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PAPER

Affective Learning in the Context of Remote Experimentation

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ABSTRACT

We analyzed the remote experiment's position on **"affective learning"** and found that it significantly influenced students' attitudes toward the applications. It emphasizes autonomy in learning and the coagulation aspects of ad hoc learning groups based on cognitive criteria, avoiding the artificial criteria (beautiful, ugly, sympathetic, unfriendly) typical of group formation in the physical environment. A detailed analysis of the students' emotional responses, according to Wlodkowski's classification, is made. The paper points out that the affective effect of the R.E. is treated as a secondary element in curricula, all assessments being oriented towards **"cognitive learning"** because the affective components involved are part of the **"internal state"** of the student. Based on Dave's (1979) psychomotor taxonomy, the importance of R.E. in blended learning has been presented, where the cognitive content of learning remains unchanged, and the affective effect of the R.E. adds to teaching the techniques and the social dimensions.

KEYWORDS

distance learning, autonomous development, computer-aided engineering, collaborative work, continuing education, experiential training, taxonomy

1 INTRODUCTION

The addition of the physical learning environment to the virtual environment has led to important positive developments in teaching and learning. Remote experiments have become an essential element of modern pedagogy since the introduction of technology (Internet) in teaching/learning. Going through the COVID-19 pandemic highlighted aspects of online education that we might not have noticed if we continued to use it sequentially. The generalization of the online approach showed that using the virtual environment for knowledge transfer has strong particularities related to the affective part of the students, which must be considered when designing online lessons.

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Another argument in favor of studying the affective aspects of remote experiments is brought by the increasingly intense adoption of IoT (Internet of Things). In essence, any IoT application is a remote experiment that enters our social life and influences it both materially and emotionally.

The remote experiment is a particular case of e-learning, which, however, retains its main feature, namely the autonomy of the learner. In the vision of Little (1999): "… *autonomy is the ability to detach, to reflect critically, to make decisions alone and to act independently*…" [1], [2]. What Little does not explicitly state is that learning autonomy does not exclude the three areas of learning: cognitive (Bloom), affective (Krathwohl), and psychomotor (Harrow) [3], [4], [5].

This idea also includes the fact that remote experiments transfer all these domains to the virtual environment, combining them in their way with autonomy, often being accused of altering social interactions. Much has been written about the remote experimentation contribution to the cognitive field. Quite little has been written about the correlation between remote experiments and affective learning, even after research has shown that the cognitive part is more successful if it goes hand in hand with educating students about feelings, beliefs, and attitudes. [6], [7], [8].

How should affective learning be implemented in the virtual environment? It seems that it is necessary to keep the same three levels as those in the physical environment, namely, the individual level, the group level, and the institutional level. These levels of affective learning have a series of particularities due to the virtual environment but also due to special features introduced by remote experiments, namely:

At the individual level: the defining feature is the autonomy that remote experiments imply (as a part of e-learning). The affective part of autonomous work begins with the student declaring the goal he wants to achieve by maneuvering a certain remote experiment. If the paper contains a subroutine for declaring goals (for example), students will feel better, will have the feeling of working on solid ground, and will have an increase in self-esteem that will protect them from the negative influences of the virtual environment. Manipulating a remote experiment with a well-defined goal can improve your mood, and with it, your school performance.

At the group level: In affective learning, interpersonal relationships between students are important. The main task in realizing these relationships falls to the creator of the remote experiment, who, deliberately, must introduce, during the maneuver of the experiment, a moment of exchange of information with other students or tutors, without which the completion of the experiment will be much more difficult. Thus, real-life moments are introduced in affective learning, and a series of social skills that are needed throughout the career are introduced.

At the institutional level: affective learning includes the relationship between students, teachers, and tutors. It refers both to the cognitive part, i.e., to the decipherment of the new theoretical and practical notions introduced by remote experiment, and to the part of creating an atmosphere that makes the students feel that they are part of a family that guides them in the accumulation of knowledge and who understands their problems, regardless of their nature. The teacher must remotely develop the experiment in the above sense so that students perceive their affectivity as unconditional support in building a career. Based on the above, a deeper analysis is necessary.

2 METHODS

To highlight the remote experiment's importance in the student's psychology, the method of critical analysis of current theories related to affectivity was applied. Unfortunately, most of these theories were developed at a time when technology had not yet entered the use of teaching and learning. As a result, the present paper took these theories as pivots and adapted them to the requirements of the virtual environment, the use of the Internet in e-learning, and the recent conclusions related to the exclusive use of distance learning caused by the COVID-19 pandemic. It was critically analyzed how the constitutive elements of the types of intelligence (IQ, EQ) are concerning the remote experiment, how Wlodkowski's theory can be integrated into the design principles of R.E. and it was critically analyzed if Krathwohl's taxonomy includes elements from the stimuli that the remote experiment brings to the area of teaching/learning. Along this line of critical analysis, the stages and manifestations of affectivity were exposed in the student's contact with the experiment at a distance, that is, with the virtual environment, which, together with the real one, changes many of the theories of affectivity known up to now.

3 DISCUSSIONS AND COMMENTS

Multiple intelligence theory was developed in the 1980s and was the basis of IQ (Intelligence Quotient) tests. In-depth studies of IQ have shown that because they are based on vocabulary, the recognition of shapes, spatial correlations, etc., they are limited in describing the chances of success in life and do not include the entire model of intelligence. Equally important for a global approach to human personality is the EQ (emotional-intelligence quotient) test [9], [10]. Because the remote experiment is a learning path, it strongly correlates with the two indicators mentioned above. However, the remote experiment also has a strong correlation with other types of intelligence, and therefore a brief analysis of these correlations is edified to illustrate which categories of intelligence are activated by remote experiments, or more generally, by the virtual experiential environment (refer to Table 1).

Table 1. Correlation between R.E. and type of intelligence

Nr Crt.	Type	Remote Experiment Position
1	Linguistic/verbal Intelligence	Working autonomously in front of the computer should not activate this type of intelligence. Practice shows that it is much more important than the name suggests. Remote experiments can be designed and performed both in the language of the country of origin and in English. Networks of remote experiments are mostly in English. When searching for similar experiments or complementary experiments to the one studied, language problems become acute and can lead either to success if English is intelligently mastered or to failure and abandonment if problems of linguistic meaning or linguistic significance are poorly mastered. The remote design of the experiment must consider linguistic intelligence so that the student finds it support and not a reason to give up the experiment.
2	Logical/mathematical Intelligence	There are remote experiments based on mathematical knowledge and logical approaches. Intelligence in this category is of the Yes-No type. Those who possess this type of intelligence can lead the experiment to an end, even if during its handling they need to stop to enrich their mathematical knowledge. Those with severe deficiencies in this type of intelligence will have to give up. Whoever designs a remote experiment must consider this type of intelligence as a development engine and not as a brake, resorting to mathematical paths from simple to complex, not directly to the maximum level, just because that is what is required in the curricula.

(Continued)

Table 1. Correlation between R.E. and type of intelligence *(Continued)*

Nr Crt.	Type	Remote Experiment Position
3	Spatial/Visual Intelligence	There are remote experiments in the virtual environment designed in 3D. The lack of spatial-visual intelligence makes it impossible to handle this category of applications. Often the remote authors of 3D experiments prepare the approach of the experiment through an introduction that tests spatial-visual intelligence and does not allow access to the actual experiment if it finds the lack of this type of intelligence. If 2D expression is possible even in a simplified form, this way is also recommended only to avoid creating feelings of helplessness and frustration.
4	Body/kinesthetic Intelligence	This type of intelligence is rarely used in the case of autonomous work in front of the computer.
5	Musical/rhythmic Intelligence	Idem
6	Interpersonal Intelligence	This type of intelligence is essential when the remote experiment requires contacting other people, more advanced in knowing it, or comrades of "*suffering*" in the attempts to decipher the paths that must be followed to reach the end. The qualities that are used (existing in the person as a cause) or those that are formed as contact progresses from experiment to experiment become, in time, defining the formation of a social personality.
7	Intrapersonal Intelligence	Overcoming obstacles in one or more remote experiments may allow for good self-knowledge. Self-knowledge is even helped by the autonomy in front of the computer and the virtual environment in which the remote experiment takes place. In order not to have characterological distortions given by the virtual environment, it is good for those who think the remote experiment permanently ensures connections with the real environment and the requirements of the virtual environment to always coincide with those of the real environment.
8	Naturalist Intelligence	The virtual environment does not make remote experiments user, nature-loving. Even if remote experiments are often related to the natural environment, their handling does not form naturalist-intelligence.

Regardless of the type of intelligence we refer to, each respects the taxonomy of emotions and feelings defined by Krathwohl (1977). From simple to complex, the steps of this taxonomy are:

"Receiving." The student has different degrees of sensitivity to stimuli. These stimuli can come from the linguistic field (i.e., the joy of understanding explanations in a foreign language or, conversely, depression in front of tests with terms encountered for the first time), from the logical/mathematical field (i.e., stimuli are formed from logical connections between information received through remote experiments or from working with abstract concepts), or from the visual/spatial field (i.e., stimuli are constituted by the manipulation of images, by the interpretation of some images, by the correct understanding of the graphics, or by visual metaphors).

The second "*affective learning*" taxonomy stage is **"Responding."** Although they are subjected to the same type of stimuli in a remote experiment, students respond differently. According to Wlodkowski (1985), four areas differentiate the emotional responses of students [11], [12]. Table 2 shows Wlodkowski's classification and its update in the case of remote experiments.

The third stage of the "*affective learning*" taxonomy is **"Valuing,"** which refers to the student's emotional commitment to a value, which is preferred and accepted. Everyone has a system of values and attitudes. The appearance of this value system is determined by the process of internalization of cognitive transfer. On this basis, returning to R.E., this is a pedagogical method related to experiential learning (Kolb, 1984) [13].

Table 2. Wlodkowski's classification in the case of R.E.

Nr. Crt.	Wlodkowski's Areas	Updating Wlodkowski's Areas in the Case of the Remote Experiment
1	Emotions influenced by student moods	These influences are relative in the case of remote experiments because there is no longer a teacher-student subordination relationship. This means that it is not a repeated situation in which the teacher holds the lessons after a program, and the student can be caught in this program in a bad mood. When the student wants to handle R.E. does not depend on the teacher's program due to the asynchronous nature of the virtual environment, thus having the freedom to choose the moment. However, the R.E. learning materials themselves, i.e., the software, the virtual montages, and the handling instructions, can have emotional influences. They can elicit an emotional response from the student and consequently influence how the student interacts with and learns from R.E.
2	The influence of the instructor	It is an important affective part of R.E. If the instructor is a person, his pedagogical qualities can add a greater interest in cognitive accumulation and thus, the affective part of augmented learning. It is possible that the instructor is very busy and therefore limits himself only to dry instructions for handling the software and hardware and thus does not arouse in the student an affective component. If the instructor is virtual (e.g., dedicated software), the emotional part is just a convention that the student accepts or rejects.
3	Reactions influenced by the learning process and teaching materials	This type of area is typical of classical "*face-to-face*" education. Autonomy in front of the computer was not addressed in 1985 when Wlodkowski developed his theory that R.E. is both a learning process and teaching material. In the virtual environment, with the student positioned alone in front of the computer, the responsibility for influencing the student's emotional reactions rests on the creators of R.E. Most of the time they are concerned with the success of the experiment itself and less with the emotional reactions that the experiment arouses in the student. As a result of this attitude of the creators of R.E., the student's affectivity will be manifested by curiosity in the proportion of 80%.
4	The student's response to the group of students	Although this affective area is also characteristic of classical learning, R.E. can determine it. Most of the time learning autonomy is accompanied by the transfer from the individual to the group level because the many stages of handling an R.E. can be overcome more easily by exchanging experiences between autonomous people. The group of students, however, has different characteristics from the group to which Wlodkowski referred. First, it is formed ad hoc. Secondly, it is based only on the exchange of information and not on friendships resulting from school coexistence as in the case of the Wlodkowski group. Third, the formation of the group is based on elements of cognitive transfer offered by R.E. and not on those determined by interpersonal relationships. Fourthly, the group exists in the virtual environment, not in the real one, and does not consider the geographical (same location) or institutional (same institution) limitations. Fifth, the virtual group is exempted from generating negative emotions typical of living in a group, such as threats, fear, physical impotence, rejection, or incompetence.

The activities involved in an R.E. often lead to affective reactions that the creator of R.E. did not specifically propose. So:

- **Use of symbols:** R.E. uses many symbols in the description of the software and the description of the hardware or the supporting explanatory materials. Some of these symbols become personal values if they are used several times and used by the student to pass on to others his new knowledge.
- **Reaction:** Often an R.E. asks the user for an immediate reaction to a stimulus, notion, software sequence, hardware button, etc. The pride of reacting correctly and with the required speed can be the subject of discussion in ad hoc groups and a value that the best can claim.
- **Critical incidents:** During the handling of the experiment, there may be critical incidents that require either the resumption of the entire experiment or new solutions necessary to overcome the situation. The value accepted by the student

when they encounter this situation is "*learning by failure*." Learning from mistakes is one of the most important values that are passed on to students within the R.E. It removes the fear of mistakes, the guilt of not finding the way to the end of the experiment, the disregard of those who make mistakes—values that for decades have affected students' grades in the process of knowledge transfer.

The fourth "*affective learning*" taxonomy stage is **"organization."** It consists of the acquired values conceptualization and placing them in their system of values. R.E. can stimulate this process by the fact that the student does not have access only to one type of experiment, as in the case of "*face to face*" laboratories, but can access the Internet so many experiments with the same topic until it is fully clarified. As the accessed experiments reflect different didactic approaches, different montages, and different software, the student will develop their own system of "*critical questioning*," their system of "*reflection on the process*," one of "*process checked,*" and one of "*memory and imagination*," etc. All these will support him in the conceptualization of values and the formation of his system of values.

The fifth stage of the "*affective learning*" taxonomy is **"characterization,"** which consists of processes of generalization and creation of one's philosophical system. This is also formed by incorporating what is learned in RE into one's philosophical system.

The student forms their own opinion and thinking based on what they were taught, regardless of the delivery method, so R.E. contributes to the formation and augmentation of the personal philosophical system. R.E. has direct implications because this stage shows that the student operates with professional and ethical standards valid in a virtual environment together with the influences of the real environment in which they live.

3.1 Remote experiment and affective learning

All the above concerning the connections that existed between R.E. and the steps of the "*affective learning*" taxonomy allow us to state that the affective domain is not explicitly included in the curricula. It can be positioned as a secondary area compared to "*cognitive learning*" because its separate assessment is not yet done, and all assessments are focused on "*cognitive learning*." The strongest and most credible justification for this secondary shift in "*affective learning*" assessment is that actions to stimulate affective components are part of the student's "*internal state*," manifest only in the mind, and are difficult to highlight by classical methods of evaluation and do not have a quantitative correspondent.

Others state that it is not the best strategy to teach the knowledge of a large group of students using traditional methods and that the use, in parallel, of other pedagogical methods is recommended [14]. R.E. is a part of these new methods being a concrete form of experiential learning, (Dewey-1938), and a part of a new learning environment—the virtual one—that can be employed only using advanced technologies (computers, and software) [15].

The main levers of R.E. that contribute to the strengthening of the affective side of learning are: the practical application of theories, understanding and appreciation of alternative variants for the studied topic, social knowledge, strengthening ethical values, knowing the satisfaction of direct work on a given topic, formation of ad hoc groups oriented on a specific topic, reflections on the experiments, and the feeling that you can deal with a topic and even that you can improve it with your ideas and actions.

In addition to the levels that determine affective reactions described above, it can be shown that R.E. converts elements of psychomotor taxonomy into affective levels. If we were to choose Dave's psychomotor taxonomy (1975) [16], the conversion would look like this in Table 3.

Table 3. Dave's taxonomy and remote experiment

Nr. Crt.	Dave's Taxonomy (Psychomotor)	Conversion to Affective Leverage Given by R.E.
1	Imitation	Even if "*imitation*" refers to the physical part of the gesture, the situation is translated into virtual actions in the virtual environment. Thus, R.E. allows the observation of several similar experiments and the imitation (copying) of some solutions. The feeling developed is that of security given by the fact that, in the absence of our solutions, there is always the possibility of finding other imitative solutions on the Internet.
2	Manipulation	Any R.E. orients its user through manipulation instructions. The developed feeling is gaining skills by manipulating an experiment according to the instructions. It is becoming a habit in life to look for instructions for use in any new process or thing encountered because of the feelings induced by R.E.
3	Precision	From the point of view of precision in thinking R.E., it is like any other educational system that requires this quality. Considering the "prefabricated" character of R.E., precision in thinking seems to be solved by the author of the experiment, but in fact, the student does not reach the stage of precision in thinking of the author from the beginning because they also go through phases of failure during the handling of the experiment. So, it can be said that R.E. involves feelings and attitudes related to precision in thinking and in obtaining results.
4	Articulation	R.E. allows the articulation of several competencies and their application in manipulation. It is also one of R.E.'s qualities in terms of learning. The feeling developed is safe if the student discovers that they possess the competencies that must be articulated to lead the experiment, sentimental ambition when the student becomes aware that they must learn to advance in the experiment, and sentimental giving up when they lack too many skills and do not have what to articulate.
5	Naturalization	It reflects the moment when the articulation of competencies is quasi-automatic, with minimal mental effort. The feeling developed is that of security, of advanced knowledge. The student's feeling of sharing what they possess at this level also increases. Reaching this stage requires a large amount of well-completed R.E.

3.2 Contributions of Virtual Learning Environment to Affective Learning

The best results of R.E. were obtained in an environment called "blended learning," a mixed environment resulting from the combination of the virtual environment with the physical environment. What is new to the field of learning through the virtual environment? The subject is, the student—acts through the hardware and software.

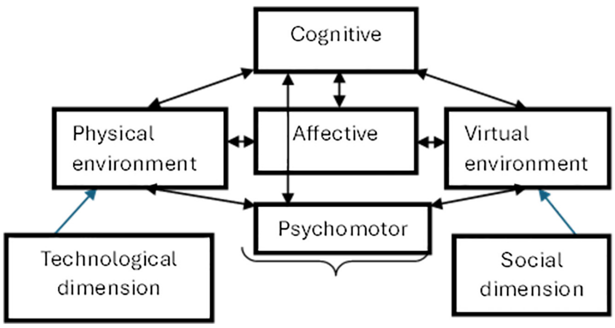

Fig. 1. Dimensions added after R.E. involvement

That is why the student must first know these technologies to be able to maneuver R.E. So, technology becomes a new dimension of affective action (see Figure 1). What remains unchanged in the mixed environment, physical and virtual, is the cognitive content. Instead, two new dimensions appear:

- **"The technological dimension"** – Without knowing what the student cannot feel as a participant in the virtual environment. The student becomes conscious and must recognize their cognitive limitations when they encounter operating difficulties.
  "The social dimension" consists of the capacity to form a learning community in a virtual environment through individual relationships.

Another dimension can be defined—the biopsychological one (Dale 1969) [16]. Its operationalization involves deliberate actions to observe gestures, heart rate, respiration, body temperature, eye movement, etc. This dimension is more related to "*psychomotor learning*" than to affective learning.

The most important finding from the synthesis of the above is that digital technologies used for learning in the virtual environment, combined with pedagogical technologies used in the physical environment, lead to important changes in the relationships between didactic subjects: teachers, students, and tutors.

The first change was mentioned in the introduction of this material and refers to autonomy. The student alone makes decisions and reacts independently. This involves the development of special psychological relationships of the student with the cognitive content of R.E. and with the learning process. According to Little (1996), the student's autonomy makes him a simultaneous experimenter (researcher), communicator, and "*intentional learner*" (i.e., to be aware of both the cognitive aspects of the learning process and the affective ones).

The motivational aspects added by the autonomy of R.E. have been defined since 1987 by Keller [17], when R.E. did not exist as a pedagogical method and digital technology was not yet supported for learning in the virtual environment. These are:

- **Curiosity:** The student approaches R.E. out of the desire to have practical explanations for a theoretical aspect or out of the desire to find new experimental facts for a virtual experiment that did not fully satisfy him as a didactic approach.
- **The challenge:** After handling an R.E. contained in the curriculum, the student wants to rise to more complex levels for the same subject and thus searches the Internet for other similar thematic R.Es.
- **Confidence:** It appears if the student finds that his cognitive acquisitions, before approaching an R.E., allow him to go through it without completing knowledge.
- **Control:** it occurs if the student finds that the operating instructions of an R.E. are clear, precise, and sufficient to complete it.

The second change is related to the transition from autonomy to "*collaborative learning,*" a transition necessary because the physical and virtual environment allows and often requires this form of learning. It should be noted that there are also changes in the relationship between teachers, students, and tutors. All the characteristics that the learning strategy designer must consider are desired to be mentioned synthetically as follows:

- **Social affinity:** In collaboration on topics, R.E. students are not united by the fact that they handle the same experiment but by their social affinities. Otherwise, they will not be able to work together.

- **Cognitive abilities:** Even if the social affinities correspond, to work together, the students must have a close cognitive level.
- **Nature of the task:** R.E. on which the collaboration is made must be part of the curriculum; otherwise, there is no motivation to learn.
- **Distribution of control:** students collaborating on an R.E. must be cognitively complementary to have the feeling not only that they receive, within the collaboration, but also the feeling that they give, that they have a position in the group.

Autonomously or in a group (collaboratively), the student always has attitudes and feelings towards an R.E. Figure 2 shows a scheme that reflects some reactions determined by the affective evaluation of the R.E. generally together with the correlations it determines.

3.3 Calculation of "*treatment effects*"

Based on what is shown in Figure 2, we can say that the strongest and most edifying affective influence occurs when the remote experiment is handled autonomously or in a group (collaboratively). This operation triggers (see Figure 2) three reactions, namely, dissatisfaction – a_1, uninteresting – a_2, and interesting – a_3. To evaluate if these reactions determine influences in the preparation of the students, an online experiment was designed, using the CVTC server (Center for Valorization and Transfer of Competence) of Transylvania University from Brasov. The Keppel method [1] of measuring "*treatment effects*" in students' affect was applied.

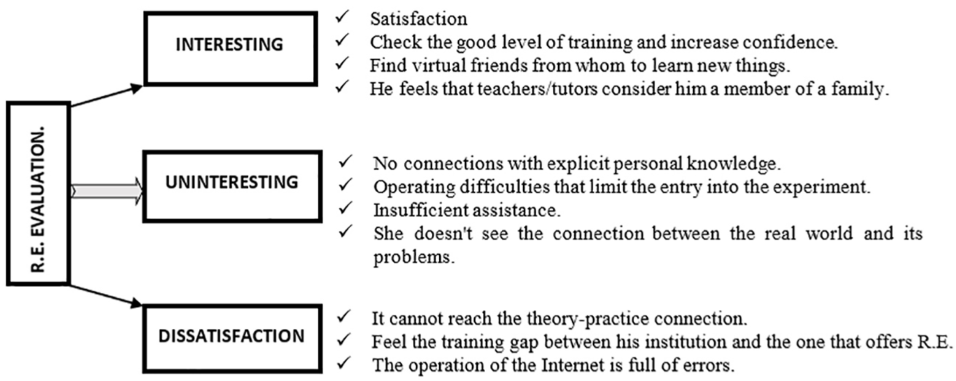

Fig. 2. Affective criteria for R.E. assessment

The tested experiments were intentionally chosen with the potential to generate the three attitudes mentioned above (a = 3), addressing those with knowledge in a certain software direction, which was not available to all, to those who had performed such experiments. and to those who had the necessary knowledge. The score was not done with grades from 1 to 10 but with points from 1 to 20 to allow a better range of appreciation and comparison. Three groups of students were formed (with s = 8 members in each group), one for each affect considered as an independent variable. The first group had to highlight the parts of the experiment that caused dissatisfaction. The second group had to mention why the experiment was uninteresting. The third group mentions what is interesting in the experiment. Considering the diversity in the prerequisite knowledge about the software and hardware of the students, the different levels of knowledge of English, and the variability of the speed of Internet connections, it can be said that the emotional situation was generated by the variables considered.

Following the responses received on each level, the notes were recorded (we use Keppel notations [1], including the form of his calculation tables) as presented in Table 4.

It is established "*between group sum of squares*":

$$SS_A = \frac{\Sigma(A)^2}{s} - \frac{(T)^2}{a \cdot s} = 217 \tag{1}$$

It is established "*within group sum of squares*":

$$SS_{S/A} = \Sigma(AS)^2 - \frac{\Sigma(A)^2}{s} = 298 \tag{2}$$

It establishes the average: $\bar{T} = 13{,}00$ and

$$SS_T = SS_A + SS_{S/A} = 515$$

Table 4. Test notes

	Treatment Levels		
	a_1	a_2	a_3
	8	10	17
	9	11	18
	9	14	16
	11	16	19
	14	13	17
	10	11	20
	9	11	14
	8	12	15
A_i	**78**	**98**	**136**
$\bar{A}_i$	**9.75**	**12.25**	**17**
$\sum_j^s (AS_{ij})^2$	**786**	**1228**	**2340**

The deviation scores analyze is referred to the deviation of grades of each student from the overall average $\bar{T}$, and these deviations are divided "*between group deviations*":

$$(\bar{A}_i - \bar{T}) \text{ and "within group deviations": } (AS_{ij} - \bar{A}_i) \tag{3}$$

The total deviation is:

$$(AS_{ij} - \bar{T}) = (\bar{A}_i - \bar{T}) + (AS_{ij} - \bar{A}_i) \tag{4}$$

This relationship leads to Table 5.

Table 5. Deviation scores

(AS_{ij})	$(AS_{ij} - \bar{T})$	$(\bar{A}_i - \bar{T}) + (AS_{ij} - \bar{A}_i)$	
Level 1			
8	8 – 13 = –5	9.75 – 13 = 3.25	8 – 9.75 = –1.75
9	9 – 13 = –4	9.75 – 13 = 3.25	9 – 9.75 = –0.75
9	9 – 13 = –4	9.75 – 13 = 3.25	9 – 9.75 = –0.75
11	11 – 13 = –2	9.75 – 13 = 3.25	11 – 9.75 = 1.25
14	14 – 13 = 1	9.75 – 13 = 3.25	14

Although $(\bar{A}_i - \bar{T})$ there are deviation scores higher than zero in the example, they are insufficient to justify the conclusion that treatment effects in the population can be noticed. The only suitable indicator for this conclusion is the ratio:

$$F = \frac{\textit{between group variance}}{\textit{within group variance}} \tag{6}$$

much more useful for verifying the validity of the null hypothesis. It is known that when its values are lower than "1" H_0 is true, and when its values are greater than "1" the alternative hypothesis H_1 is true.

For F calculation is used for the relationship:

$$F = \frac{MS_A}{MS_{S/A}} \tag{7}$$

where:

- MS_A represents the combination of the treatment effects at which is added the variance errors.
- $MS_{S/A}$ presents only variance errors.

For the calculation of these sizes, we need the value of the "*degree of freedom*." This is defined as the difference between the number of independent observations and the number of the estimated population. In our example, we have $a = 3$ representing the treatment conditions, and s = 8 representing the number of subjects analyzed. As a result:

$$df_A = \text{a} - 1 = 2$$

$$df_{S/A} = a \cdot (s - 1) = 21 \tag{8}$$

using the previously calculated values are thus determined:

$$\begin{aligned} MS_A &= \frac{SS_A}{df_A} = \frac{217}{2} = 109.5 \\ MS_{S/A} &= \frac{SS_{S/A}}{df_{S/A}} = \frac{298}{21} = 14.19 \end{aligned} \tag{9}$$

$$\text{Result: } F = \mathbf{7.716} \tag{10}$$

Even if the value is sensibly higher than "1" before concluding, it is necessary to set the critical value for $F(F')$ and compare it to the calculated value.

From the tables (Fisher and Yates, 1953) for the value F (2; 21) (i.e. F ($\text{d}_{\text{nominator}} = 2$, $\text{d}_{\text{denominator}} = 21$), at $\text{d}_{\text{denominator}} = 21$ there are several values for $\text{d}_{\text{nominator}} = 2$ (refer to Table 6).

The rule of decision is as follows: H_0 shall be rejected if, $F^{0.025}_{calculated} \geq 6.65$. Obviously, $F = 7.716$ fulfills this condition, so it is possible to reject H_0 and accept the alternative hypothesis H_1, which means that the population has experienced "*treatment effects*" (affects that were considered independent variables) following the remote experiment. This example shows that the students who were tested had enough knowledge to be able to discern between the three states that an experiment generates, without the need for additional training. The accuracy of the test can increase from 2.5% to 0.1% if students take special training in the remote experiments approach.

Table 6. Fisher and Yates values [26]

d_{demon}	α	Values F (2;21) when $d_{nom} = 2$
21	0.25	1.46
	0.10	3.18
	0.05	4.75
	0.025	**6.65**
	0.01	9.33
	0.001	18.60

4 CONCLUSIONS

The introduction of technology in the learning process has strengthened the belief that "*affective learning*" can strongly influence the accumulation of knowledge and preparation for life of students [18], [19], [20], [21], [22], [23], [24], [25]. From the perspective of the virtual learning environment, the position of R.E. concerning "*affective learning*" was analyzed, and it was found that R.E. strongly influences students' attitudes towards the remote experiment. Synthetically, the following relevant aspects of the paper can be underlined:

1. R.E. emphasizes autonomy in learning by helping students to make decisions more easily and to act independently.
2. Three levels of affective education are preserved also in the case of R.E., namely, individual, group, and institutional. R.E. emphasizes the coagulation aspects of ad hoc learning groups, since the student forms the group exclusively on cognitive criteria (i.e., I want to know, I want to understand), avoiding the artificial criteria (beautiful, ugly, nice, unfriendly) typical of a group formation in the learning physical environment where social criteria parasitize the group's coagulation process.
3. It stresses the involvement of R.E. in most types of intelligence, having significant contributions in the case of linguistic, logical/mathematical, spatial/visual, interpersonal, and intrapersonal intelligence. It is required that when designing an R.E. you permanently ensure connections with the real environment so that the attitudes and feelings provoked by R.E. are permanently correlated with real life.
4. Any R.E. passes inherently, because of the attitudes and feelings it determines, through all the five stages of the "*affective learning*" taxonomy. The paper makes a more detailed analysis of the student's emotional responses according to the classification invented by Wlodkowski (1985). It is highlighted that typically for the R.E. case, the disappearance of the student's mood in the approach is because the asynchronous character of the virtual environment breaks the teacher-student subordination.

   In the case of the virtual instructor, an interpersonal relationship disappears. The dominant sentiment (80%) in approaching an R.E. is curiosity. The particularities of forming ad hoc groups in the virtual environment are also emphasized, groups exempted from generating negative emotions given by threats, fear, physical impotence, rejection, etc.

5. The paper emphasizes that as in the case of R.E. "*affective learning*" is treated as a secondary element in curricula, all assessments being oriented towards "*cognitive learning*." The real reason for this approach is that all the affective components involved are part of the "*internal state*" of the student, which is difficult to highlight with quantitative methods. There are several levels through which R.E. contributes to the strengthening of the affective part of learning, which emphasizes the satisfaction of direct work on a given topic and the feeling that you can take the initiative to create a similar experiment or that you can improve an existing experiment through your ideas and actions.
6. Considering Dave's (1979) psychomotor taxonomy, the paper shows that there are levels influenced by R.E. such as imitation (which develops sentiments of safety), manipulation (that creates confidence in handling instructions), articulation (in which sentiments of safety are developed when possessed knowledge allows the student to handle R.E. and also the sentiment of ambition when handling requires additional knowledge), and naturalization (when the desire to share the knowledge possessed with others is developed).
7. The importance of R.E. in blended learning is stressed. It is shown that in the mixed environment, real + virtual, the cognitive content of learning remains unchanged and that R.E. adds new dimensions: the technological and the social, the latter being related to the capacity to form a learning community in the virtual environment.
8. The paper summarizes the motivational aspects defined by Keller (1987) during the period when there was neither R.E. nor the virtual environment in learning and shows what is newly brought in by R.E. in the case of curiosity, provocation, confidence, and control, thus completing an important picture of the student's autonomy.
9. If the remote experiment is well designed, the Keppel method can be applied quantitatively to evaluate cognitive effects on affective responses.

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