserving the pipeline: A model dental curriculum for research non-intensive institutions. J Dent Educ 2004; 68(1): 44-9.
6. Rushton VE, Horner K. Academic dentistry. J Dent 2008; 36(7): 472-80. DOI: https://doi.org/10.1016/j.jdent.2008.04.003
7. Istrate EC, Slapar FJ, Mallarapu M, Stewart DCL, West KP. Dentists of tomorrow 2020: An analysis of the results of the 2020 ADEA survey of U.S. dental school seniors. J Dent Educ 2021; 85(3): 427-40. DOI: https://doi.org/10.1002/jdd.12568
8. D'Souza RN, Colombo JS, Embree MC, Myers JM, DeRouen TA. Our essential and endangered dentist-scientist workforce. JDR Clin Trans Res 2017; 2(1): 10-22. DOI: https://doi.org/10.1177/2380084416673346
9. Gies WJ. Dental education in the United States and Canada. A report to the Carnegie Foundation for the advancement of teaching. 1926. J Am Coll Dent 2012; 79(2): 32-49.
10. Divaris K, Barlow PJ, Chendea SA, Cheong WS, Dounis A, Dragan IF, *et al.* The academic environment: the students' perspective. Eur J Dent Educ 2008; 12: 120-30. DOI: https://doi.org/10.1111/j.1600-0579.2007.00494.x
11. Guven Y, Uysal O. The importance of student research projects in dental education. Eur J Dent Educ 2011; 15(2): 90-7. DOI: https://doi.org/10.1111/j.1600-0579.2010.00645.x
12. Nalliah RP, Lee MK, Da Silva JD, Allareddy V. Impact of a research requirement in a dental school curriculum. J Dent Educ 2014; 78(10): 1364-71.
13. Scott JE, de Vries J, Iacopino AM. 25-year analysis of a dental undergraduate research training program (BSc dent) at the University of Manitoba Faculty of dentistry. J Dent Res 2008; 87(12): 1085-8. DOI: https://doi.org/10.1177/154405910808701209
14. Jeelani W, Aslam SM, Elahi A. Current trends in undergraduate medical and dental research: A picture from Pakistan. J Ayub Med Coll Abbottabad 2014; 26(2): 162-6.
15. Ping W. Dental undergraduate students' participation in research in China: Current state and directions. Eur J Dent Educ 2015; 19(3): 177-84. DOI: https://doi.org/10.1111/eje.12119
16. Costa-Silva D, Cortes JA, Bachinski RF, Spiegel CN, Alves GG. Teaching cell biology to dental students with a project-based learning approach. J Dent Educ 2018; 82(3): 322-31. DOI: https://doi.org/10.21815/JDE.018.032
17. Nieminen P, Uma E, Pal S, Laitala ML, Lappalainen OP, Varghese E. Information retrieval and awareness about evidence-based dentistry among dental undergraduate students-a comparative study between students from Malaysia and Finland. Dent J 2020; 8(3): 103. DOI: https://doi.org/10.3390/dj8030103
18. Grossman ES, Naidoo S. Final-year South African dental student attitudes toward a research component in the curriculum. J Dent Educ 2009; 73(11): 1306-12.
19. Franzén C, Brown G. Undergraduate degree projects in the Swedish dental schools: A documentary analysis. Eur J Dent Educ 2013; 17(2): 122-6. DOI: https://doi.org/10.1111/eje.12022
20. Franzen C. The undergraduate degree project - preparing dental students for professional work and postgraduate studies? Eur J Dent Educ 2014; 18(4): 207-13. DOI: https://doi.org/10.1111/eje.12088
21. Kyaw Soe HH, Than NN, Lwin H, Nu Htay MNN, Phyu KL, Abas AL. Knowledge, attitudes, and barriers toward research: The perspectives of undergraduate medical and dental students. J Educ Health Promot 2018; 7: 23. DOI: https://doi.org/10.4103/jehp.jehp_61_17
22. Otuyemi OD, Olaniyi EA. A 5-year retrospective evaluation of undergraduate dental research projects in a Nigerian University: Graduates' perceptions of their learning experiences. Eur J Den Educ 2020; 24(2): 292-300. DOI: https://doi.org/10.1111/eje.12497
23. Yu W, Sun Y, Miao M, Li L, Zhang Y, Zhang L, *et al.* Eleven-year experience implementing a dental undergraduate research program in a prestigious dental school in China: lessons learned and future prospects. Eur J Den Educ 2021; 25(2): 246-60. DOI: https://doi.org/10.1111/eje.12598
24. Administrative measures for the National Innovation and Entrepreneurship Training Program for College Students. Ministry of Education of the People's Republic of China. Available from: https://www.moe.gov.cn/jyb_xwfb/gzdt_gzdt/s5987/201907/t20190731_393103.html (Published 2019. Assessed 4 Apr 2021)
25. Wu ZY, Zhang ZY, Jiang XQ, Guo L. Comparison of dental education and professional development between mainland China

and North America. Eur J Den Educ 2010; 14(2): 106-12. DOI: https://doi.org/10.1111/j.1600-0579.2009.00599.x

26. Huang C, Bian Z, Tai B, Fan M, Kwan CY. Dental education in Wuhan, China: Challenges and changes. J Dent Educ 2007; 71(2): 304-11.
27. Scott JE. Undergraduate experience in dental research: The Bachelor of Science (dentistry) program at the University of Manitoba. J Can Dent Assoc 2008; 74(10): 883-5.
28. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, *et al*. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med 2018; 169(7): 467-73. DOI: https://doi.org/10.7326/M18-0850
29. Habib SR, AlOtaibi SS, Abdullatif FA, AlAhmad IM. Knowledge and attitude of undergraduate dental students towards research. J Ayub Med Coll Abbottabad 2018; 30(3): 443-8.
30. Chmar JE, Weaver RG, Valachovic RW. Dental school vacant budgeted faculty positions: academic year 2004-05. J Dent Educ 2006; 70(2): 188-98.
31. Chang Y, Ramnanan CJ. A review of literature on medical students and scholarly research: experiences, attitudes, and outcomes. Acad Med 2015; 90(8): 1162-73. DOI: https://doi.org/10.1097/ACM.0000000000000702
32. Brauer DG, Ferguson KJ. The integrated curriculum in medical educatioSn: AMEE guide no. 96. Med Teach 2015; 37(4): 312-22. DOI: https://doi.org/10.3109/0142159X.2014.970998