



# Multimedia presentation, cognitive processes, learning: an experimental research in university teaching

## Presentazione multimediale, processi cognitivi, apprendimento: una ricerca sperimentale nella didattica universitaria

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### ABSTRACT

This research project comes from the need to reflect upon formative practices and their models, focusing on the consequences, not always explicit, that they have towards behaviours and learning. The specific aim of this research was to analyse the main epistemological paradigms that guide university professors in their use of cognitive artifacts, paying particular attention to the web conferencing. In order to significantly impact learning processes, each cognitive artifact must be designed and used following precise theoretical paradigms binding its use.

Based on existing guidelines regarding multimedia learning from international studies, the didactic functionality of multimedia presentation within the ambito of university teaching was verified. Once a hypothesis was identified, experimental research was carried out with intentional manipulation of independent variables; the result was measured through a dependent variable (learnings). A control group and two experimental groups participated in the study. A methodology and the related tools to be used were prepared. Finally, after having identified the sample, an operative plan was elaborated including times and places, methods of analysis.

Therefore, whilst applying a quantitative methodology, the qualitative elements have not been neglected. The analysis undertaken in this study considered not only the relationships between data and information but also the significant connections within the studied phenomenon. It is a system consistent with a hermeneutic epistemological approach, which refers to an interpretative pedagogy. The research results confirmed the hypothesis: learning outcomes increase when the valorisation of the didactic content as presented by the university teacher through web conferencing, is in accordance with the principles relating to multimedia learning.

Questo progetto di ricerca nasce dall'esigenza di riflettere sulle pratiche formative e sui loro modelli, infine sulle conseguenze, non sempre esplicite, che le une e gli altri hanno nei confronti degli apprendimenti. Nello specifico l'obiettivo è quello di analizzare i principali paradigmi epistemologici che guidano il docente universitario nell'uso di artefatti cognitivi, con particolare attenzione alla presentazione multimediale in un ambiente di web conference. L'idea di partenza è che ogni artefatto cognitivo se deve avere un impatto significativo sui processi di apprendimento deve essere progettato e utilizzato sulla base di precisi paradigmi teorici che ne vincolano l'utilizzo.

Sulla base di linee guida sugli apprendimenti multimediali tratte da studi internazionali è stata verificata la funzionalità didattica della presentazione multimediale all'interno di un insegnamento universitario. Individuata un'ipotesi è stata messa in atto una ricerca sperimentale con manipolazione intenzionale di variabili indipendenti, il cui risultato è stato misurato attraverso una variabile dipendente (gli apprendimenti); allo studio hanno partecipato un gruppo di controllo e due gruppi sperimentali; sono state predisposte una metodologia e i relativi strumenti da impiegare. Infine, dopo aver individuato il campione è stato elaborato un piano operativo comprensivo di tempi e luoghi, modalità di analisi.

La metodologia impiegata ha un impianto di tipo quantitativo, ma non trascura nemmeno gli elementi qualitativi, in quanto indaga sulle relazioni fra dati e informazioni così come sui nessi significativi all'interno del fenomeno studiato. Si tratta di un impianto coerente con un approccio epistemologico ermeneutico, che fa riferimento ad una pedagogia interpretativa. I risultati della ricerca hanno confermato l'ipotesi: la valorizzazione del contenuto didattico presentato dal docente universitario tramite la web conference in accordo con i principi di apprendimento multimediale aumenta i risultati dell'apprendimento.

### KEYWORDS

Visuals, Video pedagogy, Cognitive artifact, Multimedia learning, Web conference.  
Visuals, Video pedagogia, Artefatto cognitivo, Apprendimenti multimediali, Web conference.

## Introduction

The field of reference is one of *teaching with media*, the essential idea being that if used according to the right methodologies, technology can contribute to the process of teaching and learning. This premise places the present work within a problematic framework, far from a technocentric vision, but at the same time close to those theories that consider cognitive artifacts, skilfully used from a pedagogical point of view, useful for teaching (Margiotta, 2005). Resources that, when linked to specific learning objectives, may be able to contribute to the learning process, to have a significant impact on the student's ability to comprehend, to solve problems, to construct complex theories, to activate processes of critical reflection, conceptualization and verbalization.

In order for this to occur, multimedia presentations must be prepared according to procedures based on research activities and precise methodological indications. This is also valid for web conferencing, which is characterised by synchronous communication and determines communication processes marked by "rich information" (Daft & Lengel, 1984); thereby reducing the risks of misunderstandings present in asynchronous communication. Thanks to its potential for interactivity, use of different modal channels, the variety of languages available and above all the presence of social indicators, web conferencing is second only to face-to-face communication. Furthermore, its ease of use allows the creation of non-invasive educational environments within which the presence of technologies tend to disappear: to overcome resistance to technological innovation in working environments (Rogers, 2003; Bauer, 1995) it is necessary to create a highly technological didactic set capable of being experienced naturally rather than a foreign instrument to be feared (technophobia). The illusion of not feeling any technological mediation in the communicative process (Lombard & Ditton, 1997) and the experimentation of a geography in which the physical environment can be decontextualized and the body of the subjects to de-physicalize (Cattaneo, 2009), seems to favor the use of web conferencing. The use of this mechanism, its naturalization and disappearance of technology, on the one hand, and application of the principles of participatory and relational culture (social and collaborative dimension), on the other, is in our opinion the best method to enable distance students to enter the classroom. Due to these characteristics, web conferencing environments are widely used for streaming university lectures.

### 1. Multimedia learning and cognitive processes: theoretical foundations

The use of multimedia presentations in the educational field must be guided by principles relating to multimedia learning which favor cognitive processes. Our field of reference was research into cognitive psychology and Instructional Design which has attributed two meanings to the concept of multimedia (Mayer, 2001):

1. multimedia as a presentation format that adopts multiple sensory channels. Under this concept, interest is directed to multimodal perceptive aspects which must be highlighted in order to render the simultaneous presentation of more effective information; and
2. multimedia as a dynamic cognitive process that leads to "assembly" information of different types of information into a functional mental representation to the learning processes".

Reference was made to theories which can assist in understanding how multimedia learning works: the work of Allan Paivio (1971; 1990) on *dual-coding theory*, related to the different coding of information, verbal and non-verbal, by the human cognitive system; *cognitive load theory* (Sweller, 1988; 2010) which explores the load imposed on working memory by the information presented, and focuses on the analysis of cognitive resources used during learning and how they can be directed toward objectives specific didactics (Chandler & Sweller, 1991); the *generative theory of multimedia learning* (Mayer, 2001; 2009), a discipline aimed at the construction of mental representations based on the combination of words (narrated or spoken) and images (illustrations, photos, animations, films); and the work of Clark and Lyons (2011) on the communicative and psychological functions of different types of images.

The integration of these theoretical references can provide useful indications to instructional designers and teachers who intend to use audiovisual and multimedia resources; and to researchers interested in deepening this line of research.

The basic idea is that a student's learning through multimedia presentations is not dependent upon the mere presentation of the necessary information, but upon the presentation of the necessary information, delivered according to the functioning mechanisms of the students' mental and cognitive processes. Experimental research shows a better level of learning is achieved when the material is presented in a variety of formats than when the presentation is solely graphic or verbal. There are however, less optimistic and simplistic comments on the effects, sometimes negative, of multimedia.

The theories investigated produced an important contribution to both the positive and negative aspects of the use of images in learning processes.

## 2. The pre-experimental phase

### 2.1. The purpose and objectives of the research

As mentioned, our analysis focused on the modality of multimedia presentation within a web conference environment in order to understand:

1. the didactic attitude of the teacher. We have already noted that in order for any cognitive artifact to have a significant impact on learning processes, it must be designed and used on the basis of precise theoretical paradigms. These paradigms determine their correct usage; and
2. a second objective of the research is to go beyond the limits of the laboratory and to offer operative indications to both university teachers and Instructional designers, in order to make media teaching communication more effective, in terms of significant learning (Ausubel, 1968).

The final aim is to contribute to the improvement of learning processes in teaching situations which involve multimedia.

### 2.2. The research questions

In the didactics with the web conference, the fundamental aspects from a teaching communication standpoint are two, beside the teacher's speech:

1. *The use of visuals to support/integrate verbal communication (multimedia presentation).* Does the use of visual elements allow deeper learning? Which visuals are more effective? How can we evaluate the appropriateness of the visual materials? Is it possible to design the correct usage of images? How can visuals be best adapted for students? How can visual materials be used to increase a student's motivation?
2. *The teacher/student relational activity.* The relational aspect, as previously stated, assumes great importance for education mediated by technologies. When web conferencing tools are used to stream the classroom lesson, the synchronous and interactive communication dynamics, if well exploited, allow students at home to "obtain the keys to enter the classroom" and fully experience the teaching process.

The main question that the research seeks to answer is the following:

Does the university professor involved in the "FaD model" experience, effectively use the web conference (audiovisual cognitive artifacts) in a media teaching system? More precisely, does the teacher appropriately utilise the educational communication guidelines of the multimedia learning principles relevant to the use of web conferencing: visuals and relational activity?

### 2.3. *The hypothesis*

As noted above, the use of visuals to support/integrate the teacher's speech and a constant relational and feedback activity (chat), are the two most important aspects of educational communication with web conferencing. Our hypothesis is as follows:

The valorization of the didactic content presented by the professor of higher education using web conferencing in according with multimedia learning principles, regarding visuals and visuals combined with chat activities, increases the learning outcomes in the FaD model experimentation.

### 2.4. *Independent variables*

We identified two independent variables.

*Independent variable 1* relates to the visuals inside the web conference tool. We used the same contents of the lesson (the teacher's speech) and intervened by modifying the visuals. The visuals were modified in compliance with the guidelines identified in the theoretical component. This is the general principle that has guided our work: learning by students through multimedia presentations does not depend on the presentation of the necessary information alone, but on the presentation of the necessary information in a manner which complements the functioning mechanisms of the students' mental and cognitive processes.

*Independent variable 2* relates to the visuals combined with interactional activities (chat). The researcher assisted the teachers with the use of 25 minute session to integrate the modified visuals (through compliance with the guidelines identified in the theoretical component). The experimental groups were then subjected in different ways to the two independent variables.

## 2.5. Dependent variable

The dependent variable is evidenced by the learning outcomes. More precisely, in the measurement of some learning elements captured by verification tests: the level of knowledge which was measured using a multiple choice question test; the level of learning skills, which was measured using an open-ended question test.

Our goal was to verify the activation of metacognitive behaviors, the results of which, can be fully evaluated over the medium and long term.

## 3. Phases and research methodology

Once a research hypothesis was formulated and the main variables of the model were identified, lessons organized in accordance the *FaD model*<sup>1</sup> were subsequently identified. Prof. A. G. (*Literature teaching for children*, first semester of the academic year 2017-2018) participated. Finally, a sample was identified and an operational plan was elaborated, including time and place, analysis method and the relative tools to be used.

### 3.1. The sample of subjects

Students enrolled in the *Children's literature* course, by Prof. A.G., were involved in the experimentation (first semester of the academic year 2017-2018). A total of 127 students were divided into 4 groups on the basis of a *voluntary sampling of convenience* (thus through a non-probabilistic methodology).

- *Group 1*. 72 students who physically attended the lecture in the classroom. These students were excluded from the study. We did not want to undertake a comparison between teaching when physically present in the classroom and at a distance.
- *Group 2 (control group)*. 18 students attended online (via web conference) following the Lesson in Conventional Mode, whereby the teacher adopted their normal teaching method (without the intervention of the researcher).
- *Group 3 (experimental group)*. This experimental group consisted of 18 students with the same characteristics as the control group attended via web conference and the Modified Lesson from the Researcher was utilised.
- *Group 4 (experimental group)*. This second experimental group consisted of 19 students with the same characteristics of the control group, followed via web conference and the Modified Lesson from the Researcher was utilised (as for group 3). Further, this group participated in 25 minutes of relational activity (via chat).

On the basis that 72 students in Group 1 were excluded from the study (because they physically attended lessons in the classroom), the sample subjects of the study were reduced to 55 from 127.

1 The context of the study is a conventional university teaching setting, supported by the use of technology, at the University of Ferrara. The classroom lesson is live streamed (through a web conferencing system) enabling students who are not physically present to attend a virtual classroom (on any device with an internet connection).

### 3.2. The content sample

The experimental phase impacts only part of the teaching. The module used for experimental research, lasting 2 hours (the total teaching lasts 30 hours), is called *Literature for children and new digital technologies*.

### 3.3. Measurement of learning outcomes (dependent variable)

The tool used to measure the learning outcome was a written questionnaire:

- *Multiple choice question tests* (test\_0 and test\_01) to measure the level of knowledge;
- *Open-ended question tests* (test\_02) to measure the level of competence.

The control group and the experimental groups carried out the tests at different times: the control group immediately after attending the conventional lessons, the experimental groups after attending the lessons modified by the researcher. To avoid minimise interference factors that could nullify the reliability of the research, two different tests were prepared: one for the control group and one for the two experimental groups. The tests were prepared keeping the same didactic objectives, only the formal structure was changed. In this way the passage of information from the control group to the experimental groups was avoided.

The results of groups 3 and 4 (experimental) were compared with those of control group (group 2). To obtain a more objective analysis, the results were compared with the students' pre-existing knowledge, measured with a multiple choice questionnaire (test\_0).

### 3.4. Preparation of questionnaires

The construction of the questionnaire and their correction grids was carried out by Prof. A.G. The work carried out by the researcher concerned the analysis and intersection of data through a statistical program ("R" Project for Statistical Computing). Set out below are the various phases of work, including the preparation, the method of execution and evaluation of the questionnaires:

1. definition of the research objective and evaluation related to the choice of the sample;
2. clear and precise definition of the teaching objectives to be tested;
3. questionnaires' typology;
4. item's content;
5. decisions on the verbalization of the items: terminology to be used, that is to say the use of simple and clear language, with terms known to the students; avoiding negative sentences or double negation; it was important to verify the student's ability to respond rather than their ability to understand the question;
6. actions for the organization of the items in the test: number of questions, sequence of questions according to the levels of difficulty;
7. form and scale of measurement of responses (assessment grids);
8. execution tests modality: this involved thoroughly explaining the structure of the tests to the students (to avoid the possibility of copying), the time permitted for each test, etc.
9. pre-test and subsequent revision.

### 3.5. Data analysis methods

Table no.1 summarises the general framework including tools, independent and dependent variables, and the relationships between variables and groups.

1. test\_01, comparing the results of the two experimental groups (both exposed to independent variable 1) with those of the control group, indicates whether independent variable 1 has worked;
2. test\_02, comparing the results of the experimental group 4 (exposed to independent variable 2) with the control group, indicates whether the simultaneous use of visuals and chat has worked;
3. test\_02, comparing the results of the control group with those of experimental group 3 (still exposed only to independent variable 1) indicates whether independent variable 1 continued to work. It is an indicator of validity: utilising the same sample but different contents;
4. by comparing the difference between test\_01 and test\_02, of the experimental group 4 and of control group 2, we were able to measure whether independent variable 2 had a greater impact than independent variable 1. If the results were higher for experimental group 4 in test\_02, compared to the control group's results for test\_01, then independent variable 2 produced more effective results. This is an indicator of how chat plays an important role;
5. the comparison between the differences in outcomes of the two experimental groups (test\_0/test\_01; test\_0/test\_02; test\_01 / test\_02) also provides other information on the significance and impact of the two independent variables.

Tools	Independent variables	Dependent variable	Group 2	Group 3	Group 4
Test_0		Pre-knowledge	X	X	X
Test_01 (a)		Knowledge	X		
Test_02 (a)		Skills	X		
Test_01 (b)	VI 1: visuals	Knowledge		X	X
Test_02 (b)	VI 1: visuals	Skills		X	
Test_02 (b)	VI 2: visuals and chat	Skills			X

**Table 1. General pictures**

## 4. The experimental stage

### *Phase 1 - Entry exam (Test\_0) to test pre-existing knowledge*

On the day of the first lesson (26 September 2017), after very precisely explaining the objectives of her course, Professor G. asked all students present in the classroom to answer an entry exam (test\_0). The aim was to test the pre-existing knowledge possessed by the students on a part of the course topics, related to the module on *Children's literature and new digital technologies*.

### *Phase 2 - Sampling participants in the trial on a voluntary basis*

During the first lesson, the teacher asked the students present (127) to decide whether to attend lessons in person in the classroom or in the virtual classroom (with web conference): 72 students opted for classroom attendance (group 1), 55 opted for virtual classroom attendance. These 55 students were then randomly

divided into three groups, two groups of 18 (group 2, group 3) and one of 19 (group 4). As noted above, group 1 was excluded from the study because they physically attended lessons in the classroom. The study population was thereby reduced from 127 to 55; from which a further 6 students did not complete the course; accordingly the sample population of the study was 49 subjects. Group 2 was defined as a control group; groups 3 and 4 experimental groups.

*Phase 3 – Group 2 (control group) attends the virtual classroom lesson (lessons 1 and 2)*

Group 2 attends the lessons of the *Children's literature and new digital technologies* module in the virtual classroom, via web conference. On 17 October 2017, 16 students were present in the virtual classroom (lesson 1); On 19 October 2017, 16 students (lesson 2). Students were not otherwise permitted access to registered. The lesson was prepared by the teacher autonomously together with the power point slides.

*Phase 4 - Assessment tests (group 2)*  
Assessment tests group 2:

1. on 18 October 2017 the first assessment test (Test\_01) was carried out, at 18.30. It was a multiple choice question test;
2. on 20 October 2017 the second assessment test (Test\_02) was carried out, at 18.30. It was an open-ended question test.

*Phase 5 - Analysis by the researcher of the visuals utilised in lesson*

The researcher analyzed the recording of the lesson to verify the communication-teaching functionality and use of the visuals. The reference parameters, on the basis of which the verification was carried out, were the guidelines identified through the study of the theories of multimedia learning in relation to cognitive processes.

Despite the teacher's good communication skills, their colloquial and persuasive style, the relationship between the word and images were misaligned. Many of the visuals did not appear to be in line with the guidelines identified in the theoretical part which were being verbally communicated by the teacher. Here are the most obvious:

1. use of words (teacher's speech) and images were not arranged in a complementary logic;
2. use of images with a decorative function;
3. use of very long texts and absence of the principles of adaptation (division into paragraphs, highlighting key words or concepts, use of targeted lists presented in synchronous mode, etc.);
4. redundancy effects;
5. lack of graphics to explain relationships and organize information;
6. noise (visual and sound disturbances) due to lack of slides and some technical problems.

*Phase 6 – Modification of visuals by researcher (Independent variable 1)*

The researcher modified the visuals on the basis of the guidelines identified to favor multimedia learning. The modified power point replaced the original one through a post production operation.

Phase 7 – Attendance by group 3 and 4 at the lesson modified in the virtual classroom (web conference).

Group 3 attended the lessons in the virtual classroom as follows:

1. the verbal component was identical to the lesson attended by group 2;
2. the multimedia presentation was modified on the basis of multimedia learning principles.

The mode of lesson delivery was similar to “live streaming”. The lessons were attended on 24 and 26 October 2017, there were 17 and 16 students respectively.

Group 4 follows the lesson in the virtual classroom (a virtual classroom different from that of group 3).

The lesson on 24 October 2017 was identical to that followed by group 3. The lesson on 26 October 2017 was identical to that followed by group 3, plus it included 25 minutes of virtual chat during which the teacher answered the students’ questions.

Phase 8 - Assessment tests: Test\_01 and Test\_02 (group 3 and group 4)

On 25 October 2017, the first assessment test was given (Test\_01), at 18.30. The test related to lesson 1;

on 27 October 2017, the second assessment test was given (Test\_02), at 18.30. The test related to lesson 2.

## 5. The post-experimental stage (data analysis)

Table 2 highlights the general picture.

Group 2 (control group)				Group 3 (experimental group)				Group 4 (experimental group)			
Nome	T_0	T_01	T_02	Nome	T_0	T_01	T_02	Nome	T_0	T_01	T_02
Id2	10	22	26	Id4	12	27	X	Id8	8	26	28
Id6	9	22	21	Id11	10	25	28	Id21	5	X	X
Id10	9	X	X	Id19	12	24	23	Id31	8	26	28
Id14	14	27	25	Id23	10	25	24	Id35	13	23	26
Id17	8	14	20	Id25	4	28	26	Id36	6	25	29
Id28	14	25	24	Id40	15	26	27	Id39	10	28	30
Id44	14	30	28	Id52	4	22	24	Id47	8	26	29
Id54	13	X	X	Id56	4	23	25	Id58	13	27	30
Id57	10	24	23	Id61	6	25	28	Id63	7	X	X
Id60	10	22	13	Id65	6	14	21	Id71	16	24	27
Id77	7	23	23	Id72	10	X	X	Id75	12	26	28
Id88	13	24	25	Id79	14	28	30	Id76	10	25	28
Id89	8	23	20	Id92	14	26	29	Id83	10	24	27
Id101	14	26	24	Id97	15	24	26	Id86	11	25	24
Id105	14	22	21	Id103	10	25	25	Id93	9	26	30

Id107	9	22	23	Id11	8	20	21	Id99	14	27	30
Id109	14	25	23	Id115	12	15	13	Id116	11	25	26
Id122	14	22	24	Id120	12	30	30	Id124	18	25	27
								Id127	10	25	28
Media A	11,3	23,3	22,7		9,75	23,8	25		11	25,5	27,9
Media B		23				24,4				26,7	

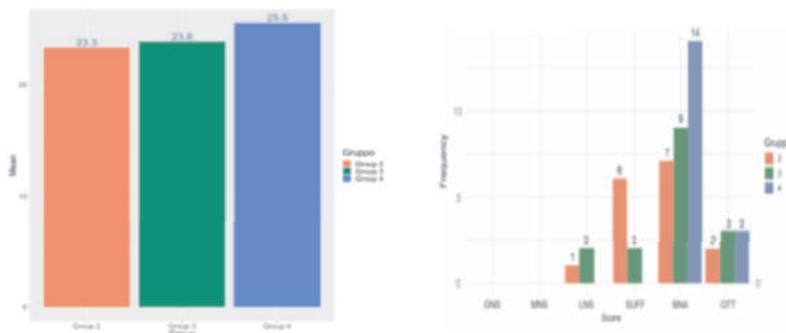
**Table 2. Results of the three groups in the 3 tests**

The outcome of the test\_0 highlights the normal distribution of the sample, the average result of the pre-existing knowledge test is: 11.3 for group 2; 9.75 for group 3; 11 for group 4.

If we observe the average scores of the two tests (t\_01 and t\_02) we see how the two experimental groups obtained a higher score, respectively 24.4 (experimental group 3) and 26.7 (experimental group 4), compared to control group 2 (23); the comparison between the control group 2 and the experimental group 3 consistently shows a small difference (equal to 1.4); the comparison between the control group 2 and experimental group 4 shows a significant difference of 3.7 points; the comparison between the two experimental groups is in favor of group 4: 2.3 points more than group 3. This data immediately indicates that the independent variables have had positive effects. However this analysis is too general, research variables require more in-depth analysis.

#### *Test\_01 and Independent variable 1*

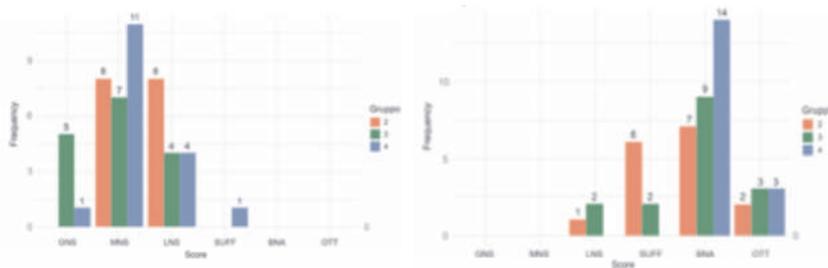
In test\_01 the control group 2 reported an average score of 23.3; the experimental group 3 a slightly higher average score (23.8); the experimental group 4 is the one that reported the highest average score (25.5). The final results are rather homogeneous, especially between the control group 2 (23.3) and the experimental group 3 (23.8). Experimental group 4 (25.5) appears to have had a better response to the independent variable 1 (Graph 1).



**Graph 1 - Test\_01\_Score and score classes**

For a more objective evaluation we considered the difference in increment between the input test that measured the pre-existing knowledge (test\_0) and the test\_01. The results are as follows: in group 2 the increase was 12; in group 3 the increase was 14; in group 4 the increase was 14.4.

*Result one.* With independent variable 1, we observe that the use of visuals according to the identified international guidelines, has had a positive impact on dependent variable (learning outcomes). It appears that the two experimental groups seem responded well to the manipulation of the independent variable 1, obtaining higher learning outcomes than the control group (Graph 2).

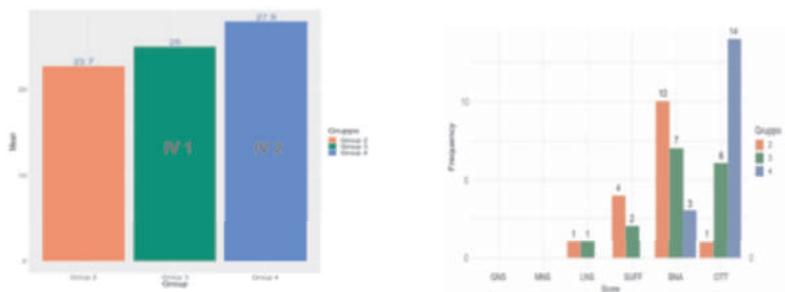


Graph 2 - Test\_01\_Score classes

*Test\_02 and Independent variables 1 (visuals) and 2 (visuals and chat)*

In test\_02, the average score of the control group was 22.7; the average score of the experimental group 3 was 25; the average score of experimental group 4 was 27.9. The two experimental groups still obtained a higher score than the control group (Graph 3).

Experimental group 3, exposed to independent variable 1, obtained better learning results than control group 2 (2.3 points more). This result improved by 1.8 points the performance of experimental group 3 on the control group compared to the first test\_01 (the difference was 0.5). The result is even better if we take into account the difference in increase between the two groups, comparing the results of test\_0 (on the pre-existing knowledge) and test\_02 (the experimental group 3 increases almost 4 points more than the control group).



Graph 3 - Test\_02\_Score and score classes

Experimental group 4 (subjected to independent variable 2) obtained better learning results than the control group: 5.2 points more; increasing to 5.7 if we consider the difference in increment between test\_0 and the test\_02.

Moreover in test\_02, experimental group 4 achieved 3 points more than experimental group 3. This also indicates that independent variable 2 had a positive impact, higher than the independent variable 1.

*Result two.* In test\_02 experimental group 3 improves its learning outcomes compared to the control group. Therefore the single use of independent variable 1 continues to have a positive impact on the dependent variable.

Experimental group 4 achieved the best results, both compared with control group and experimental group 3. Accordingly, independent variable 2 has had a positive impact on the dependent variable, higher than independent variable 1: both experimental groups have improved compared to the control group, but experimental group 4, also exposed to the chat, improved the most.

*Independent variable 1 and Independent variable 2 compared: differences in increase of two experimental groups (test\_0/test\_01, test\_0/test\_02, test\_01/test\_02)*

To further highlight the effectiveness of the chat functionality, we can verify the differences in increase between the two experimental groups. Table no.3 shows the comparison of the learning outcomes of the two experimental groups.

	Increment Group 3	Increment Group 4	Differences
t_0/t_01	14 (VI 1)	14,5 (VI 1)	+ 0,5 gruppo 4
t_0/t_02	15,25 (VI 1)	16,9 (VI 2)	+ 1,65 gruppo 4
t_01/t_02	1,25 (VI 1)	2,5 (VI 2)	+ 1,25 gruppo 4

**Table 3. Differences in increase between the two experimental groups (with indication of variables involved)**

The difference in increase between test\_0 and test\_01 shows a small increase of 0.5 points in favor of the experimental group 4. The difference in the increase between test\_0 and test\_02 shows an increment of 01.65 in favor of experimental group 4. The difference in increase between test\_01 and test\_02 is equal to 1.25, always in favor of experimental group 4.

These results support our hypothesis. When the experimental groups were exposed to both independent variable 1, they grew in the same way, with a slight difference in score. When the experimental groups were exposed differently to variables 1 and 2: the increment in scores for experimental group 4 was higher. This indicates that independent variable 2 resulted in a greater increase than independent variable 1.

Improved learning outcomes were achieved, most likely due to the utilisation of the chat functionality, although this should be verified in a more scientific way (with an independent variable focused only on this aspect). It is also possible to assume from our data how the relational aspect between teacher and student (central to the concept of physically attending classes), assumes greater importance in the training mediated by technologies. In the case of web conferencing, the dynamics of synchronous and interactive communication, if well exploited,

enables students at home to obtain the keys to the classroom for a fully integrated teaching experience. In practice, continuous interaction and feed-back activity (via chat) is, as indicated by pedagogical research, indispensable for the success of teaching processes (the teacher can intervene based on the students' response) and learning processes (students can improve their performances if they are aware of their didactic criticalities) (Domenici, 2016).

## Conclusions

The learning outcomes of experimental groups confirmed the hypothesis: *the valorization of the didactic content presented by the professor of higher education using web conferencing in accordance with multimedia learning principles regarding visuals and visuals combined with chat activities, increased the learning outcomes in the FAD model experimentation*. In conclusion, this leads us to draw the following brief observations.

The use of the web conferencing can not be considered a "communication fashion" accessory, but must be carefully prepared and planned in order to be used effectively rather than to contribute to cognitive overload and create learning difficulties. In order to have a significant impact on learning processes, each cognitive artifact must be designed and used following precise theoretical paradigms binding its use.

More generally, multimedia integrated education must be considered part of an epistemologically complex environment; one that is characterized by a dynamic and potentially problematic relationship between teaching and learning and where digital technology can play a determinative factor of change and added value.

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