

Impact of Digital Dentistry Technologies on the Educational Motivation of Dental Students Experiencing Stress on the Background of Ongoing War in Ukraine

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Abstract

Objective of the study was to assess the impact of implementing digital dental technologies into the study process on the educational motivation of dental students experiencing stressed environment on the background of ongoing war in Ukraine.

Research was held in the form of online questionnaire-based survey among academical groups of students of 2nd and 3rd years of study during their education within the Department of Restorative Dentistry. Evaluation of stress level observed among dental students was provided based on original Depression Anxiety Stress Scale – Short Form (DASS-21), evaluation of students educational motivation was held based on adapted version of Science Motivation Questionnaire II (SMQ-II), while also additional questionnaire was designed to assess students' subjective grading regarding possible connections between the educational motivation and related factors. Implementation of digital dental technologies within the study process and students' possibility to interact with such helped to increase students' intrinsic motivation, while also career motivation to the levels of $14,12 \pm 1,79$ and $13,94 \pm 2,05$ correspondingly, which were statistically higher compared to the situation of providing dental education in conventional mode ($p < 0.05$). Willingness to get higher grade in the class demonstrated the lowest but still statistically significant correlation with educational motivation ($r=0.35$, $p < 0.05$).

Obtained results should be interpreted with the caution, since students educational motivation was registered at some specific time point corresponding to cross-sectional study design, while it may change and vary in time considering students familiarization with digital dentistry instruments and impact of other personal, social or environmental factors.

Students accessibility to the digital dental technologies, like intraoral scanning, cast model scanning, 3D printing and milling both at the preclinical and clinical courses of studying enhance students' motivation toward education by helping to overlook and analyze aspects related with specific clinical aspects, while also forming conditions where some theoretical study topics could be 3D visualized, which in turn improves students' clinical thinking patterns.

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Introduction

Digital dentistry advances represent highly variable spectrum of instruments that can be effectively adapted and implemented for the educational purposes.^{1, 2, 3} Already several

educational approaches with the included digital dentistry components have been approbated, and most of them demonstrated positive feedbacks and outcomes.^{2, 3, 4, 5} It should be pointed out that COVID-19 pandemic restrictions even though affected dental education in negative manner all around the world, but forced and stimulated development of new educational online techniques involving different digital dentistry measures and features being shared among dental student through various platforms, software and simulations.⁶ Effect of dental

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education digitalization was so prominent and effective, that even after having chance to return to the fully offline education mode, universities continue to develop more advanced digital dentistry-based educational technologies, like such associated with virtual reality's or augmented reality's features.^{7, 8, 9, 10}

Also previously it has been shown that usage of specifically developed digital dental patient study concept (based on the complex implementation of digital dentistry advances into the education process) may potentially improve quality of dental education during the conditions of war or sanitary restrictions, when students had only limited access to the clinical practice.¹⁰ Such outcome has approved already established thesis that digital dental technologies may help to retain high quality standard of dental education during online study mode, nevertheless nowadays number of universities exploring mixed educational modes combining both online and offline study components.^{1, 2, 3, 4, 6} However, it is still unclear how the impact of digital dentistry educational instruments have changed through moving from just online to mixed mode of education. Moreover, even though it has been established that digital dentistry advances improve quality of dental education assessed by the students, but there is still a gap in understanding what specific mechanisms are responsible for such effect at the student's personal level, while also at the level of educational system in general. Also it would be beneficial to objectify how impact of digital dentistry instruments implemented within study process interact with the influence of other different educational, social and environmental factors.

Huge social changes associated with mass disasters, military conflicts or war have their negative notional effects on the educational environment, affecting not just education process flow, but well-being of students, their safety and emotional status.^{11, 12, 13} Educational motivation of students has been deprived in the situation when education environment safety and comfort could not be guaranteed, while increase of emotional stress considering the disaster- or war-related background could not be compensated without additional effort, which in sum decrease chances for effective educational process to take place. Considering the impact of stress factor caused by ongoing war in Ukraine it is important to establish

the role of digital dental technologies in educational motivation of dental students, which are experiencing mixed modes of education.

Objective: To assess the impact of implementing digital dental technologies into the study process on the educational motivation of dental students experiencing stressed environment on the background of ongoing war in Ukraine.

Materials and methods

Study design

Research was held in the form of online questionnaire-based survey among academical groups of students of 2nd and 3rd years of study at the Faculty of Dentistry (Uzhhorod National University, Ukraine) to clarify the effect of implementing digital dental technologies on the students' educational motivation. Design of the study was formulated in the manner to correspond to the consensus-based checklist for the reporting of survey studies.¹⁴ Research was held during the education of students within the Department of Restorative Dentistry (Faculty of Dentistry, Uzhhorod National University, Ukraine).

The survey was held in the stage-by-stage approach stratified in time periods for two parts. First part was held in September 2023 and was realized in the form of online questionnaire, which included two components: evaluation of stress level among students based on the Depression Anxiety Stress Scale – Short Form (DASS-21),^{15, 16} and evaluation of students' educational motivation based on adapted version of Science Motivation Questionnaire II (SMQ-II).¹⁷ During period of September 2023 dental education among academic groups of 2nd and 3rd course at the Department of Restorative Dentistry was held in conventional manner.

In October 2023 dental education within the above-mentioned department was held in mixed mode combining conventional manner with the elements of previously developed Digital Dental Patient Study Concept.¹⁰

Second part of survey was held in November 2023 with repeated evaluation of both stress level and students' educational motivation due to the previously mentioned questionnaires, while also additional evaluation was provided to obtain students subjective grading regarding potential links which may have place between the educational motivation and factors of impact.

First and second parts of survey, while also implementation of Digital Dental Patient Study Concept were held among the same two academic groups of students from 2nd year of study and among two academic groups of students from 3rd year of study, which together formed 96 students (study cohort).

Both assessments realized in form of complex questionnaires were organized through the Google Forms, link to which was sent to the emails of 2nd and 3rd year students together with the official invitation to participate in the study. Invitations were sent to the emails of students, which were available at the domain of the university, and online survey's parameters within Google Forms were modified in the way that only students with verified university domain-linked emails (uzhnu.edu.ua) could participate in the survey.^{10, 12} Overall 96 students received invitation to participate in each of two survey's parts.

Questionnaire design

First part of survey held in September 2023 was presented by two questionnaires: one was dedicated to the evaluation of stress level observed among dental students, while second was based on the evaluation of students educational motivation.

Second part of survey held in November 2023 was presented by three questionnaires: one was dedicated to the evaluation of stress level observed among dental students, second was based on the evaluation of students educational motivation, while third was focused on the assessment of students subjective grading regarding potential links which may have place between the educational motivation and factors of impact.

Evaluation of stress level observed among dental students was provided based on original Depression Anxiety Stress Scale – Short Form (DASS-21) (translated into Ukrainian), from which items related specifically to the stress assessment were extracted (items 1, 6, 8, 11, 12, 14, 18).^{15, 16} Students could answer DASS-21 stress evaluation linked questions based on one-to-four-point Likert scale with the following interpretation of answers: 0 – «Never - Did not apply to me at all», 1 – «Sometimes - Applied to me to some degree, or some of the time», 2 – «Often - Applied to me to a considerable degree, or a good part of time», 3 – «Almost always -

Applied to me very much, or most of the time».^{15, 16}

Evaluation of students educational motivation was held based on adapted version of Science Motivation Questionnaire II (SMQ-II), in which word «science» was changed to the word «dentistry».¹⁷ SMQ-II represents complex instrument to assess different component of educational motivation, including intrinsic motivation, self-determination, self-efficacy, career motivation, and grade motivation.¹⁷ Responses on the SMQ-II could be provided with the 5-point rating scale, while interpretation of the possible answers was following: 0 – never, 1 – rarely, 2 – sometimes, 3 – often, 4 – always.¹⁷

Third questionnaire within the second part of survey was designed to assess students' subjective grading regarding possible connections between the educational motivation and related factors, such as professor's/lecturer's personal effort, content of educational material, personal interaction with digital dental technologies during the classes, possibility to provide practical manipulations, provision of innovative educational strategies (including case-based learning), willing to get higher grades in the class, seeing perspective of using education material in personal dental practice in future.^{10, 12} This questionnaire included following questions:

1. Q1: Rate the connection between the professor's/lecturer's personal effort and your personal educational motivation.
2. Q2: Rate the connection between the content of educational material and your personal educational motivation.
3. Q3: Rate the connection between the fact of your personal interaction with digital dental technologies during the classes and your personal educational motivation.
4. Q3: Rate the connection between the possibility to provide practical manipulations and your personal educational motivation.
5. Q4: Rate the connection between the provision of innovative educational strategies (including case-based learning) and your personal educational motivation.
6. Q5: Rate the connection between the willing to get higher grades in the class and your personal educational motivation.
7. Q5: Rate the connection between the seeing perspective of using education material in personal dental practice in future and your personal educational motivation.

Students could answer questions based on one-to-five-point Likert scale with the following interpretation of answers: 1 – no connection, 2 – weak connection, 3 – moderate connection, 4 – good connection, 5 – strong connection.

All the above-mentioned questionnaires were organized in multiple-choice, closed-end format, so for the students it was possible only to choose one the most appropriate answer from those already available within questionnaire.

Only fully completed questionnaires were taken into the consideration during further data analysis.

Statistical Analysis

Responses obtained through the Google-forms' underwent conversion into the xls-spreadsheet files for their corresponding statistical analysis within Microsoft Excel 2019 software (Microsoft Office 2019, Microsoft Corp., USA) with the additional use of XLSTAT add-in (Addinsoft Inc., Long Island, NY, USA) for inferential statistics processing.^{10, 12} Primary data presented in the form of answers obtained on the each of the questionnaire was tabulated and analyzed for distribution patterns, while also mean values, and standard deviations were calculated. Relationships between the educational motivation and related factors were assessed using Pearson correlation coefficient (Pearson's r), and established correlation was considered statistically significant only under condition of $p < 0.05$.¹⁸ Grouped results of mean values for different educational motivation components obtained in two different time periods (before and after the implementation of Digital Dental Patient Study Concept) were compared, and differences in such was assessed with the use of Student's t-tests, taking into account registered pattern of data distribution. Significance of observed differences was approved only if condition $p < 0.05$ was established through statistical analysis.

Ethical aspects

Correspondence of present study and its' design with generally-accepted ethical standards was confirmed by Institutional Review Board of Faculty of Dentistry at Uzhhorod National University (Ukraine). Provided research is a part of complex scientific research work of the Department of Restorative Dentistry at Uzhhorod National University (Ukraine). Participants have not disclosed any personal information during the survey, no registration was obligatory during the survey, so none of the obtained responses on

questionnaire include data that potentially may be linked to participants' identities. Moreover, questionnaire were built in the multiple-choice, closed-end format, so students were able only to choose the answer from those that were available. All these steps were taken to fully realize principle of anonymity during provided research.

Results

Response rate for the first part of survey was 72.91% (70 students out of 96), while for the second part of survey it was 69.79% (67 students out of 96).

Analysis of answers obtained on the DASS-21 items focused on stress assessment revealed that mean value of stress during first part of survey reached the level of 19.26 ± 2.57 points, while during second part of survey it was 18.54 ± 2.39 points. Both mean values correspond to the moderate stress level and difference between such observed during first and second part of survey was not statistically approved ($p > 0.05$).

Table 1 represents mean values of educational motivation components registered among students before and after implementing Digital Dental Patient Study Concept. Generally mean values of students' educational motivation components during September 2023 were at the average or below average levels, with intrinsic motivation showing the highest value ($11,61 \pm 2,32$) and grade motivation demonstrating the lowest value ($8,44 \pm 3,42$). Difference between intrinsic motivation and grade motivation before implementing Digital Dental Patient Study Concept was the only statistically significant ($p < 0.05$), while differences between all other educational motivation components were not statistically approved ($p > 0.05$).

Educational motivation components	Before implementing Digital Dental Patient Study Concept		After implementing Digital Dental Patient Study Concept		Significance of difference p-value
	Mean value	SD (standard deviation)	Mean value	SD (standard deviation)	
Intrinsic motivation	11,61	2,32	14,12	1,79	$p < 0.05$
Career motivation	10,83	1,96	13,94	2,05	$p < 0.05$
Self-determination	9,8	3,74	11,47	2,56	$p > 0.05$
Self-efficacy	10,23	2,89	11,73	2,12	$p > 0.05$
Grade motivation	8,44	3,42	10,32	2,63	$p > 0.05$

Table 1. Mean values of educational motivation components registered among students before

and after implementing Digital Dental Patient Study Concept (based on SMQ-II responses obtained during first and second parts of survey)

Implementation of digital dental technologies within the study process and students' possibility to interact with such helped to increase students' intrinsic motivation, while also career motivation to the levels of $14,12 \pm 1,79$ and $13,94 \pm 2,05$ correspondingly, which were statistically higher compared to the situation of providing dental education in conventional mode ($p < 0.05$). It is worth to mention that positive changes with increase trend of mean values was observed for all analyzed components of educational motivation, but such could not be sufficiently statistically argued ($p > 0.05$). It was also found that difference between mean levels of intrinsic motivation and career motivation both registered after implementing Digital Dental Patient Study Concept was not significant ($p > 0.05$), and both of these parameters has shown analogical pattern of increasing compared to the period of September 2023. Also, mean values of both intrinsic motivation and career motivation were statistically higher then mean value of grade motivation when analyzing all of them during the second part of survey after implementing Digital Dental Patient Study Concept ($p < 0.05$). Even though mean value of grade motivation was increased after implementing digital dental technologies within the study process, but such parameter still demonstrated the lowest mean value compared to other components of educational motivation, even though differences between such and outcomes of self-determination and self-efficacy were not approved ($p > 0.05$).

Considering distribution of responses obtained on the third questionnaire within the second part of survey, which was focused on the assessment of students' subjective grading regarding possible connections between the educational motivation and related factors, it was found that factors of professor's/lecturer's personal effort, content of educational material and approach of its presentation, personal interaction with digital dental technologies during the classes, possibility to provide practical manipulations and provision of innovative educational strategies (including case-based learning) were statistically correlated with

educational motivation, and quantification of such relationship could be represented with the following Person's coefficient of $r=0.76$ ($p < 0.05$), $r=0.73$ ($p < 0.05$), $r=0.70$ ($p < 0.05$), $r=0.72$ ($p < 0.05$), and $r=0.70$ ($p < 0.05$) respectively. Seeing perspective of using education material in personal dental practice in future also was found to be statically correlated with educational motivation ($r=0.68$, $p < 0.05$), while willingness to get higher grade in the class demonstrated the lowest but still statistically significant correlation with educational motivation ($r=0.35$, $p < 0.05$) (Table 2).

Factors	Educational motivation	
	r	p-value
Professor's/lecturer's personal effort	0.76	$p < 0.05$
Content of educational material and approach of its presentation	0.73	$p < 0.05$
Personal interaction with digital dental technologies during the classes	0.70	$p < 0.05$
Possibility to provide practical manipulations	0.72	$p < 0.05$
Provision of innovative educational strategies (including case-based learning with digital dental technologies)	0.70	$p < 0.05$
Willingness to get higher grades in the class	0.35	$p < 0.05$
Seeing perspective of using education material in personal dental practice in future	0.68	$p < 0.05$

Table 2. Correlations between studied parameters and students' educational motivation

Discussion

Motivation of choosing dental specialty previously was found to influence motivation of studying dentistry and further professional improvement within the field, which is explaining why most of the student entering dental education trying to keep successful educational record.¹⁹ However, confidence in choosing dentistry as targeted specialty may not be obtained by the student till advanced clinical phase of dental education, because sometimes choice of dental specialty is based not only on personal beliefs, but also on socioeconomic factors and family impact.²⁰ Moreover, different factors may alter educational motivation and change students' vision regarding their future and perspectives. Number of pedagogical and education approaches have been proposed to cover educational motivational issues and provide proactive support, but variety of circumstances that may impact education process argument the need for searching different methods aimed at retaining high dental education quality supported by sufficient students

educational motivation and satisfaction with educational environment.^{21, 22}

In present study it was found that students experienced moderate level of stress even during the period of study process beginning during September 2023, which was free of exams and other stress-linked event. Study was held among students of 2nd and 3rd year of study, but not among of 1st year students, since they may experience stress because of first impressions of being involved in university education. Also SMQ-II results demonstrated that mean values of students' educational motivation components during September 2023 were at the average or below average levels, which potentially may be linked to the established moderate level of stress, since latter may negatively impact educational motivation. It may be hypothesized that both the moderate stress level and established below average values of educational motivation linked to the fact of ongoing war in Ukraine, since impact of such could be found in all aspects of social environment, including education.¹² In present study quantification of relationship between the fact of ongoing war, registered level of stress and students education motivation was not provided since it was considered that study is taking place just at the background of war conditions, but in previous research it was found that war negatively affect quality of dental education.¹²

Digital dental advances incorporated into the study process are highly appreciated by dental students, especially when they become familiar with digital dentistry instruments in the first time.¹⁰ Digital dentistry propose number of instruments and software, which may enhance deeper understanding and detalization of theoretical topics, while also help students to get familiar with relevant technologies that potentially may be used in their own clinical practice.^{1, 2, 3, 6, 10} In present study it was revealed that implementation of digital dental technologies into the study process positively impact intrinsic motivation of students. Such outcome is highly important because previously it was found that high intrinsic motivation supports better learning characteristics of students regardless of their controlled motivation scores, and quality of motivation matters for the dental students' affective and behavioral outcome.^{23, 24, 25}

Present study also demonstrated that positive effect of interaction with digital dentistry

instruments was associated with students' vision and willingness to use digital dental technologies further in future for the practical purposes, while also increasing their career motivation in general, which also was represented by previous research.²⁶

On the other hand implementation of digital dental technologies into the study process was not associated with significant changes within students' self-determination, self-efficacy and grade motivation compared to the situation noted during conventional mode of study. Considering the increase within intrinsic motivation and career motivation it may be resumed that self-determination, self-efficacy and grade motivation could be the motivational components that need longer time for development and improvement under the influence of improved educational instruments, since such educational motivation components highly depends on the conditions that surround study process and social interactions of individuals. On the other hand grade motivation remained with lowest mean value even after implementing digital dental technologies within the study process, and students subjectively categorize the willingness to receive a better grade with the lowest correlation regarding educational motivation. Based on these outcomes it may be assumed that in condition of ongoing war in Ukraine grade is no longer playing a role of dominant motivator for the dental students, or at least its' role is significantly reduced.

Even though positive impact of interaction with digital dentistry technology was noted among all study participants in present research, it should be kept in mind that stability and retention of such effect must be assessed in future studies. Considering first impression effect which may have arisen among students, it is important further to highlight all the advantages and objectives for the focused use of digital dentistry technologies under specific indications, which should be explained to students in detailed manner. Previous observation study has also approved positive attitude of students regarding digital dentistry within study curriculum, but authors pointed up that importance of critical thinking, self-learning and understanding, which should not be neglected on the background of prominent students enthusiasm toward digital dentistry.²⁷ Attention should be paid for students

understanding that digital dentistry instruments are not to replace of conventional mode and methods of dental education, but to improve and supplement them.²⁸

Also it should be noticed that rather the teacher, who instruct dental students with digital dentistry instruments, is a main source to enhance students educational motivation, but not digital dentistry technology solely. In present study students rated importance of teachers' professional effort as the most important factor influencing educational motivation. Questionnaire survey provided by Schlenz et al. demonstrated analogical outcomes: even though students demonstrated positive attitude regarding digital dentistry, they still prefer personal evaluation by instructor compared to such provided though computer-based learning.²⁹ Previous study has also demonstrated that under condition of students' migration and continuation of education in only online mode, negative effect of war may be overcome by personal effort of teaching staff, quality of prepared educational materials, and provided technical support.¹² Such results are relevant for the cases when the risk of direct war impact' on the students' health and well-being is minimized or leveled by physical distancing; on the other hand foreign students noticed that need of migration from Ukraine itself negatively impacted quality of provided education.¹²

Context of learning also has an important role within educational motivation among dental students,³⁰ and implementation of digital dentistry should be focused mostly on enriching such context, but not on presenting advantages of digital dentistry in separate manner. In present study it was found that content of educational material and approach of its presentation demonstrated second the highest correlation with educational motivation, while provision of innovative educational strategies (including case-based learning with digital dental technologies) also was strongly linked with latter parameter. Such outcomes are in accordance with previously reported results that demonstrated students positive perception toward innovative pedagogical strategies, software and active (interactive) learning in general especially during undergraduate courses.^{22, 31}

Present study demonstrated that incorporation of digital dental technologies into the educational process could not overcome general stress among the students which

potentially may be related with ongoing war, but it helps to improve students educational motivation at the intrinsic and career domains. Somewhat analogical results were noted regarding students' subjective perception of education quality provided in online mode with implementing so called digital dental patient study concept into the educational process: students were more satisfied with provided education while implementing digital dental advances into its' structure, even though it had no impact on students' perception regarding safety of surrounding environment.¹²

Limitation of present study related with the fact that it was provided among students of Uzhhorod National University, which is located far west at Ukraine, and thus educational community do not experience direct consequences of the war in means that no war actions or missile attack have been observed in the region of university location. On the other hand air raid alarms sometimes several per day are still resulting into the interruption of study process and students dislocation to the shelter right away, while also students experiencing all the other indirect negative consequences of the war in different meanings. One more limitation was related to the fact that implementation of digital dentistry instruments was provided only within one department and only within courses of Propeutics of Restorative Dentistry and Restorative Dentistry provided for 2nd and 3rd years of study, which covering topics of tooth and jaws anatomy and morphology, caries and tooth restorations, while also pulpitis, periodontitis and endodontic treatment due to the approved study programs. It would be beneficial to verify potential impact of digital dentistry advances on the process of education while implementing them into the various study subjects among different departments, while also to assess impact of separate course, such as «Basics of Digital Dentistry» on the general students' motivation and perspective vision. It should be noted that elective course «Basic of Digital Dentistry» has been developed by the Department of Restorative Dentistry for the students of 4th year of education, while impact of such on the students motivation would be available in the upcoming years. Tripathi et al. presented instructional module of «Digital Dentistry» focused on prosthodontics for undergraduate students, which potentially may

be implemented in present form or modified due to the available resources within different universities.³² Relevant problem still exist regarding establishing generally accepted standards of digital dental education, which should be correspondingly validated for different study curriculums, within different study modes and among different universities.⁴

Obtained results should be interpreted with the caution, since students educational motivation was registered at some specific time point corresponding to cross-sectional study design, while it may change and vary in time considering students familiarization with digital dentistry instruments and impact of other personal, social or environmental factors.

Conclusion. Students accessibility to the digital dental technologies, like intraoral scanning, cast model scanning, 3D printing and milling both at the preclinical and clinical courses of studying enhance students' motivation toward education by helping to overlook and analyze issues related with specific clinical aspects, while also forming conditions where some theoretical study topics could be 3D visualized, which in turn improves students' clinical thinking patterns. The highest impact of digital dental technologies on the students educational motivation was noted regarding intrinsic motivation and career motivation, while grade motivation continue to demonstrate the lowest values compare to other motivation component regardless the improvements within education mode on the background of ongoing war in Ukraine. Nevertheless, it is still unclear how stable is such pattern of changes within educational motivation of students, and what other factors potentially may have an impact on it. Questionnaire results also demonstrated that implementation of digital dental technologies into the study process has an impact on students' motivation regarding their use in future clinical practice. First impression effect of demonstrating digital dental technologies during the study process, while also of giving possibility for students to use such technology themselves during the classes potentially may decrease students' understanding of all the real advantages and limitations of such advances within real-life clinical practice or for the specific clinical reason; that is why it could be usable to implement digital dental advances into the separate course of education in the first place, and then

incorporate its' elements within the related clinical topics of other subjects.

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