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The evaluation of the processes of problem based learning tutorials: Online or face-to-face?

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ABSTRACT

Objective: The purpose of this research is to evaluate e-PBL tutorials and compare these sessions with face-to-face PBL sessions.

Materials and Methods: This research is a program evaluation study in which quantitative methods were used. In the research, four 90-minute e-PBL sessions held between April and June 2020 were evaluated. Sessions conducted online were realised using the seven-step approach in groups of 13-14 students and a tutor. Video recordings were analysed with the thin slicing method. In addition, various quantitative data on evaluation were analysed using multiple tools and materials, including the end-of-program evaluation form. Friedman test and Mann-Whitney U test were used in the analyses of quantitative data.

Results: Upon evaluating the analyses of the feedback received from the students about the structure, content and process of the program regarding the e-PBL tutorials, the students gave a positive opinion of 80% or more. In regards with the cases, the students had positive opinions of over 80% in terms of "motivation for learning and researching", "daily life and its relation to their individual development", "suitability to their levels of knowledge and skills", "reinforcement of topics". Support, guidance and feedback received from the tutor as a group and individually during online tutorials were statistically significantly higher than the face-to-face PBL tutorials ($P<0.05$).

Conclusion: Research on the effectiveness of e-PBL tutorials, including ours, point out that e-PBL practices may constitute a viable alternative besides face-to face ones. However, for a sounder framing and better results, the subject should be studied in different aspects and more evidences be gathered in this area. These studies will provide evidence to educational institutions and practitioners on how to adapt and modify educational practices, including PBL.

Keywords: Evaluation, Problem-based learning, Tutorial, Online, Face-to-face

I. INTRODUCTION

Problem-based learning (PBL) has been widely used in medical schools for over 50 years. In recent years, various e-learning applications, including e-PBL, have been on the rise [1,2]. E-learning can be defined as formal learning system with the help of electronic resource or learning conducted via electronic media. E-learning, e-assessment applications have taken their places among the sine qua non of the new normal after the corona virus 19 (COVID-19) pandemic, and educational practices, especially lecturer courses and PBL, have mostly been transformed into e-learning applications [3,4]. Accordingly, PBL sessions held face-to-face since 2000-2001 during the preclinical education period of Marmara University, School of Medicine were made online starting 2019-2020 academic year and including 2020-2021 academic year.

With the learner-centered PBL carried out with small groups of students, the objectives are the acquisition of high level cognitive and metacognitive learning such as in-depth learning, problem solving and reflective thinking. PBL session processes have a complex nature in terms of their emotional, motivational and group interaction aspects. Several parameters like the characteristics of the cases used in PBL sessions, group dynamics, tutor's orientational skills, students' and tutor's motivation may affect the learning environment/climate and tutorial processes and learners' acquisitions [2,5-10]. Although, relevant research exists in literature, similar research need to be made on e-PBL practices.

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Learners may have various communication and interaction ways with the group and the tutor in e-learning platforms via chat rooms, forums, e-mail or interactive white boards [11]. Synchronous and asynchronous tools may be used in sharing materials and their sources related to the problem. Also learning administration systems incorporating all of these together may be used in e-PBL sessions [12,13].

The aim of this study is to evaluate e-PBL tutorials and compare these sessions with face-to-face PBL sessions. As per this aim the research problems have been defined as follows:

1. What are the characteristics, in terms of learning content and process, of the e-PBL of four sessions carried out with the seven-step approach?
2. What kind of a learning environment and climate have been formed in the e-PBL practice?
3. Are PBL sessions carried out online as effective as the ones carried out face-to-face?

2. MATERIALS and METHODS

The study was approved by the Trakya University Faculty of Medicine Scientific Research Ethics Committee (approval no: 09/21, date:12.04.2021).

This research is a program evaluation study in which quantitative methods were used. In the research an e-PBL program of four sessions of 90 minutes each held with year 1 medical students (age range 18-22 and gender distribution close to each other) between April and June 2020 was evaluated. Sessions carried out online were realised using Maastricht's seven-step approach in groups of 13-14 students and one tutor for each group [14]. Video recordings of the sessions were taken with permission of the groups. Sessions were held with 12 groups. Due to the limited number of groups consenting to be recorded and technical reasons such as unable to take records for various reasons or sound quality, connection problems and interruptions in the process in recorded videos, video recordings of only four groups out of 12 groups could be used. Quantitative data for evaluation were gathered using more than one tool and material. Methods and tools used are as follows:

Thin slicing method

Video recordings of the sessions were evaluated on macro and micro levels using two tools for observation and evaluation prepared by the researchers. The evaluation of the sessions was made globally from the beginning to the end (macro evaluation) by three researchers (OE, AG, EA), and the chosen slices were evaluated (micro evaluation) by two researchers (OE, AG) separately. Thin slicing method was used for micro evaluation. In thin slicing method, an evaluation of slices of 30-40 seconds taken from different steps of each session instead of the whole of video recordings is made [15-17]. In this research, slices of 40 seconds from each pre-discussion and discussion step of sessions were taken. In order to evaluate each session, over all 30 slices were taken and 20 minutes out of 90 minutes of a session recording was analysed.

A two-axis tool of 5-degree scale titled "Session Environment/ Climate Observation and Evaluation Tool" and "Content and Process Observation and Evaluation Tool" formed by the researchers was used for the evaluation. Three researchers separately evaluated the recordings of overall four e-PBL cases as a whole over the "problem identification and pre-discussion" and "discussion" parts using the "Session Environment/Climate Observation and Evaluation Tool". After the first evaluations, two researchers evaluated one by one the thin slices taken out of these two parts. A similar evaluation was made using the "Content and Process Observation and Evaluation Tool".

The consistency in the evaluation among the three researchers was analysed using the "intraclass correlation coefficient (ICC)", and after a consensus was reached among the researchers over the observation and evaluation scales on the items whose ICC values were not on requested levels, the parts in question were re-evaluated by the researchers. And the researchers reached a consensus on their average rates. The ICC was computed using the two-way random effect models and "average" unit to assess the agreement among the three raters in rating each aspect (interaction, togetherness, participation, confirmation, openness/flexibility, liveliness, conflict, ease, support/guidance, mood) of the first tool. There was a good consistency among the three raters where ICC ranged from 0.71 to 1. Regarding the agreement among the three raters in rating each aspect (content sharing, content presentation, content arrangement, arrangement of the session process, relating with the case, asking questions, tutorial support/guidance, emotional environment and support) of the second tool, there was also a good consistency among the three raters where ICC ranged from 0.62 to 0.97.

End of program evaluation

At the end of the program, students' opinions on e-PBL sessions were gathered via a questionnaire of 26 questions. The evaluation questionnaire prepared by the researchers consisted of three parts that are "general functioning" (12 items), "cases" (6 items), "face-to-face compared to online" (8 items), and the evaluations were requested to be made over scales of 5 and 10.

Statistical Analyses

R 0.4 program was used to analyse quantitative data statistically. Friedman test was employed to compare cases based on relation to the subjects handled in the related course. Scores for Pre-discussion and Discussion parts evaluated in thin slicing were compared using Mann-Whitney *U* test. Lastly, one sample median test was employed to compare face-to-face and online PBL. $P< 0.05$ was accepted for statistical meaningfulness.

3. RESULTS

Observation and Evaluation of e-PBL Tutorial Processes

Two different tools were used to evaluate the video recordings of e-PBL tutorial processes. With the first tool, the 10 aspects (interaction, association, participation, confirmation, openness/flexibility, liveliness, conflict/disagreement, ease,

support/guidance, mood) of the e-PBL session environment/climate were graded over a scale of two axes (negative axis of 5-point Likert scale and the positive axis of 5-point Likert scale). As seen on Table I, the average grades were calculated on the positive axis, in each aspect, except for the conflict/disagreement grade, between 3.0-4.0; and in the conflict/disagreement aspect as 2.0. Although, the level of constructive conflict appears to be low, these scores point out a medium-high level learning environment and climate. Furthermore, the fact that a meaningful difference was not identified between the Pre-discussion and Discussion parts of e-PBL processes shows that a confirmatory learning environment was attained for all the tutorial processes of seven steps.

With the second tool, the eight aspects related to handling the content and coordinating the session process (content sharing, content presentation, content arrangement, arrangement of the session process, relating with the case, asking questions, tutorial support/guidance, emotional environment and support) were graded over a scale of two axes (negative axis of 5-point Likert scale and the positive axis of 5 – point Likert scale). As seen on Table II, the grade averages for the aspects of asking questions, tutorial support, emotional environment were calculated between 2.8-4.0 on the positive axis. The average scores in the remaining 5 aspects were between 0.3-3.0. These grade averages point out a positiveness of medium-high level. No statistically significant difference between average scores of Pre-discussion and Discussion parts was identified in any of 8 aspects.

End of Program Student Evaluations

In this part, first of all, results of the evaluations received from students at the end of the program by way of three different forms were included. With the first form, the structure, content and process of the program, and with the second form results related with the cases used were obtained. By way of data obtained with the third form student opinions on face-to-face and online tutorial processes were compared.

Upon evaluating data regarding the structure, content and process of the program, it was observed that students expressed positive opinions above 90% in 9 items. As for the remaining three items (sufficiency of personal performance during tutorials, usability/functionality of the learning media and sufficiency of the recommended sources) the percentage of students who expressed positive opinions was just 80%, and 12-19% of opinions were identified to be not positive (Figure 1).

When student opinions on the quality of the cases used were examined, all three cases were evaluated above 80% positively in terms of "motivation for learning and researching", "daily life and its relation to their individual development", "suitability to their levels of knowledge and skills" and "reinforcement of topics". Percentage of students with positive opinions on the cases regarding "relationship with their professional life" and the "integration with the other topics in the program" varied between 50-79. Especially student opinions on "integration with the other topics in the program" were observed to shift toward medium or low level of 17-50% (Figure 2).

Table 1. *Scores on learning environment/climate in e-PBL tutorial processes*

Aspects related to Learning Environment/Climate	e-PBL Tutorial Process			
	Pre-discussion *Median (Q1, Q3) Min-max*	Discussion *Median (Q1, Q3) Min-max*	Whole Process *Median (Q1, Q3) Min-max*	p
Interaction (interactive, multidirectional, complex)	4.0 (3.0, 4.0) 3.0 – 4.0	3.8 (3.2, 4.0) 3.0 – 4.0	4.0 (3.0, 4.0) 3.0 – 4.0	0.893
Togetherness (collaborative)	4.0 (3.0, 4.0) 3.0 – 4.0	3.8 (3.2, 4.0) 3.0 – 4.0	4.0 (3.0, 4.0) 3.0 – 4.0	0.893
Participation (engaged)	4.0 (3.0, 4.0) 3.0 – 4.0	4.0 (4.0, 4.0) 3.0 – 4.0	4.0 (3.0, 4.0) 3.0 – 4.0	0.456
Confirmation (confirmatory, respectful, non-judgmental attention/care)	4.0 (4.0, 4.0) 4.0 – 5.0	4.0 (4.0, 4.0) 4.0 – 4.0	4.0 (4.0, 4.0) 3.0 – 5.0	0.359
Openness, flexibility (open and flexible attitude and behaviour)	4.0 (4.0, 4.0) 3.0 – 5.0	4.0 (4.0, 4.0) 3.0 – 4.7	4.0 (4.0, 4.0) 3.0 – 5.0	0.659
Liveliness (energetic, uplifted)	3.0 (3.0, 4.0) 2.0 – 4.0	3.3 (3.0, 3.9) 3.0 – 4.0	3.0 (3.0, 4.0) 2.0 – 4.0	0.699
Conflict (constructive conflict, seeking consensus, seeking for the better)	2.0 (2.0, 2.5) 2.0 – 3.0	2.0 (2.0, 2.0) 2.0 – 3.0	2.0 (2.0, 2.3) 2.0 – 3.0	0.401
Ease (safe, challenging)	4.0 (3.0, 4.0) 3.0 – 4.0	4.0 (3.2, 4.0) 2.7 – 4.0	4.0 (3.0, 4.0) 2.7 – 4.0	0.814
Tutorial support/ guidance (supportive, guiding)	4.0 (4.0, 4.0) 2.0 – 5.0	4.0 (4.0, 4.0) 4.0 – 4.0	4.0 (4.0, 4.0) 2.0 – 5.0	1.000
Mood (interested, willing, enthusiastic)	3.7 (3.0, 4.0) 3.0 – 4.0	3.0 (3.0, 3.0) 3.0 – 4.0	3.0 (3.0, 4.0) 3.0 – 4.0	0.153

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Table II. *Scores on content and practice process of e-PBL tutorials*

Aspects related to content and practice process	e-PBL Tutorial Process			
	Pre-discussion	Discussion	Whole Process	p
	Median (Q1, Q3) Min – max	*Median (Q1, Q3) Min – max*	*Median (Q1, Q3) Min – max*	
Content sharing (unidirectional, linear, passive, relational, in-depth)	2.7 (1.8, 3.7) -1.3 – 4.0	2.0 (1.7, 3.1) -1.7 – 4.7	2.7 (1.7, 3.7) -1.7 – 4.7	0.432
Content presentation (information transmitting - - concretization, relating, narrating)	2.0 (1.3, 3.0) -1.3 – 3.0	1.8 (-0.8, 2.0) -3.3 – 3.3	2.0 (1.3, 3.0) -3.3 – 3.0	0.528
Content arrangement (piece by piece, superficial – - – complete, detailed)	2.7 (2.0, 3.7) 1.7 – 4.0	2.5 (-0.4, 3.4) -2.3 – 4.7	2.7 (2.0, 3.7) -2.3 – 4.7	0.753
Arrangement of the session process (step by step, superficial – - – complex, in depth)	2.0 (1.7, 3.2) -2.0 – 4.0	0.3 (-1.6, 3.0) -1.7 – 4.0	2.0 (-1.3, 3.3) -2.0 – 4.0	0.503
Relating with the case (limited reference – - – relating the whole process with the case)	3.0 (2.3, 3.8) -1.7, 4.3	2.2 (-0.3, 2.9) -4,3, 4.3	2.7 (2.0, 2.3) -4,3, 4.3	0.240
Asking questions (constructive, opening and deepening learning)	3.0 (2.8, 3.7) 2.0 – 4.7	2.8 (2.7, 3.5) 2.3 – 4.0	3.0 (2.7, 3.7) 2.0 – 4.7	0.581
Tutorial support/guidance (sufficient support, guidance)	4.0 (3.5, 4.0) 2.0 – 4.7	3.8 (3.7, 4.2) 3.7 – 4.7	4.0 (3.7, 4.0) 2.0 – 4.7	0.660
Emotional environment and support (emotional awareness, arrangement)	3.0 (2.7, 3.2) 1.3 – 4.3	3.0 (3.0, 3.0) 2.7 – 3.7	3.0 (2.7, 3.0) 1.3 – 4.3	0.654

The three cases were compared with each other using the Friedman test, and results are presented in Table III.

A statistically significant difference was observed in all items over the Freidman test (P <0.001). The values for each item were calculated as follows: for "integration with other subjects in the program"; X^2 (2) = 118; P <0.001; Kendall's W effect size = 0.438 (large); for "reinforcement of topics"; X^2 (2) = 102.83; P<0.001; Kendall's W effect size = 0.381 (moderate); for "suitability to their levels of knowledge and skills"; X^2 (2) = 106.58; P<0.001; Kendall's W effect size=0.381 (moderate); for "motivation for learning and researching"; X^2 (2) = 118; P<0.001; Kendall's W effect size=0.437 (moderate); for "daily life and its relationto their individual development"; X^2 (2) = 140.3; P<0.001; Kendall's W effect size=0.520 (large).

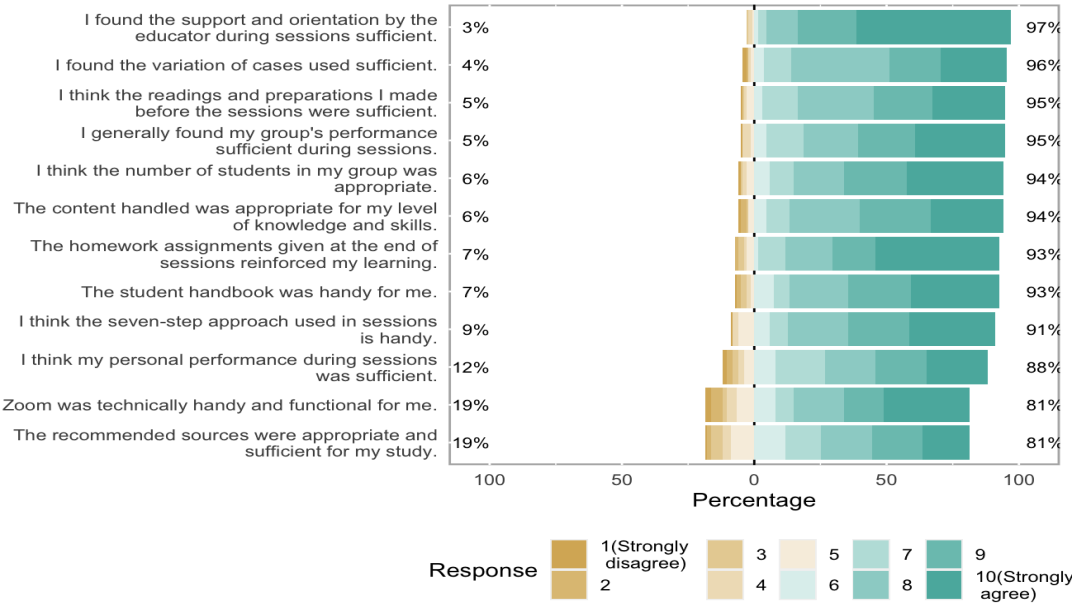

Figure 1. *Student opinions on the structure, content and process of the program*

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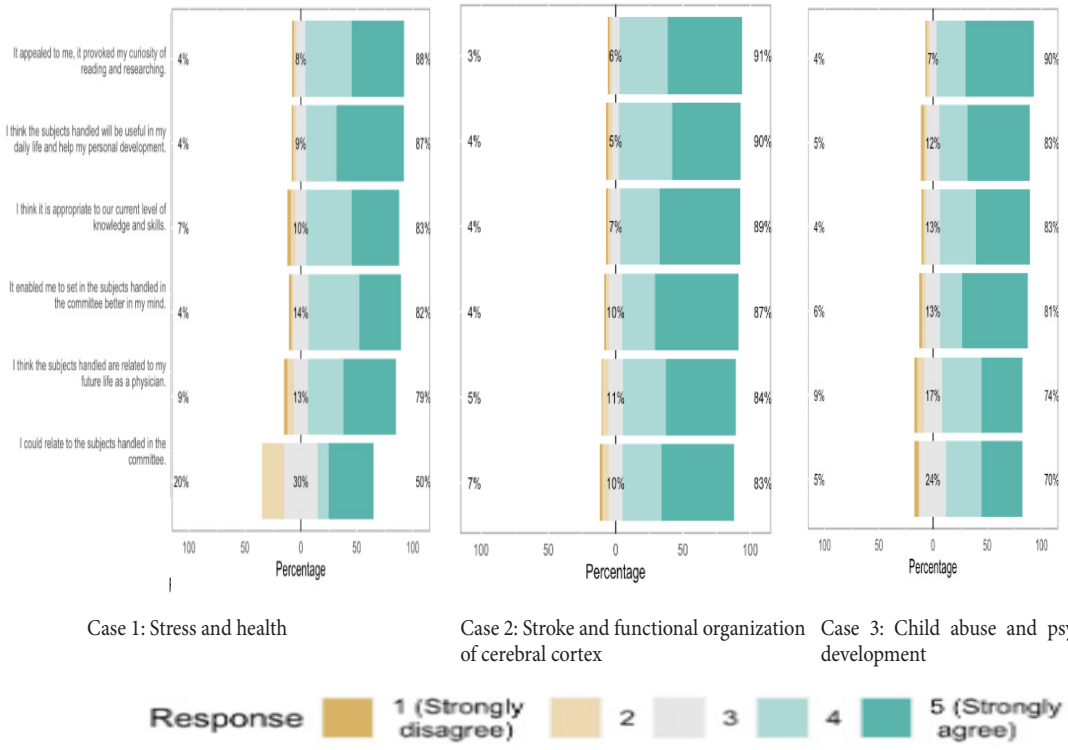

Case 1: Stress and health

Case 2: Stroke and functional organization of cerebral cortex

Case 3: Child abuse and psychosocial development

Figure 2. *Student opinions on the quality of the cases used*

Table III. *Comparison of student feedbacks on cases*

	Case 1 (n=135) Md (IQR) Min; Max	Case 2 (n=135) Md (IQR) Min; Max	Case 3 (n=135) Md (IQR) Min; Max	p	Effect size
I could relate to subjects handled in the courses	5 (1) 1; 5	4 (2) 1; 5	3 (2) 1; 5	<0.001	0.438
It helped me better comprehend the subjects handled in the courses	5 (1) 1; 5	4 (2) 1; 5	3 (2) 1; 5	<0.001	0.381
I think it was in line with our actual level of knowledge and skill	5 (1) 1; 5	5 (1) 1; 5	3 (1) 1; 5	<0.001	0.395
It attracted my attention; it aroused curiosity of reading and researching	5 (1) 1; 5	5 (1) 1; 5	3 (2) 1; 5	<0.001	0.437
I think the subjects handled are related to my future profession as a medical doctor	5 (1) 1; 5	5 (1) 1; 5	3 (0) 1; 5	<0.001	0.520
I think the subjects handled will help me in daily life and will improve me	4 (1) 1; 5	5 (1) 1; 5	3 (1) 1; 5	<0.001	0.444

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The significant differences were followed by pairwise Wilcoxon post-hoc test with Bonferroni adjustment where "integration with the other topics in the program" for case 1 is significantly higher than case 2 and case 3 (P<0.001 and P<0.001 respectively) and case 2 is significantly higher than case 3 (P<0.001); where "reinforcement of topics" for case 1 is significantly higher than case 2 and case 3 (P<0.001 and P<0.001 respectively) and case 2 is significantly higher than case 3 (P<0.001); where "suitability to their levels of knowledge and skills" for case 1 and case 2 are significantly higher than case 3 (P<0.001 and P<0.001 respectively); where "motivation for learning and researching" for case 1 and case 2 are significantly higher than case 3 (P<0.001 and P<0.001 respectively); where "daily life and its relation to their individual development" for case 1 is significantly higher than case 2 and case 3 (P<0.001 and P<0.001 respectively) and case 2 is significantly higher than case 3 (P<0.001). These results show that in general the "Stress and Health" case is relatively the most qualified one, "Stroke and Functional Organisation of Cerebral Cortex" case is a fairly qualified one, and "Child Abuse and Psychosocial Development" case is relatively less qualified.

Comparisons of student opinions on face-to-face and online PBL tutorials are provided in Figure 3. It was observed that online tutorials were evaluated more positively by 93% of the students in terms of "discussion level", 65% in terms of "tutor support/direction" and 50% in terms of "group environment/climate" compared to face-to-face tutorials. 31-62% of the students are of the opinion that there is no difference between online and face-to-face tutorials in all other items, except for the "discussion level". 19% of the students evaluted the online tutorial weaker than the face-to-face tutorial in terms of "tutor support/direction", 26% of them evaluated it weaker in terms of "group environment/climate", 33% of them in terms of "practicality of seven-step", 26% of them in terms of "individual participation level" and 13% of them in terms of "effective use of time".

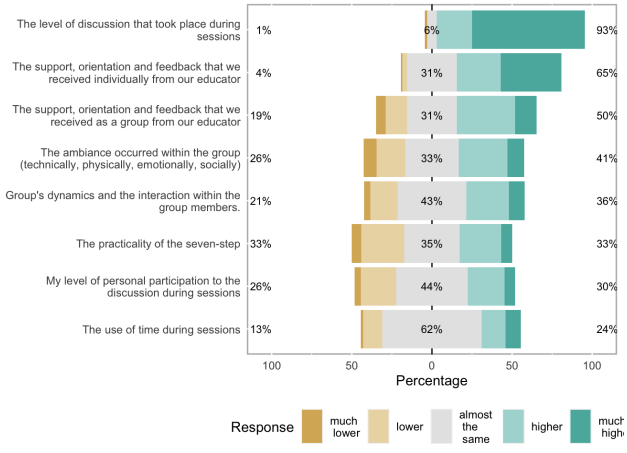

Figure 3. *Comparison of face-to-face and online PBL tutorials*

In this comparison between online and face-to-face tutorials, it was tested whether the median of each item was 3, assuming the average degree of positivity was 3. As a result of the analyses made with the one sample median test, the level of the discussion during the online sessions was found to be much higher (P<0.001, high impact) than the level of the face-to-face discussion. The support, guidance and feedback received from the trainer as a group (P<0.001, medium impact) and individually (P<0.001, high impact) during online tutorials were statistically significantly higher than face-to-face PBL tutorials.

4. DISCUSSION

The quality of the cases used, the arrangement of the content handled, the coordination of the learning process, the learning environment formed during the tutorials and the group dynamics related to it are among the factors that determine the quality of the learning processes in PBL. Studies have pointed to problems such as superficial processing of knowledge, inadequate integration, insufficient individual preparation, unsatisfactory student participation, poor group dynamics and lack of motivation in face-to-face PBL tutorials. According to these results, various improvements are made in this direction in PBL practices [18, 19]. With the pandemic, e-PBL practices have become widespread, and this has led to the need for similar studies to be conducted in online PBL tutorials. The results obtained in this study indicate that a medium-high level of positive tutorial environment/climate has been formed in all aspects except "constructive conflict". The results regarding the handling of the content and the coordination of the e-tutorial process indicated a medium-high level of positive e-PBL practice in terms of asking questions, tutorial support and the emotional environment created. These results point to the effectiveness of online PBL tutorials. However, the e-PBL practice was evaluated positively at a low-medium level in the aspects of the coordination of the content and process as well as in associating the content with the case. More data on the effectiveness of e-PBL practices are needed with new studies to be carried out in this direction.

In our study the scores on interaction, togetherness, participation, confirmation, openness, flexibility, liveliness, constructive conflict, ease, support and guidance as well as mood in e-PBL sessions were determined to be high. The positive learning environment created in e-PBL sessions, group collaboration and interaction make learning more interesting and attractive, as well as supporting the learners' exchange of information with their peers [20]. It is claimed that the self-efficacy perception and transfer skills of the learners increase with the PBL conducted in the online medium [21]. The e-PBL practice is seen as an important alternative for solving the problem of organizing the physical space and the tutor in terms of taking learning outside the classroom walls [13].

When observed in terms of learning outcomes, e-PBL practices were seen to support learners' knowledge acquisition, critical thinking and clinical reasoning skills [22-24]. In the research by Gavgani et al., it was found that there was no difference between digital and paper-pencil based scenario presentation in terms of its effectiveness and contribution to clinical reasoning skills [25].

In our study, it was determined that 80% or more of the students reported positive opinions about the PBL program carried out online. Regarding the quality of the cases used, it was evaluated that the over 80% of students had positive opinions in terms of "motivation for learning and researching", "daily life and its relation to their individual development", "suitability to their levels of knowledge and skills" and "reinforcement of topics". The rate of positive opinions about the integration of cases with professional life and with other subjects in the program is between 50-79%.

Several studies conducted on e-PBL indicate parallel findings with ours. For instance, according to a 2013 study a vast majority of students were satisfied with the overall learning process in e-PBL and perceived it positively in fostering knowledge acquisition and clinical reasoning [22]. Students felt that e-PBL increased their flexibility for learning, enhanced their ability to deeply process content, and provided access to valuable learning resources [26]. The general attitude of another group of students was found to be high in a positive way towards the web-based problem-based learning process [27]. A recent study from 2021 identified that e-PBL sessions were acknowledged positively by students, and "contribution of the quality of group discussion to students" in PBL sessions received high score [28]. A study conducted with a computer-mediated problem-based learning group reveals that the group spent significantly more time on learning than the traditional problem-based learning group in face-to-face [29]. A 2022 study puts forward that the majority of students found e-PBL to be efficient and effective, despite having deficiencies compared to face-to-face application [30]. The results of a different one showed that e-PBL sessions are as good as face to-face sessions [31].

In our study students evaluated online PBL sessions more positively compared to face-to-face PBL sessions held in previous years in terms of discussion level by 93%, tutor support and guidance by 65% and group environment/climate by 50%. In other aspects, one third to two thirds of the students think that there is no difference between online and face-to-face sessions. It was found that students evaluated the face-to-face PBL sessions more positively than online sessions in terms of the usefulness of the seven-step approach by 33%, in terms of the group environment and individual participation by 26%, in terms of tutor support by 19% and in terms of effective use of time by 13%. It was determined that the discussion level in online PBL was significantly higher than the face-to-face, and the support, orientation and feedback received as a group and as individuals from the tutor in online PBL tutorials were statistically significantly higher compared to face-to-face PBL tutorials ($P<0.001$, high impact).

In conclusion, studies on the effectiveness of online PBL tutorial processes including ours point to the fact that e-PBL practices may be considered an important alternative besides face-to-face practices. However, for a sounder framing and conclusion, it is important that the subject be researched with different aspects and more evidence be obtained. Further research will provide evidence to educational institutions and practitioners in the process of reconsidering all educational practices, including PBL, according to the "new normal" that started with the pandemic process.

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Compliance with the Ethical Standards

Ethics Committee approval: Trakya University Faculty of Medicine Scientific Research Ethics Committee (approval no: 09/21, date:12.04.2021).

Conflicts of interest: Authors declare no conflicts of interest.

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Authors contributions: AG has provided substantial contributions to the conception, design of the work, literature review, interpretation of data and writing the manuscript. OE has provided substantial contributions to the literature review, interpretation of data, writing the manuscript. EA has provided substantial contributions to the analysis and interpretation of data and writing the manuscript. MAG has provided substantial contributions to the design of the work, interpretation of data, revising and final approval of the manuscript. All authors reviewed the manuscript.

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