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RESEARCH ARTICLE

Using Virtual Reality as Support to the Learning Process of Forensic Scenarios

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ABSTRACT Virtual Reality (VR) represents a computer technology to create a simulated three-dimensional (3D) environment. Compared to the traditional user interfaces, VR places the user inside an experience. This research aimed to implement and examine modern learning strategies and activities with the VR for teaching crime scene investigation. The target group of this piloting study consisted of all students who enrolled in a crime scene investigation course at Al-Istiqlal University during the Spring semester of 2021. An online item-based questionnaire has been developed. It is used to assess students' perceptions towards using cooperative, discussion, field trip and problem-solving learning strategies and activities implemented with the VR technology. This study showed that VR is a helpful tool to practice modern learning strategies and skills in learning forensic science and crime scene investigation. We can conclude that using VR technology for educational purposes supports the learning process.

INDEX TERMS Forensic science, learning strategies, problem solving, virtual reality.

I. INTRODUCTION

Education and technology are an interconnected synergy transforming the world we live in with each leap made from both perspectives. While education has not changed for years in terms of teaching approaches and techniques applied, we are witnessing a continuous innovation in instructional technologies, ICT infrastructure (Information and Communications Technology), and the delivery methods related to education. Despite the advantages of online education, it turned out to be a double-edged sword. Every student needs assistance that interactive systems do not provide at some point in their learning. Virtual reality promises to deliver the best aspects of both real-world classrooms and online distance learning into a single platform [1], [2].

The term 'virtual reality (VR)' was used for the first time in the 1980s. It presents an environment where a user can interact with spatial data in real-time. For that reason, a lot of virtual reality systems have been developed. They are comprised of computer hardware and software (including input and output devices). There are three types of virtual reality. They are defined as immersive, non-immersive or augmented reality. In an immersive environment, the user can interact with others at a high level. The user can walk around, modify or work in groups and this interaction feels natural. They do this through specialist hardware (head-mounted or large wall-mounted displays). In non-immersive virtual reality, the user doesn't perceive being physically present in the simulated environment. Augmented reality enhances natural environments or situations and offers perceptually enriched experiences (direct or indirect view of a physical, real-world environment whose elements are augmented by computer-generated sensory input) [12]. Head Mounted Devices (HMDs) are viewing systems built into helmet-like assemblies that are worn by field operatives. Concerning a type of technology, which is attached to the

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displays, these systems can use augmented sensing overlays to paint IR emissions around concealed equipment or people, detect radar reflections, paint virtual tracking vectors for missiles and other projectiles, etc. A very good review of the educational uses of 6DoF HMDs has been prepared by Atsikpasi *et al.* [13].

Augmented reality has emerged into education tools emphasizing interactive learning, practical doing, and a broader understanding of complex subjects [14], [15]. Studies have shown that augmented reality can help trainees better understand safety concerns around food contamination and common dangers in kitchens [16].

Time and money are also important factors. Training is necessary to ensure that people can perform their jobs or learn a subject to be fully productive. However, the costs can be prohibitive, for example, for developing a series of prototypes. Virtual reality removes the need for repeated prototyping and/or implementation, which we know can be expensive. Instead, it replaces this with a single model used repeatedly. In addition, it is accessible from different locations. Both of these save time and money. Besides, it comes with little or no risk, realistic scenarios for real-life study cases, and it can be done remotely, saving time and money. It improves retention and recall and simplifies complex problems/situations; it is suitable for different learning styles, and finally is innovative and enjoyable [3], [4]. Researchers or teachers worldwide discovered the great potential of virtual reality to simulate various issues of interest (from medicine, veterinary medicine, agriculture, mining, business, architecture to manufacturing and many more) [5]. Virtual reality is often used in medicine to find practical solutions for treatments such as PTSD, social disorders or anxiety, train medical students in surgery, and treat patients [6]–[9]. Also, a benefit of virtual reality can be found in the business sector (carmakers, travel agencies, language teaching) [10]. It has many use-cases, like entertainment and gaming, or acting as an educational or training tool [11]. As an educational tool, virtual reality combines a traditional with virtual reality approach, where a trainee performs specific tasks in a virtual environment through an avatar. The immersive environment can be similar to the real world to create a lifelike experience.

Virtual reality is an innovative concept in Palestine and the whole world. It is not explicitly used only for education. It is also used for mobility and travel, citizenship values, cultural heritage, and awareness campaigns, emphasising intelligent learning and blurring more the boundaries between formal and informal education.

Al-Istiqlal university recently finished the project entitled TESLA (Virtual Reality as an Innovative and Immersive Learning Tools for HEIs in Palestine). Due to the special geopolitical context of Palestinian territories and restrictions imposed by occupation, the virtual reality will offer students, researcher and academic staff in Palestinian universities the ability to conduct research in simulated virtual labs and avoiding on the same time mobility issues, access to material, lack of specialized laboratories, and the expensive character of such experiences. The main aim is to implement immersive learning experiences into technical courses with a high - level of abstraction like topography, criminology, and geography.

Based on the TESLA project outcomes, involved Palestinian Universities are in a position to create their own local, unique VR content that will cater for the wide range of local learning needs [17].

The innovative character of the project serves not only the capacity-building aspect for Palestinian High Education Institutions (HEIs), but also addresses the challenges faced by the EU countries regarding e-inclusion, technological developments, and creating a global research framework for innovation and development regarding the integration of newest technologies into instruction and learning.

Al-Istiqlal University developed the VR concept (pilots) based on the above synopsis. Palestinian HEIs worked on a double configuration with a familiar web-based VR content and lab-based VR content depending on the course idea and objectives. A student is immersed in a virtual crime scene where he/she defines the crime-scene perimeter, define the multiple types of evidence, calculate the estimated time of death in case of an actual homicide, and analyse the environment surrounding it. Experiences in a natural process of collecting and preparing criminal pieces of evidence (body fluids, hair, nails, etc.) for DNA analysis is also part of the activities, e.g., DNA extraction or using a profiling kit for PCR analysis in an entirely virtual environment using haptics/Eye-tracking capabilities and immersion [17].

There are some other inventive trends in VR technology that are already existing and could dramatically impact the educational process. For example, some of them are crime scene investigations [18]–[21]. There is a lack of studies on the application of VR to forensic science education. In order to make a contribution to the use of VR for forensic investigation, our study aims to fill gaps in existing literature.

II. METHODOLOGY

This study included all undergraduate students of the crime scene investigation course at Al-Istiqlal University.

A total of 125 respondents participated in the conducted research. From a demographic point of view, we monitored the age of the respondent, their gender and place of residence. From the point of view of the age of the respondent, its mean value is expressed by an arithmetic average of 30.688 ± 0.271 years with a standard deviation of 4.243 years. However, due to the fact that at the selected level of significance $\alpha = 0.05$, the normal distribution of the age of the respondents was not confirmed (Doornik-Hansen test with a p value $= 0.000935$, Shapiro-Wilks test with a $p = 0.0000106$ and Jarque-Bera test with a $p = 0.01946$), the mean value is the more accurate median age of the respondent. The median is 31 years, while the minimum value is 24 years and the maximum value of the respondent's age is 37 years. The second investigated characteristic of the respondents is their gender. A total of 35 women participated in the research, which represents 28% of the research sample

and 90 men (72%). From the point of view of the residence of the respondents, the ''Camp'' option was chosen by a total of 20 respondents (16% of the research sample), 45 respondents (36%) indicated a city as their residence, and a total of 60 respondents (48%) indicated a village.

Before the student was immersed in a virtual crime scene, safety instructions, on how to deal with the tools used were provided and the scenarios were introduced. Within 30 minutes in the VR environment, students were instructed to examine and deal with the crime scene. They asked to preserve the crime scene, document it by using photography, searching for and collect forensic evidence. During the virtual trip to the crime scene, students were exposed to questions that urge them to brainstorm, think, discuss and problem solving, such as: What happened? Where did it happen? When did it happen? Why did it happen? Who may have perpetrated these actions? How was the incident carried out?

A. USED SOFTWARE

This paper reports results from design and implementation of several collaborative and adaptive learning objects within a 3D experimental educational simulator on OpenSimulator platform in the field of forensic science education. The OpenSim (DivaDistro 9.0) with MySQL database was used. An outdoor crime scene simple scenario was designed in the yard of the victim's house. It will offer the ability to allow students to visualize abstract concepts, observe events, visit environments and interact with events that make distance, time or safety factors avoidable. The student teleported to the crime scene area and read the outline for this area from the main menu at the entrance. After she/he observed the crime scene, where the victim's body lying on the ground and next to him a bloody knife, cigarette butts, hair and other biological evidence, students watched a YouTube video, about forensic evidence collection from the crime scene. Students were instructed how to think forensic and how to enhance brain stormy by reading that in the adjacent panel in the scene area.

3D Studio Max and Blender external software development applications were used to create medium complex objects and interactions. However, the 3D models were converted into formats compatible with OpenSimulator. The VR environment contains 2D image contents, e.g., for texturing specific objects. For this purpose, freely available content was used. Adobe Photoshop was used to customise the content. Similarly, sound content is generated and edited using dedicated tools like SoundForg and Adobe Audition. In OpenSimulator, simple animations of objects were implemented using scripting. In addition, some predefined animations were provided. To implement personalized animation for the avatar, motion capture technology was used, in which the motion description file is imported into OpenSimulator.

In OpenSimulator, simple animation of objects can be implemented using scripting. In addition, some predefined animations are provided. To implement personalized animation for the avatar, motion capture technology can be used, in which the motion description file is imported in to OpenSimulator. For some learning content, videos might be of great value. There are practically two possibilities for including videos into the environment: linking to external video databases like youtube or Vimeo or uploading the video content to the system server and making a link to it as an embedded file. OpenSimulator is written in C# and is designed to be easily expanded through the use of plugin modules. OpenSimulator can operate in one of two modes: stand alone or grid mode. In grid mode, various aspects of the simulation are separated among multiple processes, which can exist on different machines.

B. QUESTIONNAIRE

The target group of this study consisted of all students (125 students) from Al-Istiqlal University who enrolled in a crime scene investigation course during the Spring semester of 2020/2021. The content validity of the initial questionnaire was measured through a peer review approach online according to the pre-test method. Five peer reviewers were faculty staff members responsible for learning in their universities. In its final form, the study tool consisted of five parts containing a total of 50 items, all of them closed questions (5-point Likert scale). The items were grouped into the following five main areas: Collaboration strategies and activities (14 questions), Field trip learning strategies and activities (10 questions), Problem-solving learning strategies and activities (7 questions), Discussion learning strategies and activities (8 questions), and Teacher Performance (11 questions).

Co-operation, discussion, excursion, and problem-solving strategies and activities implemented using VR technology provide valid support for the learning process. Research tool - the questionnaire, in terms of research intentions, consists of five separate areas:

1. Collaboration strategies and activities – questionnaire items Q1_1 - Q1_14
2. Field trip learning strategies and activities – questionnaire items Q2_1 - Q2_10
3. Problem-solving learning strategies and activities – questionnaire items Q3_1 - Q3_7
4. Discussion learning strategies and activities – questionnaire items Q4_1 - Q4_8
5. Teacher Performance – questionnaire items Q5_1 - Q5_11

We evaluated the individual areas of the research tool separately within the analysis. For the complexity of data analysis for individually defined areas, the reliability value is expressed by the Cronbach's alpha coefficient for the first area (Collaboration strategies and activities) by 0.934. Due to the application of factor analysis, we have verified the fulfilment of the basic preconditions for its correct use for individual areas. The Kaiser-Mayer-Olkin (KMO) statistic is an index that compares the size of experimental correlations to the size of partial correlations. If the sum of the squares of the partial correlation coefficients between all character pairs is small compared to the sum of the squares of the pairwise

correlation coefficients, the KMO rate of the statistic is close to 1. Small KMO statistics indicate that factor analysis of the original characters will not be a good approach because the correlation between character pairs cannot be explained by other characters. According to the Keizer-Mayer-Olkin statistic (0.719) and the Kaiser definition, the correlation rate is good if the choice of factor analysis for data analysis based on the research tool used is justified. Bartlett's sphericity test is a statistical test of the correlation between the original features. It tests the null hypothesis, H0: ''there is no correlation between the characters'', so the correlation matrix is a unit matrix. The achieved value of the Bartlett's sphericity test $p = 0.000$ is less than the chosen level of significance $\alpha = 5\%$, and thus we can reject the null hypothesis that the implementation of a sample correlation matrix with 14 considered variables is a unit matrix. Thus, for the introductory part, we can state that factor analysis is suitable for the analysis of the first defined area. The Cronbach's alpha coefficient value for the second defined area (Field trip learning strategies and activities) reached the level of 0.747. The value of KMO statistics reaches the level of 0.709, and the achieved level of significance of the Bartlett test of sphericity $p = 0.000$. Cronbach's alpha coefficient value for the second defined area (Field trip learning strategies and activities) reached the level of 0.747. The value of KMO statistics reaches the level of 0.709, and the achieved level of significance of the Bartlett test of sphericity $p = 0.000$ reached the level of 0.725. The value of KMO statistics reaches the level of 0.709, and the achieved level of significance of the Bartlett test of sphericity $p = 0.000$. The fourth defined area (Discussion learning strategies and activities) is at the level of 0.791 in terms of reliability, and the value of KMO reaches the level of 0.782 with the achieved value of the level of significance $p = 0.000$. The last fifth evaluated area (Teacher Performance) reaches the level of reliability, which is expressed by the Cronbach's alpha coefficient at the level of 0.775. The value of KMO statistics reaches the level of 0.784, and the achieved level of significance of the Bartlett test of sphericity $p = 0.000$. Based on the fulfilment of the basic preconditions, it can be said that the individual defined areas of the research instrument meet these requirements, and it is possible to evaluate them separately.

Confirmatory factor analysis is the basic methodology for the analysis of individual research areas. Statistical data processing was performed through IBM SPSS Amos 22, IBM SPSS Statistics 22 and Statistica 13.5. Confirmatory Factor Analysis (CFA) was used to verify the expected factor structure. Although the polychoric correlation method is preferred for ordinal variables, in the current study, we chose the maximum likelihood method. We chose the CFA method based on the results of research [22], [23], which accepts the application of classical cut-off estimators by the ML method (machine learning) even in the case of ordinal variables. Interval variables can be considered if they have at least five response categories. The distribution of responses to all items of the research tool corresponded to the normal distribution. The normality of the respondents' answers was tested by the Shapiro-Wilks test at a significance level of $\alpha = 0.05$. In the first step, we defined a hypothetical data structure based on a theoretical construct – factors, manifest variables and relationships between them. To test the suitability of the verified model, we used the following procedures and indices: chi-square statistics and the following overall indices of agreement with optimal values: ($\chi 2$/df $<$ 2, RMSEA $<$ 0.08, comparative index TLI $>$ 0.90, CFI $>$ 0.90, SRMR $<$ 0.08) and sub-indices (statistical significance of model parameters). CFI and TLI indices can take values from 0 to 1, with values higher than 0.90 indicating the suitability of the applied model. Index RMSEA – the root mean square error of approximation is less than 0.08 for good models, and at values above 0.1, the model should be rejected. The chi-square test considers the chi-square ratio and the number of degrees of freedom. The ideal chi-square is closer in size to the number of degrees of freedom, and with several models, the one with the lowest chi-square is considered a more suitable model. For these suitable models, the chi-square is statistically insignificant, but this is considered to be a fairly strict criterion, especially for larger samples.

III. RESULTS AND DISCUSSIONS

The basic recommended evaluation indicators [24] and their real values achieved on five applied models for five defined areas are given in Table 1.

TABLE 1. CFA fit indices for all models used in the research.

Fit Indices Used	Perfect Fit Indices	Acceptable Fit Indices	CFA Results				
			Model 1	Model 2	Model 3	Model 4	Model 5
$\chi 2/df$*	$0 \leq \chi 2/df \leq 2$	$2 \leq \chi 2/df \leq 3$	2.334	1.508	0.0945	1.346	2.887
*GFI**	$0.95 \leq GFI \leq 1.00$	$0.90 \leq GFI \leq 0.95$	0.985	0.989	1.000	0.999	0.943
*AGFI**	$0.90 \leq AGFI \leq 1.00$	$0.85 \leq AGFI \leq 0.90$	0.908	0.967	0.999	0.976	0.856
*CFI**	$0.95 \leq CFI \leq 1.00$	$0.90 \leq CFI \leq 0.95$	0.996	0.997	1.000	1.000	0.966
*NFI**	$0.95 \leq NFI \leq 1.00$	$0.90 \leq NFI \leq 0.95$	0.994	0.990	1.000	0.999	0.964
*TLI**	$0.97 \leq TLI \leq 1.00$	$0.95 \leq TLI \leq 0.97$	0.977	0.992	1.000	0.995	0.957
*RMSEA**	$0.00 \leq RMSEA \leq 0.05$	$0.05 \leq RMSEA \leq 0.08$	0.067	0.032	0.000	0.029	0.066
*SRMR**	$0.00 \leq SRMR \leq 0.05$	$0.05 \leq SRMR \leq 0.10$	0.0571	0.0244	0.0014	0.038	0.0585

Based on Table 1, it can be said that all evaluated indices confirm the correctness of the proposed model – Model_1 for the first defined area (Collaboration strategies and activities). The achieved level of significance of the $\chi 2$ test reached the value $p = 0.067$. A graphical representation of the model for the first evaluated area – Collaboration Strategies and Activities – is shown in Figure 1.

For the first research area defined as Collaboration strategies and activities, it is clear from Table 2 that at the level of significance $\alpha = 0.05$, all relationships between the individual items of the questionnaire and the associated partial factors are significant. The first partial extracted factor (F1_1 – b Communication in team cooperation) is most influenced by the item of the research tool Q1_3 (My team members communicate with each other frequently) with the value of the standardised regression weight at the level of 0.988. The item of the research tool Q1_6 (Communicating with team members regularly helps me to understand the team project better) with the value of the standardised regression weight at

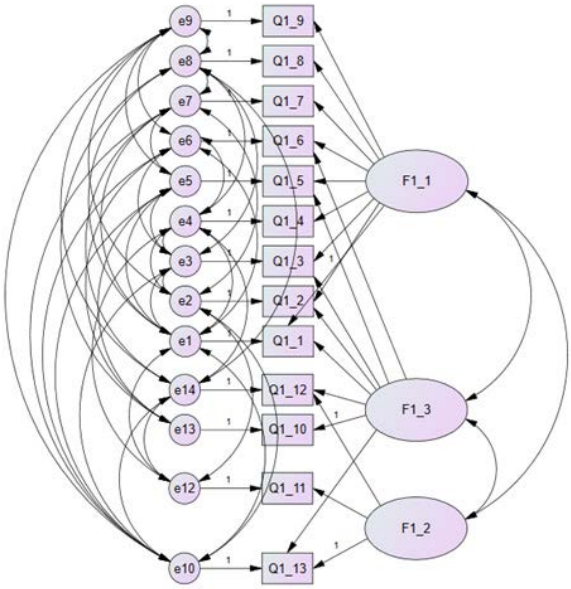

FIGURE 1. Model 1 for the first defined research area (Collaboration strategies and activities).

the level of 0.969 is also very important for the respondents in relation to communication in team cooperation. The third most important item for respondents of the research tool in relation to the first area of research is the item Q1_8 (My team is receiving guidance on the group project from the instructor) with a standardised regression weight of 0.907. When solving a given task by several participants who create a team, mutual disagreements and differences in the joint problem-solving process, different views and approaches of team members are also natural, which is related to the second most important item of the research tool Q1_6 (Communicating with team members regularly helps me to understand the team project better).

Based on Table 2, it can be said that the standardised regression weights were statistically significant ($p < 0.05$) for all items of the first research area of the research tool. We see the most significant impact in Q1_11 (Interacting with other members can increase my motivation to learn), where it is clear that if the value of the second common factor (F1_2) of the first research area increases by one unit of standard deviation, the value of Q1_11 increases by 1.357 of standard deviation. The second very important relationship is between the first common factor (F1_1) and the questionnaire item Q1_3 (1.088) and the item Q1_6 (1.069). In addition to the direct links between the extracted common factors, in Table 2, we also observe negative dependences on the second common factor (F1_2) and the questionnaire item Q1_12 (−0.605), the third common factor (F1_3), the questionnaire item Q1_6 (−0.309), and the questionnaire item Q1_3 (−0.337). However, it must be said that all relationships between the extracted factors and the items of the questionnaire are significant at the level of significance $\alpha = 0.05$.

If we look at the items of the research tool, which are due to the first defined subfactor (F1_1 – Communication in Teamwork), we see that the most important thing in team

TABLE 2. Regression weights and standardised errors of model 1 for the first research area.

Relationship			*Estimate*	*Std. estimate*	*Std. error*	*t -static*	*p-value*
Q1_1	<---	F1_1	1,000	0.525	0.232	8.244	0.000*
Q1_2	<---	F1_1	0.836	0.347	0.153	5.449	0.000*
Q1_3	<---	F1_1	2.470	0.988	0.332	7.444	0.000*
Q1_4	<---	F1_1	1.862	0.814	0.234	7.952	0.000*
Q1_5	<---	F1_1	1.229	0.572	0.16	7.662	0.000*
Q1_6	<---	F1_1	2.527	0.969	0.335	7.536	0.000*
Q1_7	<---	F1_1	1.914	0.888	0.241	7.950	0.000*
Q1_8	<---	F1_1	2.289	0.907	0.294	7.775	0.000*
Q1_9	<---	F1_1	1.859	0.850	0.239	7.762	0.000*
Q1_13	<---	F1_2	1,000	0.481	0.212	7.553	0.000*
Q1_11	<---	F1_2	2.535	0.998	0.547	4.637	0.000*
Q1_10	<---	F1_3	1,000	0.894	0.394	10.211	0.000*
Q1_12	<---	F1_3	0.643	0.689	0.051	12.644	0.000*
Q1_2	<---	F1_3	0.702	0.498	0.069	10.221	0.000*
Q1_12	<---	F1_2	-1.358	-0.605	0.48	-2.827	0,005*
Q1_5	<---	F1_3	0.598	0.475	0.045	13.34	0.000*
Q1_13	<---	F1_3	0.131	0.151	0.033	3.954	0.000*
Q1_6	<---	F1_3	-0.428	-0.309	0.061	-7.007	0.000*
Q1_3	<---	F1_3	-0.447	-0.337	0.067	-6.711	0.000*
Q1_1	<---	F1_3	0.279	0.250	0.069	4.053	0.000*

* - significant at the level of significance $\alpha = 0.05$

cooperation is the high frequency of mutual communication between team members in solving a joint team task. This importance is self-evident because communication is an essential part of successful teamwork. This regularity in communication between team members helps its members to understand the team project, its essence, meaning, and the process of its solution better. Again, the communication between the team members is a necessary condition for fulfilling this precondition. The effectiveness of teamwork also depends on effective communication. ''Social interaction or communication can be understood as the most important feature of the group. Therefore, the importance of communication structures belongs to the most intensively researched areas of organisation and work of small groups. An important factor in communication is the creation and acceptance of the order in the course of communication so that social interaction takes place only exceptionally without rules, for example, when ''talking over the top of others''. Good communication does not mean just sending and receiving. Good communication is also not just a mechanical exchange of data. Even if we organise the communication perfectly, when no one is listening, everything is lost. The best communication will make you listen. A key feature of an effective team is the ability of its members to say what they think or feel without humiliating others or themselves. They need to work in an environment of mutual support, respect and trust; they need to feel valued and listened to, even if they do not always achieve what they want. Without such an atmosphere, individuals may fall into a communication trap, stop communicating effectively, and instead:

- they will hesitate to contribute – they will feel frustrated and useless, and the whole team will miss their ideas and opinions,
- consequently, they will get caught up in their emotions and worry about them, leading to mutual dislike and mistrust and manifesting in deliberate actions and negative behaviours,
- they will go their own way and secretly defend themselves against what the rest of the team is trying to do.

However, if we look at the process of solving a team problem, team members have high expectations that the team as a whole will receive instructions regarding the group project from the instructor. It is, therefore, possible to observe a certain degree of non-independence, which is confirmed by the high value of the standardised regression weight of the relevant item of the research instrument. The second significant group of research instrument items that are related to the first defined subfactor (F1_1) with standardised regression weight values greater than 0.800 consists of Q1_7 items (The instructor acts as a referee when our members cannot seem to resolve differences) with standardised regression weight values at 0.888, research tool item Q1_9 (My team members are sharing knowledge during the teamwork processes) with a standardised regression weight value of 0.850 and research tool item Q1_4 (My team is receiving feedback from each other) with a standardised regression weight value of 0.814. Every teamwork always includes certain disagreements between its members, which result from different personality characteristics of individual members, different levels of knowledge and acquirements, and approaches to solving a group project. The research concludes that team members have the expectation that disagreements will be resolved by the instructor/teacher, who indicates that the lecturer is considered a leader by each team member. In the life of each group/team, there are three interrelated needs, namely:

1. The task – the need to achieve something, to solve a problem. The need of the group is to fulfil this task. As long as the task is not completed, there will be tension in the group and pressure to do so.
2. The group – the need to maintain a group. The need to develop and maintain working relationships between group members. When people do not understand each other and do not try to develop the suggestions of other members, the group will not fulfil the task.
3. The individual – the needs of individuals.

If a common task is fulfilled, it will also affect the group, where a sense of unity will be created. It will also affect the individual. For example, if there is an effective group, the task is more likely to be completed. If individuals are involved and well-motivated, they will do much more to benefit roles and groups. If the group fails, it also affects other needs. In order to meet these three needs, it is necessary:

- to encourage – keep the group running
- to regulate – influence the direction and pace of the group's work
- to inform – provide group information and opinions
- to promote – create a climate that keeps the group together: harmonisation, stress relief, encouragement
- to evaluate – to assist the group in evaluating its decisions, objectives, and procedures

In an effective team, not only the leader but all its members participate in these activities, but the leader is responsible for all three circles. However, the role of team leader/leader in the form of an instructor is essential. However, certain requirements are also defined that are placed on the leader of the team to which the lecturer is placed. An effective leader is part of the team, not someone who stands aside, sets the rules, or behaves autocratically. The leader sets the tone, participates in the game, and feels the winnings and losses of the team. He or she listens carefully to other team members, helps them, and gives them feedback. Effective team leaders should:

- know exactly what they want to achieve,
- share their goals and tasks with other team members,
- be loyal to their team and its members and defend them if someone attacks them from the outside,
- trust their team and its members,
- delegate tasks to help people learn and develop their skills,
- do not dodge tasks – face them,
- be able to praise if the team is doing well, but honestly and openly point out mistakes if they are not doing so,
- be happy and proud to see that the team and its members are doing well,
- be sure that the team has some clear rules of operation,
- take the view that work should bring joy wherever possible, and that job satisfaction is important for everyone.

Part of effective teamwork in the studied environment is communication in time, in which the mutual exchange of knowledge is important. At the same time, internal team feedback is also significant for team members.

The second defined subfactor F1_2 of the first research area (Collaboration Strategies and Activities), which we defined based on the results as Mutual motivation of team members, is most significantly affected by the research tool Q1_11 (Interacting with the other members can increase my motivation to learn) with a standardised regression weight at 0.988. The goal of project teaching is not to sell a large amount of information in a short time but to evenly shape the student at all levels. The task of project teaching is to lead students to independence, activity, and creativity, and, therefore, they are based on the principles of free choice and maximum connection of study with practical life. However, project teaching not only develops general knowledge and competencies but also leads to the acquisition of specific professional knowledge and skills. It is the acquisition of knowledge within the application of project teaching that takes place on two separate levels. The first is the general transfer of information needed to solve the individual steps of the project by the lecturer/instructor. The second level is the

mutual transfer of knowledge by individual team members acquired in solving partial tasks during the project. And it is precisely this communication between the team members that causes the students to emphasise the increase in interest and motivation to learn in order to become full members of the project team and thus contribute to the success of the whole group. However, at the same time, we also observe a negative attitude towards group solutions to partial problems to be solved by individual team members. This fact is represented by the item of the research tool Q1_12 (I like solving problems with my teammates in group projects) with the value of the standardised regression weight at the level of −0.605. It is clear that a relatively important fact is closely linked to the previous statement and the personality of the student. We assume that if a student is given the task of solving a partial problem based on the results listed in Table 2, he is more motivated to learn to solve the problem on his or her own to contribute to the success of the whole team and creates a problem if he or she cannot solve this partial problem. In relation to the team, the respondent can become useless, and, therefore, there is a negative perception of a common solution to partial problems, which, however, is contrary to the basic idea of teamwork.

Based on the results listed in Table 2, we defined the third defined subfactor (F1_3) of the first research area (Collaboration strategies and activities) as Online cooperation in group/team problem-solving. This subfactor is most affected by the item of the research tool Q1_10 (I gain online collaboration skills from the teamwork processes) with the achieved value of the standardised regression weight at the level of 0.894. This relatively high importance of this variable is influenced by two facts. Due to the existence of the global COVID-19 pandemic, there have been significant changes in social life, to which, of course, schools have also responded. The traditional way of teaching has moved to the online space, which is more natural for a generation of contemporary students due to the development of social networks and their use by young people. The trend of mutual communication without the personal presence and personal interaction with other team members is reflected in the second important item, namely Q1_12 (I like solving problems with my teammates in group projects) with a standardised regression weight of 0.643. However, it is possible to observe that if this item is perceived negatively in personal problem-solving communication, then when the problem-solving is moved to the online space, team members assess this option, i.e., collective solution of partial tasks assigned to a particular team member as a positive. It is an interesting paradox of the present time, when young people, in particular, lose their communication skills during direct, personal meetings, which, however, is in some contradiction with project management and teamwork in real life. It turns out that this area needs to be given great attention and focus on the school environment.

Table 3 shows the values of covariance and correlation coefficients for the first research area (Collaboration strategies and activities) and extracted common factors according

TABLE 3. Covariance a Correlation extracted model 1 factors for the first research area.

Relationship			Covariance				Correlation
			Estimate	*Std. error*	*t - static*	*p-value*	Estimate
F1_1	<-->	F1_3	0.166	0.025	6.720	0.000*	0.738
F1_2	<-->	F1_3	0.007	0.006	1.247	0.212	0.043
F1_1	<-->	F1_2	0.027	0.007	3.560	0.000*	0.282

* - significant at the level of significance $\alpha = 0.05$

to the model shown in Figure 1. Based on the above, it is clear that there is a strong correlation with the value of the correlation coefficient at the level of 0.738 between the common subfactor F1_1 (Communication in teamwork) and the subfactor F1_3 (Online cooperation in group/team problem solving), while at the level of significance $\alpha = 0.05$, this positive correlation is significant.

It is possible to conclude that if mutual communication in teamwork is perceived positively, naturally, also with regard to two levels of changes in social life, online cooperation between team members will be positively perceived. However, one subfactor conditions the other. We consider the internal integrity of the team and the efforts of its members to be successful in solving the problem/project as a basis for successful communication and online cooperation. The second significant relationship is observed between subfactors F1_1) Communication in teamwork and F1_2 (Mutual motivation of team members) with a correlation coefficient value of 0.282 ($p = 0.000$).

The second research area, namely Field trip learning strategies and activities is defined by the model according to Figure 2. The basic characteristics and indicators of Model 2, listed in Table 1, point to the fact that the model is designed correctly and is suitable for the description of the second research area. Model 2 represents, as in the case of Model 1, a 3-factor model. It contains three common exogenous variables – factors and ten observed endogenous variables (Q2_1 to Q2_10).

Based on Table 4, it can be said that the standardised regression weights were statistically significant ($p < 0.05$) for all items of the first research area of the research tool and thus for all interrelations of exogenous (F2_1, F2_2, and F2_3) and endogenous variables (research tool items for the second investigated area) in the sense of Model 2 according to Figure 2. It is further apparent from Table 4 that all interdependencies are significant at the chosen level of significance $\alpha = 0.05$.

It is clear from Table 4 that the first subfactor (F2_1) of the second research area (Field trip learning strategies and activities) is most influenced by the item of research tool Q2_5 (Taking the forensic molecular biology course with a virtual site visit allows me to identify and solve practical problems) with a standardised regression weight value of 0.900. This fact presupposes that students perceive to a greater extent the positive impact of the use of virtual reality in the practical area of the forensic molecular biology course. The second most significant impact is the item of the research tool Q2_4

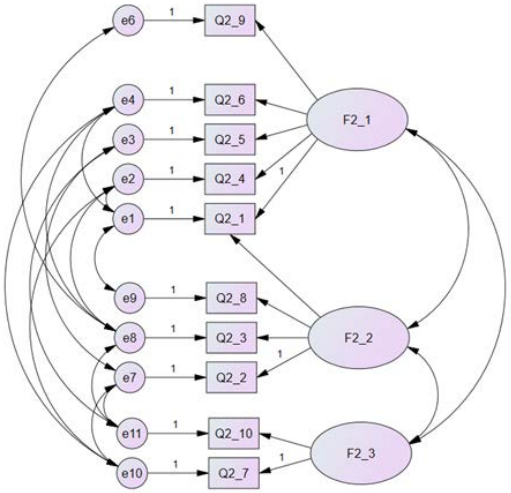

FIGURE 2. Model 2 for the second defined research area (Field trip learning strategies and activities).

TABLE 4. Regression weights and standardised errors of model 2 for the second research area.

Relationship			*Estimate*	*Std. estimate*	*Std. error*	*t -value*	*p-value*
Q2_1	<---	F2_1	1.000	0.599	0.075	10,226	0,000*
Q2_4	<---	F2_1	1.516	0.880	0.109	13,869	0,000*
Q2_5	<---	F2_1	1.544	0.900	0.104	14,821	0,000*
Q2_6	<---	F2_1	0.910	0.646	0.079	11,497	0,000*
Q2_9	<---	F2_1	1.430	0.705	0.106	13,459	0,000*
Q2_2	<---	F2_2	1.000	0.933	0.112	10,367	0,000*
Q2_3	<---	F2_2	0.768	0.868	0.037	20,520	0,000*
Q2_8	<---	F2_2	0.320	0.486	0.027	11,697	0,000*
Q2_1	<---	F2_2	-0.251	-0.540	0.020	-12,511	0,000*
Q2_7	<---	F2_3	1.000	0.785	0.057	9,837	0,000*
Q2_10	<---	F2_3	0.613	0.518	0.082	7,510	0,000*

* - significant at the level of significance $\alpha = 0.05$

(Taking the forensic molecular biology course with a virtual site visit allowed to think creatively and innovatively) with the achieved value of the standardised regression weight at the level of 0.880. The first common subfactor of the second research area points to the fact that the application of virtual reality in the course of forensic molecular biology has a positive impact on creative and innovative thinking for students, in addition to practical consequences in solving problems. It is, therefore, expedient and necessary to introduce modern elements in the form of virtual reality technologies into the teaching process. The second defined subfactor (F2_2) of the second research area (Field trip learning strategies and activities) concerns the area of using virtual reality technology in the study of a specific place/building within the course of forensic molecular biology. It turns out that the use of virtual reality can provide students with the same amount and type of information as a physical visit to a given place, which also supports the preference for the use of virtual reality over a physical examination of a particular location. The third subfactor F2_3 of the second research area mainly

TABLE 5. Covariance and correlation extracted model 2 factors for the second research area.

Relationship			Covariance				Correlation
			Estimate	*Std. error*	*t - static*	*p-value*	Estimate
F2_1	<-->	F2_2	0.101	0.024	4.128	0.000*	0.211
F2_2	<-->	F2_3	0.637	0.069	9.283	0.000*	0.629
F2_1	<-->	F2_3	0.162	0.02	8.203	0.000*	0.573

* - significant at the level of significance $\alpha = 0.05$

concerns the very form of the implementation of the forensic molecular biology course. On the one hand, respondents prefer courses with the possibility of using virtual reality, which is represented in the research tool by Q2_7 (I prefer to take the forensic molecular biology course with a virtual site visit) with a standardised regression weight of 0.785). On the other hand, it is important for respondents to have other study materials from lectures as a necessary prerequisite for sufficient understanding of various aspects of forensic molecular biology (Q2_10, The lecture materials are sufficient to understand different aspects of forensic molecular biology) with the achieved value of standardised regression weight on level 0.518.

From the results presented in Table 4, it is clear that students, on the one hand, prefer courses where virtual reality technology is applied, which, in addition to the contribution in the field of identification and solving practical problems, the development of innovative and creative thinking, helps students in replacing the need for physical presence at the research site, but on the other hand, the availability of traditional lecture materials for better understanding is also important for students. It is, therefore, necessary to realise that the use of modern technologies in the teaching process becomes a necessity due to the attractiveness of the study, but it is always necessary to combine modern approaches with traditional teaching methods.

Table 5 shows the values of the covariance coefficients and correlations of exogenous factors. All mutual correlations between factors in the sense of Figure 2 are statistically significant at the significance level $\alpha = 0.05$.

Table 5 shows that the most significant relationship between the subfactors of the second research area exists between subfactor F2_2 and subfactor F2_3, i.e., between the use of virtual reality technology when visiting and examining the site and the use of virtual reality technology in the course study, but with additional and accessible study materials. This interrelation of subfactors of the second research area with the value of the correlation coefficient at the level of 0.629, supports our statement and the need to connect modern technologies in forensic molecular biology courses with traditional forms of study with the availability of study materials. On the one hand, virtual reality makes the course attractive, and students have the opportunity to get acquainted with modern procedures, but it is still very important and irreplaceable to have the traditional study materials supplemented by lectures. At the same time, however, there is a significant relationship between subfactors F2_1 and F2_3,

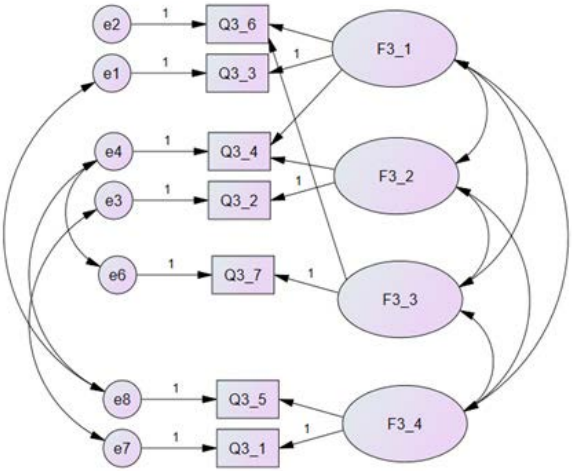

FIGURE 3. Model 3 for the third defined research area (Problem-solving learning strategies and activities).

TABLE 6. Regression weights and standardised errors of model 3 for the third research area.

Relationship			*Estimate*	*Std. estimate*	*Std. error*	*t -static*	*p - value*
Q3_3	<---	F3_1	1.000	0.708	0.474	0.931	0.036*
Q3_6	<---	F3_1	1.759	0.702	1.625	1.082	0.034*
Q3_2	<---	F3_2	1.000	0.401	0.255	2.554	0.041*
Q3_4	<---	F3_2	7.216	0.603	1.412	0.538	0.021*
Q3_7	<---	F3_3	1.000	0.381	0.263	1.489	0.042*
Q3_1	<---	F3_4	1.000	0.889	0.633	0.997	0.001*
Q3_5	<---	F3_4	0.641	0.551	0.074	8.692	0.000*
Q3_4	<---	F3_1	1.756	0.964	2.853	0.616	0.008*
Q3_6	<---	F3_3	7.512	0.643	1.342	0.726	0.016*

* - significant at the level of significance $\alpha = 0.05$

i.e., between the areas that touch on the contribution of virtual reality in solving practical problems and developing creative and innovative thinking, and, at the same time, using virtual reality technology in course study; however, with the addition and accessibility of study materials with a correlation coefficient of 0.573. The use of virtual reality technology in the courses of forensic molecular biology is evidently justified, but it is necessary to combine it with traditional lectures, which are supported by the availability of study materials.

The third research area, namely Problem-solving learning strategies and activities, is defined by the model according to Figure 3. The basic characteristics and indicators of Model 3, listed in Table 1, point to the fact that the model is designed correctly and is suitable for the description of the third research area. Model 3 is a 4-factor model that contains four common exogenous variables – factors and seven observed endogenous variables (Q3_1 to Q3_7) – items of the research tool.

It is clear from Table 6 that all items of the research tool significantly affect the individual subfactors of the third research area (Problem-solving learning strategies and activities) at the selected level of significance $\alpha = 0.05$.

The results in Table 6 show that the first subfactor (F3_1) of the third research area (Problem-solving learning strategies and activities) is defined primarily by item Q3_4 (Problem-solving skills are important in this major area of study) with a standardised regression weight at 0.964. It is clear that students in the course of forensic molecular biology consider it most important to have skills in the field of study in solving problems. This attitude of students places great emphasis on the combination of modern teaching methods and traditional methods with an emphasis on the acquisition of skills in the field. At the same time, we observe that students feel frustrated if they cannot solve problems (Q3_3) with a standardised regression weight value of 0.708, and, at the same time, consider it important that the scenario used in VR contains problems that need to be solved (Q3_6). Thus, the need to acquire skills when using VR to solve field of study problems is crucial for students. Insufficient fulfilment of these basic starting points is reflected in the frustration of students if they do not know how to solve the problem. The second subfactor (F3_2) of the third research area (Problem-solving learning strategies and activities) is primarily created by the research tool item Q3_4 (Problem-solving skills are important in this major area of study) with a standardised regression weight value of 0.603. This item of the research tool proves to be important in the second common subfactor, which implies the importance and necessity of skills in solving problems in the given field of study. From this, it is necessary to conclude that in addition to the necessary theoretical knowledge, students are aware of the need for knowledge of procedures and methods in practical use, i.e., the acquisition of skills. To acquire the knowledge and, of course, the necessary skills in the field of DNA forensic analysis in the application of virtual reality, students consider it important to divide the tasks into smaller parts (Q3_2). The achieved value of the standardised regression weight for this item of the research tool is 0.401. The third significant subfactor (F3_3) of the third researched area is mostly influenced by the item of the research tool Q3_6 (The scenario used in this VR world contains problems to be solved) with the value of the standardised regression weight at the level of 0.643. From this result, it is obvious, and indeed necessary, that the scenarios used in virtual reality tasks should include issues that are directly relevant to the field of study. Virtual reality is a very interesting teaching tool, but respondents believe that virtual reality needs to be used effectively to acquire knowledge and skills in forensic molecular biology and not just as a ''marketing'' tool to attract students. At the same time, it turns out to be an important fact that students have a basic knowledge of the problems they faced in virtual reality (Q3_7, 0.381). The last, fourth subfactor (F3_4) of the third research area is defined mainly by the item of the research tool Q3_1 (Solving problems within virtual-world applications can increase my interest in learning more about forensic DNA analysis and crime scene investigations) with the achieved value of standardised regression weight at 0.889. This shows the fact that the use of modern technologies in teaching, such as virtual reality, is an important factor that

TABLE 7. Covariance and correlation extracted model 3 factors for the third research area.

Relationship			Covariance				Correlation
			Estimate	*Std. error*	*t - static*	*p-value*	Estimate
F3_1	<-->	F3_2	-0.103	0.022	-4.636	0.000*	-0.748
F3_2	<-->	F3_3	0.018	0.006	3.046	0.002*	0.453
F3_3	<-->	F3_4	0.018	0.011	1.541	0.123	0.202
F3_1	<-->	F3_3	-0.086	0.023	-3.704	0.000*	-0.608
F3_1	<-->	F3_4	-0.150	0.023	-6.682	0.000*	-0.498
F3_2	<-->	F3_4	0.040	0.017	2.377	0.017*	0.476

* - significant at the level of significance $\alpha = 0.05$

affects the attractiveness of the course itself. It is clear from the previous results that students who attend the course of forensic molecular biology also perceive the justification of the use of virtual reality in the teaching process or in solving specific tasks. Based on the analysis of model 3 (Figure 3) for the third research area (Problem-solving learning strategies and activities), we defined the following common subfactors:

1. F3_1 – Increased interest in the subject of the study due to the VR
2. F3_2 – Existence of a strategy for solving tasks in the VR environment
3. F3_3 – Knowledge of problems solved in the VR environment
4. F3_4 – Adequacy of the VR environment

The values of the coefficients of covariance and correlation (Table 7) indicate the fact that significant relationships at the level of significance $\alpha = 0.05$ are among the exogenous variables F3_1 a F3_2 (-0.748), between F3_1 and F3_3 (0.608), and F3_1 and F3_4 (-0.498). Interestingly, the first factor extracted has a negative relationship with all other factors in the study area. Thus, it can be assumed that the use of virtual reality technology in the course of forensic molecular biology by the institution may increase the attractiveness of the course itself for students. However, only the presentation of virtual reality by the institution without its subsequent material use in the course with the existence of a strategy in solving tasks, knowledge of problems solved in the virtual reality environment and the adequacy of the virtual reality environment bring negative attitudes to its presentation. Therefore, it is very important to apply and use the presented virtual reality technology in an adequate way in the ongoing course. This statement also supports another significant relationship between the extracted sub-factors with the achieved value of the correlation coefficient at the level of 0.453 ($p = 0.002$) between Existence of a strategy for solving tasks in the VR environment (F3_2) and Knowledge of problems solved in the VR environment (F3_3) and also between Existence of a strategy for solving tasks in the VR environment (F3_2) and Adequacy of the VR environment (F3_4). The achieved value of the correlation coefficient in the last defined relation is 0.476 ($p = 0.017$).

The fourth defined area (Discussion of learning strategies and activities) is described by model 4 according to Figure 4.

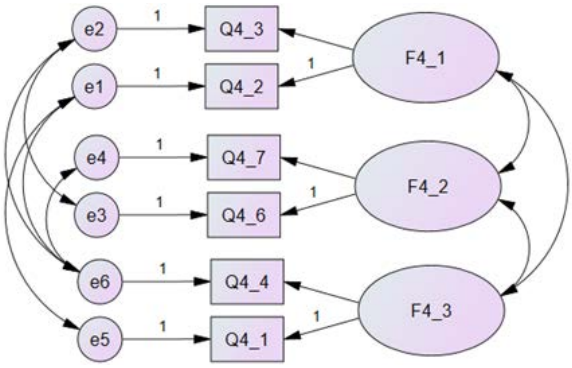

FIGURE 4. Model 4 for the fourth defined research area (Discussion of learning strategies and activities).

TABLE 8. Regression weights and standardised errors of model 4 for the fourth research area.

Relationship			*Estimate*	*Std. estimate*	*Std. error*	*t -static*	*p - value*
Q4_2	<---	F4_1	1.000	0.943	0.136	4.952	0.000*
Q4_3	<---	F4_1	0.580	0.729	0.113	5.138	0.000*
Q4_6	<---	F4_2	1.000	0.614	0.058	4.661	0.000*
Q4_7	<---	F4_2	1.163	0.926	0.132	8.817	0.000*
Q4_1	<---	F4_3	1.000	0.956	0.337	12.935	0.000*
Q4_4	<---	F4_3	0.012	0.062	0.212	0.054	0.957

* - significant at the level of significance $\alpha = 0.05$

The basic characteristics of the model given in Table 1 create the assumption that the description of the data by the model is correct. The achieved level of significance of the $\chi 2$ test is $p = 0.194$.

Model 4 is a 3-factor model consisting of 3 exogenous variables (F4_1, F4_2, and F4_3) and 6 endogenous variables. The values of regression weights and standardised model weights are given in Table 8. It is clear from Table 8 that all mutual relations between exogenous and endogenous variables, which are defined by the model according to Figure 4, are significant at the level of significance $\alpha = 0.05$ with the exception of the F4_3 factor link and the Q4_4 questionnaire item. Furthermore, we can see that the strongest link is between the questionnaire item Q4_1 and the factor F4_3. All bonds defined in Table 8 are positive.

From Table 8 and the above basic information about the fourth-factor model, the fourth research area (Discussion learning strategies and activities), it can be said that the first extracted subfactor F4_1 (Optimal size of the group in terms of the number of its members) consists mainly of research tool Q4_2 (Small group discussions as a waste of time in terms of benefit) with the achieved value of the standardised regression weight at the level of 0.943, and, at the same time, the item of the research tool Q4_3 (I afraid to speak out in front of a whole big group of people) with the achieved value of the standardised regression weight at 0.729. These two items point to the fact that, on the one hand, if the discussion is to take place within a small group/team of students, it is a waste of time. The reasons can, of course, be various, from the inappropriate composition of teams in terms of the level of knowledge to the uneven and incorrect distribution of partial

tasks in solving the problem to its individual members. This, of course, implies the requirement to design a team task very precisely into parts so that all team members are loaded evenly with approximately the same level of difficulty, but in such a way that the result of solving the task is collective work, and all group members contribute to it. On the other hand, the research tool item Q4_3 (I think discussions usually made the class more engaging) represents the second pole of the same problem. Here, students express the opinion that they feel the fear/apprehension in connection with speaking in front of a large group. So, on the one hand, students see small group discussions as a waste of time, but, on the other hand, they are afraid to talk in front of a large group. However, this phenomenon is widely observed and is to some extent caused by the rapid development of impersonal communication within social networks, as well as the disruption of social contacts due to measures during the global COVID-19 pandemic. For successful management, it is, therefore, necessary that the size of the group that creates the team and solves the assigned task is optimal in terms of its size. However, what is optimal, from the point of view of the number of team members in solving tasks within the subject of the study of forensic molecular biology, while respecting the above facts, should be the subject of further research. The second extracted subfactor (F4_2), the fourth research area (Discussion of learning strategies and activities), is created by two items of the research tool: Item Q4_7 (Whole-class discussions were more consistent and positive experience) with a standardised regression weight of 0.926 and Q4_6 (I think there is homogeneity among group members in terms of participation and knowledge level) with a standardised regression weight of level 0.614. In general, students see class discussions as beneficial and positive, which certainly expands their knowledge as well as approaches to problem solving and tasks. Here, according to the results, it is important that the members of the class have an approximately homogeneous composition in terms of knowledge, which can enrich the class, but on the other hand, knowledge deviates from the average, which does not give other members a sense of inferiority. This condition is one of the basic preconditions for group success and group problem-solving. However, this needs to be aligned with the first extracted subfactor and the optimal number of students in the class defined. However, if students have approximately the same knowledge, we assume that the groups can be larger. Students in such a homogeneous group can discuss and present their views and findings with others without much fear. They thus avoid negative consequences and criticism from team/class members who have more knowledge in the subject. The last extracted subfactor (F4_3) of the fourth research area significantly affects only the item of the research tool Q4_1 (Small group discussions occur very frequently in this VR scenarios and the world) with the achieved value of the standardised regression weight at the level of 0.956. Despite a certain negative attitude to the discussion in small groups, which is perceived by the respondents as a waste of time, the purpose of teamwork on a given task/project is mutual communication and exchange of information between team members. In a sense, this need for mutual communication represents a preparation for real practice, where solving complex problems within forensic molecular biology requires cooperative action. Therefore, it is right to include discussions about a problem in small groups/teams very often.

TABLE 9. Regression weights and standardised errors of model 4 for the fourth research area.

Relationship			Covariance				Correlation
			Estimate	*Std. error*	*t - static*	*p-value*	Estimate
F4_1	<-->	F4_2	0.109	0.027	4.069	0.000*	0.180
F4_2	<-->	F4_3	0.093	0.015	6.131	0.157	0.064
F4_1	<-->	F4_3	0.025	0.034	0.740	0.459	0.007

* - significant at the level of significance $\alpha = 0.05$

The values of the covariance and correlation coefficients (Table 9) of exogenous variables point to the fact that at the significance level $\alpha = 0.05$, there are significant links only between factors F4_1 and F4_2 (0.180). In terms of absolute value, however, this link can be considered small. From the above conclusions, which touch on the fourth research area (Discussion of learning strategies and activities), a direct relationship between the optimal group size (F4_1) and the positive influence of the group in mutual discussion (F4_2) is evident. However, a necessary condition based on the results is that the groups are homogeneous in terms of knowledge level and, at the same time, that the size of the group is optimal. Based on the analysis, it is clear that if the group is small, the discussion is a waste of time for the student, and if it is large, students are afraid to join in the discussion.

The last fifth research area defined as Teacher Performance (Model 5) is defined by the model according to Figure 5. It is clear from Table 1 that the indicators describing the suitability of the model structure acquire limit values in several indicators, but they are still within the set limits. Therefore, we can consider Model 5 to be good in describing the fifth research area. The three-factor model consists of three exogenous variables and ten endogenous variables and is defined in Table 10 in terms of regression coefficients.

Based on Table 10, it can be said that all interrelationships between defined endogenous and exogenous variables are significant at the significance level $\alpha = 0.05$, except for the association of factor F5_1 and the questionnaire item Q5_10 (Teacher reviews ideas previously learned). However, this research tool item is significant in relation to the third extracted subfactor (F5_3) of the fifth study area.

From the analysis of the results of the confirmatory factor analysis of the model for the fifth research area (Teacher Performance), it is clear that the first extracted subfactor is created by items of research tool Q5_6 (Teacher breaks the task down when students are struggling) with the achieved value of standardised regression weight at -0.916. The second, the most important item of the research tool for the respondents is the item Q5_8 (Teacher allows time for students to process and does not immediately give the answer) with the

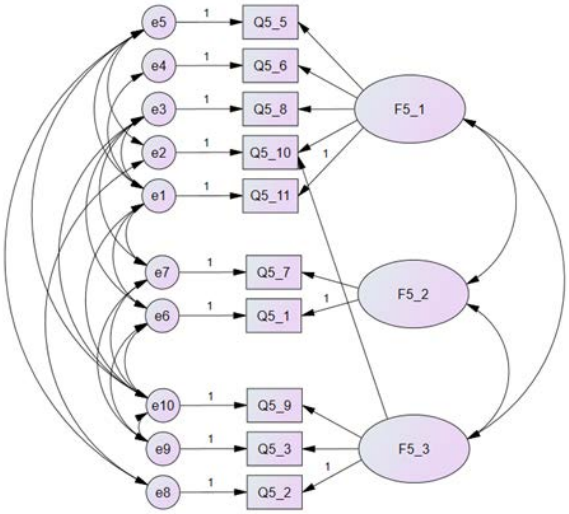

FIGURE 5. Model 5 for the fifth defined research area (Teacher Performance).

TABLE 10. Regression weights and standardised errors of model 5 for the fifth research area.

Relationship			*Estimate*	*Std. estimate*	*Std. error*	*t -static*	*p - value*
Q5_11	<---	F5_1	1.000	0.464	0.087	9.844	0.000*
Q5_10	<---	F5_1	-0.064	-0.062	0.082	-0.787	0.431
Q5_8	<---	F5_1	-0.910	-0.76	0.104	-8.769	0.000*
Q5_6	<---	F5_1	-1.126	-0.961	0.101	-11.117	0.000*
Q5_5	<---	F5_1	-0.969	-0.715	0.088	-11.013	0.000*
Q5_1	<---	F5_2	1.000	0.848	0.115	10.235	0.000*
Q5_7	<---	F5_2	1.202	0.852	0.115	10.467	0.000*
Q5_2	<---	F5_3	1.000	1.041	0.163	12.991	0.000*
Q5_3	<---	F5_3	0.623	0.679	0.042	14.849	0.000*
Q5_9	<---	F5_3	0.562	0.563	0.042	13.45	0.000*
Q5_10	<---	F5_3	0.945	0.960	0.091	10.442	0.000*

* - significant at the level of significance $\alpha = 0.05$

achieved value of the standardised regression weight at the level (−0.760) followed by the item Q5_5 (Teacher focuses on specifics, not just right and wrong) with a regression weight of −0.715. The three items of the research tool represent the negative attitude of the respondents, and if we define the first extracted subfactor of the fifth research area called: Teacher as a tutor, they point to facts that are perceived badly regarding the teacher. First of all, it is the pedagogical and didactic activity of the teacher in the process of solving the assigned task by students. Students consider it appropriate for the teacher to be able to identify problems in solving the problem, in which case the problem will be further subdivided into smaller, more manageable parts. Of course, in addition to the teacher's pedagogical skills, this also requires deep professional knowledge of the issues addressed. The second critical area of this subfactor is the teacher's patience. If the teacher lacks this quality, it is highly criticised by the students.

Students assume that the teacher does not require answers immediately after assigning the task but will allow the student time to think about the answer in peace. Thus, the educator does not put pressure on performance but on the process of thinking and defining answers, which is supported by the third significant item of the research tool, which creates this first subfactor, item Q5_5 (Teacher focuses on specifics, not just right and wrong). In addition to acquiring knowledge, the learning process is also a process of building and gradually solving a defined problem. Because students of forensic molecular biology are aware of this, they perceive negatively if the teacher focuses only on the outcome. We named the second extracted subfactor (F5_2) of the fifth research area: Teacher as a tutor. This subfactor is mainly created by the research tool item Q5_1 (Teacher helps in constructing the hypotheses and how to solve the problem) with the achieved value of the standardised regression weight at the level of 0.848 and the research tool item Q5_7 (Teacher reminds students of a rule or strategy to use) with an achieved value of the standardised regression weight at the level of 0.852. It is clear from the values of the standardised regression weight that both items have approximately the same weight for the respondents. Respondents/students state that the teacher is an irreplaceable factor in successfully solving the task, so in many respects, they rely on teachers. This is especially noticeable in methodological issues, where obviously the teacher has more experience, and it is a fundamentally new thing for students. Furthermore, we can assume that students are trying to acquire the methodology by repeating it by the teacher. We named the last extracted subfactor (F5_3) of the fifth research area: Teacher as a tutor. This subfactor consists mainly of items of the research tool Q5_10 (Teacher reviews ideas previously learned) with the achieved value of the standardised regression weight at the level of 0.960. The second significant item of subfactor F5_3 with the achieved value of the standardised regression weight at the level of 0.941 is the item Q5_2 (Teacher turns responsibility back to students for thinking through and figuring out ideas). The third most important item of the research tool that creates subfactor F5_3 is the item Q5_3 (Teacher interprets what students are trying to express and rephrases ideas so students can become part of the discussion) with the achieved value of the standardised regression weight at 0.697. From these results, it can be concluded that the respondents expect the teacher to evaluate their ideas in the process of solving the assigned tasks but, at the same time, expect that the responsibility for thinking and coming up with ideas is transferred by the teacher back to the students. On the one hand, respondents/students expect ongoing correction, guidance and evaluation, but, at the same time, they expect that they should be responsible for the progress of the solution. This statement also supports the significance of Q5_3, and students expect that if they are unable to express their ideas sufficiently, the teacher will reformulate them so that students can re-engage in the discussion and continue. These are high expectations of students from the teacher as a tutor. The analysis of the fifth research area shows that students perceive the teacher on three mutually complementary levels: as a teacher, scientist, and tutor. It turns out that all three levels are very important from the student's point of

view to achieve the set tasks. At the same time, it turns out that the teacher is irreplaceable and necessary in the process of a forensic molecular biology course.

This study aimed to establish whether the cooperative, field trip, discussion and problem-solving strategies and activities implemented with the digital technology represents good support to the learning process. From the results of this study, all evaluated indices confirm the correctness of the proposed Model_1 for the cooperative strategies and activities. Most students reported having a positive experience with the collaboration strategies and activities during learning crime scene investigation using a virtual environment. These results are compatible with a previous study conducted by Back at al [25] who concluded that a collaborative virtual reality environment maximizes benefits for both learners and educators. Our results suggest that students of forensic science courses reported higher motivation in the field trip activities inside the VR environment. These results agree with [26], who studied the impact of field visits on learning through virtual reality and compared them with actual field visits from the students' point of view. Virtual reality outcomes resulted in higher scores on learning experience and perceived learning outcomes than in a real field visit.

The results showed that VR is a helpful tool for learning and practising problem-solving skills in forensic science and crime scene investigation. These results are compatible with [27], who studied the extent to which students interact and succeed in problem-solving skills while learning using VR technology, they reached results similar to the results of this study.

IV. CONCLUSION

This piloting study concludes that creating virtual tours for educational purposes is considered a tool for learning forensic sciences and crime scene investigation.

From this finding, we can derive that VR technology facilitates the didactic experience of the cooperative, field trip, discussion, and problem-solving learning strategies and activities.

The study results emphasize that VR may act as an efficient track to improve the learners' forensic science knowledge. Future research should evaluate other factors like cost-effectiveness and adverse reactions when evaluating the teaching impact of VR in forensic science.

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