Analysis of the Cognitive Load Produced by the Use of Subtitles in Multimedia Educational Material and Its Relationship with Learning

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***Abstract*—The research aims to develop an analysis of the cognitive load produced by the use of subtitles in multimedia educational material and its relationship with learning. The methodology used for the development of the research presents a qualitative approach of experimental type, the population selected for experimentation is made up of 100 students of the fifth year of secondary school of Regular Basic Education, of which a sample of 45 students was selected through a simple random sampling, which have been divided into 3 groups of 15 students each, four learning sessions are developed using subtitled multimedia videos and without subtitle and a pre test and post test are applied in order to analyze the cognitive load involved in the use of subtitled videos in the learning sessions, the scale standardized by Pass and Van Merrienboer is used. The results show that the application of subtitles in the videos mean a potential proposal in the teaching-learning processes, due to the improvement in learning since 30% of students improve their performance in relation to the initial Pretest, in addition to promoting inclusion through support for people with hearing disabilities, they also represent a constant support material. In conclusion, the application of subtitles in multimedia material is evaluated by the student and the developer, because not all videos are productive to apply them if there are videos where subtitles of an intralinguistic, bilingual and other nature are required; except for situations where the learning condition warrants it.**

***Index Terms*—Analysis, cognitive load, subtitles, videos, multimedia, learning.**

I. Introduction

Technology has opened doors to different branches of support such as multimedia material, since the 80's it has been seen as a great support in education, because as educational material it has revolutionized education due to tutorials, documentaries or informative videos that have been the protagonists of non-face-to-face education, however these have always been accompanied by different contents that are part of multimedia, using visual material (Videos), auditory material (Audios) and textual material (Subtitles), the latter being the most questioned, since subtitling supposes a greater cognitive demand because according to the Theory Proposed by Sweller [1] in the Theory of Cognitive Load, it affirms that the human being is capable only of processing only 3 of the 7 things that are around him, because the process of these would suppose a cognitive overload in the working memory of the knowledge agent, however these also suppose an improvement to the learning because they function as educational material of support to the student. In this context, this research focuses on analyzing and comparing learning based on the Theory of Cognitive Load [1] and the Theory of Multimedia Learning [2].

From the perspective of cognitive load theory, there can be many reasons for lack of learning. The level of experience can serve as both a facilitator and a barrier, as can the investment effect of the experience [3]. Cognitive load theory is basically a group of principles that guide efficient learning [4] and is rooted in cognitive perspectives. This theory assumes that meaningful learning is possible if the foreign load is removed in addition to benefiting from the German load. According to [4], there are several ways to use cognitive load sources. Based on the assumptions of [5], some of the guidelines have a specific focus on multimedia learning environments. For example, in their ninth (9th) and tenth (10th) directives, [4] they define how to deal with redundancy. According to the principle of redundancy [5], it is assumed that on-screen text does not contribute to the learning process when accompanied by graphics and narratives. Text becomes redundant, so designers need to be aware of it and avoid cognitive overload. In their study,[5] they tried to observe the learning processes of non-native English learners in multimedia environments and found that providing audio and video together contributed to the learning process, while adding subtitles to video made no difference. In a normal learning scenario, a video narrated with subtitles is not an adequate teaching material due to redundancy, but the case may not be valid in a learning environment with a second language. The use of subtitles is accepted as a common way to support non-native learners and reach more people [6].

Subtitling means the translation of a text transmitted orally in an original language from a multimedia product (commonly dialogues in films), it is usually overwritten to the image of the product, however in later studies it states that subtitling is a communication prepared for the language that uses written language and that works as an additional and synchronous channel semiotically, which is part of a transitory and polysemiotic text [7].

According to [8] types of subtitles are presented: Intralinguistic: Those that occur after the transfer of information from one standard language to another, that is, a translation; Reverse Intralinguistic Subtitles: They are those

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that are in a language other than audio, being considered the strangest because they are not found in the cinema or in the arts and Bilingual Subtitles are those that the soundtrack is in one language and subtitling is applied in two different dialects, they are usually used in film festivals. The ability to combine applications and knowledge is what characterizes the realization of multimedia [9], so that since the twentieth century with the appearance of communication tools as powerful as television and computers people were able to expand their knowledge, product of new multimedia applications.

Cognitive load is related to the amount of cognitive resources a person requires to perform a given task [10], from another perspective, mental workload is described in terms of an interaction between task requirements and human capabilities or resources [10]. Likewise, Sweller [5] states that cognitive load is the workload imposed by a particular task on the human cognitive system. In short, mental load is closely related to the interaction that occurs between the characteristics of the learner and the complexity of the task. Among these characteristics can be taken into account its format, its complexity, the use of multimedia, time pressure and the pace of instruction, on the other hand the age must be taken into account the level of expertise and spatial ability of the apprentice.

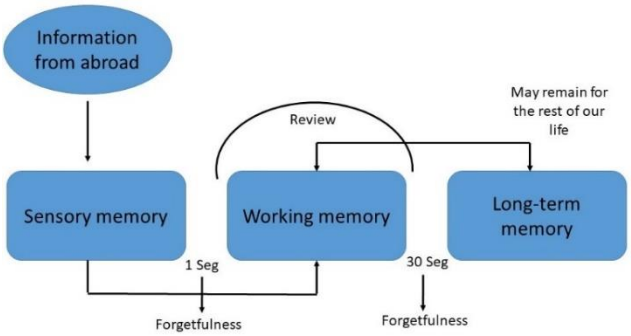

Fig. 1. Structure of human cognitive architecture (ACH).
Source: Retrieved from [11]

Fig. 1 shows how the architecture of working memory works and its functions, because it is the information from the outside that enters the sensory memory, only as stimuli, it is not processed, the stimuli remain in the memory for 1 to 3 seconds and then they are forgotten, these if necessary pass to the working memory in which they are processed to build them as relevant and processed information, in 30 seconds it is a matter of reviewing keep it constant in the long-term memory, it is for this reason that the greater the stimuli from the outside the wasted information is greater and details of the information are left aside, because the working memory only consists of 7 stimuli in process, the others are discarded and from these a perception of the outside and what is happening in the environment is obtained.

There are three types of cognitive load: intrinsic, extrinsic and pertinent, the first arises from the interaction between the nature of the object or complexity and the experience of the learner; it is not related to instructional design, so it is impossible to modify it. As for the extrinsic, it is the one that has more information than necessary and can become distracting and hinder the task, this type of cognitive load is unnecessary as detailed by Sweller [5] and finally the Germanic or pertinent load, this is the product of a good instructional design, with it the resources of the working memory are used for the beneficial construction of schemes, through processes of abstraction and elaboration [12].

Sensory Memory: they constitute sensory channels such as visual and auditory, which are the main key to our ability to find different stimuli in the environment, which are stored for a short period of time, this does not assign meanings to any of these stimuli. Therefore; as these channels are separated, the information is processed independently and the Working Memory: Sweller [5] defines it as short-term memory (name with which it was previously known), is characterized by its limited storage capacity, this memory is responsible for the work and processing consciously around two or three elements at the same time, paying attention to it for 15 to 30 seconds [13]

As for the measurement of cognitive load, the elements that are presented: Mental load: It is originated by the interaction between the characteristics of the task and the characteristics of the subject. Different tasks can be more complex because the steps to follow are taken into account or how much precision these require, on the other hand several subjects may have different skills and different levels of expertise; Mental effort: This aspect refers to all the resources necessary or that are destined to solve a specific task, this reflects the instantaneous cognitive load, this is usually measured when the participants are in realization of the same or immediately after its completion; Performance: According to [14], performance is an aspect of cognitive load, this is understood as the quantifiable achievements of the learner, as would be his score after a success of questions. This can be measured while the task is being carried out; Methods of measuring cognitive load: According to [11] in his article Theory of Cognitive Load, multimedia design and learning: a state of the art, he discerns two different methods for the measurement of cognitive load, an analysis based on estimating the amount of mental load that a person would require to perform a task, basing these estimates on critical judgments in the domain of the task and on mathematical models of analysis, however, there is also the empirical method that measures mental effort through subjective methods or instruments, such as the Likert test, which records the introspective report of mental effort, on the other hand there are also assessment scales or tests such as the one proposed by [14] which I would consider more accurate.

At the end of the twentieth century with the rise of multimedia, it was concluded that this type of material could not only be applied to graphic computers, but that these could be applied as a learning tool. Thus, two theories emerge that support the use of this material in learning, the first is the Theory of Cognitive Load (CBT) formulated by Sweller in 1994 and later the Theory of Multimedia Learning (TCAM) formulated by Mayer in 2005, as a response to new study techniques. These are presented as a conceptual framework belonging to the cognitive sciences that aim to improve multimedia environments or e-Learning [15].

Currently, multimedia material has become an indispensable part of the education sector, since video conferences are used, which have replaced the limitations in space and time in situations of distance education, which is

why it is used in higher education [16]. The multimedia material has been applied in education in order to achieve a better interaction of students with their learning environment, in the first instance being applied for the benefit of people with auditing disabilities [17], however in the following years it would be applied in university programs to improve academic performance and little by little in the different educational programs [18]

Thus, little by little, the use of subtitles in educational material would become popular for the beginning of the twenty-first century, because they constitute a source of support when capturing stimuli from abroad, because, in working memory, it perceives stimuli from the outside making it process them, maintaining similar information in cases of both channels (auditory and visual) generating a greater assimilation of the information [19].

The Cognitive Load Theory (CLT) identifies three different forms of cognitive load [1]:

- Intrinsic cognitive load: the inherent difficulty of the material itself, which can be influenced by prior knowledge of the topic
- Extraneous cognitive load: the load generated by the way the material is presented and which does not aid learning
- Germane cognitive load: the elements that aid information processing and contribute to the development of schemas.

CLT suggests that if the cognitive load exceeds our processing capacity, we will struggle to complete the activity successfully. In summarizing CLT, [20] states that 'cognitive load theory asserts that learning is hampered when working memory capacity is exceeded in a learning task'.

Working memory should be seen as short term and finite, whereas long-term memory can be seen as infinite. The aim should be to move knowledge to long-term memory because when a student is exposed to new material, they can draw on this previous knowledge and the cognitive load is reduced. However, if subject knowledge is incomplete, the student is unable to fall back on the long-term memory and the working memory becomes overloaded, leading to working memory failures. According to Gathercole and Alloway [21], indications of working memory failures include:

- Incomplete recall
- Failing to follow instructions
- Place-keeping errors
- Task abandonment.

Of course, there are many other reasons for these that are not related to CLT; however, if teachers understand how this theory applies to their classroom, they can plan their lessons in a way that takes into account cognitive load.

An important question, though, is whether it is useful in the classroom. Ashman [22] has explained that an understanding of CLT changed his math's teaching, and offers the following four examples:

- I don't read out my slides – avoid simultaneous oral and text presentation
- Break it down, further – pause for practice between individual problem types (this leads directly into number 3)
- Example-problem pairs – give a worked example alongside an almost identical question
- Stop after five minutes – advise students never to spend more than five minutes trying to solve a homework problem

So, is CLT the single most important thing for a teacher to know? Perhaps not – it is a bold claim. But, if used correctly, it can improve teacher instruction, which is an important variable in the complex classroom environment.

II. Methodology

A. Objectives of the Research

Analyze the cognitive load produced by the use of subtitles in multimedia educational material and its relationship with learning.

B. Research Hypothesis

The application of subtitles in multimedia educational material supposes an increase of elements to be processed in the sensory and working memory, causing an increase in the levels of cognitive load producing a greater storage of information reflected in the improvement of learning.

C. Research Variables

- Independent Variable:

Educational material Multimedia subtitled (Fully subtitled, partially subtitled, without subtitle)

- Dependent variable:
- Cognitive load produced by the application of subtitles.
- Controlled Variables:

Duration time, theme of the video.

D. Population and Sample

The population selected for experimentation is 100 students of the fifth grade of Regular Basic Education secondary, from which 45 students were selected through a simple random sampling, divided into 3 groups of 15 students at random.

In this population, the inexperience and learning capacity of each student is contemplated, because in relation to what is established by the theory of multimedia learning [11], the theory of cognitive load [5] and the research proposed by [23] in the investigation of the effect of the presentation of subtitles in multimedia material, the factors that are included in the subject's expertise and the complexity of the task, which in this situation is minimal, must be considered.

E. Activity Planning

TABLE I: Activity Planning

Pre test	**Application of a pre-test to evaluate students' knowledge of Excel modeling and simulations.**			**Competences and capacities to be developed**
Viewing the videos Topic: Modeling in Excel.	First group uses material Subtitled and without subtitle.	Second group uses subtitled and partially subtitled material.	Third group uses complete subtitling material	Interact in Virtual Environments: Document school projects when you combine animations, videos and interactive
Viewing the	First	Second	Third	

second video Topic: E-Commerce	group uses material Subtitled and without subtitle.	group uses subtitled and partially subtitled material.	group uses complete subtitling material.	material in different formats with creativity and initiative. Manage virtual communities assuming different roles, establishing links according to their needs and interests, and valuing collaborative work.
Post test	A post test is applied in relation to the subject, to evaluate the level of learning in all three cases.			

F. Data Collection Instruments

A test is used to collect data on learning and another test to measure cognitive load uses the cognitive load scale developed by Pass and Van Merrienboer in 1994 [24].

- Pre-test: A survey test is applied to know the degree of learning that students have on the subject.
- Post-test: The same initial test is applied; in this case a section of visual questions is added that contemplates questions that have been extracted from visual material in the video provided.

G. Procedure

1) Application of the pre test

The participants divided into 3 groups randomly, are subjected to a pre-test of knowledge on the subject modeled in Excel and formulas included in the program, the duration of the test will be 5 minutes including 12 questions extracted from the information provided in the video (Video 1: Topic Modeled in Excel).

2) Viewing multimedia material

The duration of the video is approximately 6 minutes, in this information about Excel and Electronic Commerce is detailed in two different videos as a small introduction to the subject, information of which questions are proposed for the pre and post-test.

3) Post test application

The participants are again subjected to the same test, this time after viewing the videos whose duration is 10 minutes, 20 questions are asked extracted from the information provided in the video.

III. Analysis and Interpretation of the Results

In the following tables, the percentage of successes that each of the questions of both the pre-test and post-test have is observed in a general way, where in a global way the difference in score as learning between the three groups can be observed: First group uses videos without subtitling; second group uses partially subtitled videos and third group uses subtitled videos.

TABLE II: Percentage of successes Pre Test Video Excel

	Pre-Test Results: Excel Video			Knowledge Questions
Question	***Group 1***	***Group 2***	***Group 3***	
1 °	66.66%	53.33%	60.00%	
2 °	60.00%	66.66%	66.66%	
3 °	66.66%	66.66%	66.66%	
4 °	66.66%	46.66%	53.33%	
5 °	46.66%	53.33%	46.66%	
6 °	46.66%	60.00%	66.66%	
Average	58.88%	57.77%	60.00%	
Standard deviation	0.098	0.081	0.084	

TABLEIII: Percentage of Success Pre Test Video e-Commerce

	Pre Test Results: Video E-Commerce			Knowledge Questions
Question	***Group 1***	***Group 2***	***Group 3***	
1 °	66.66%	66.66%	53.33%	
2 °	46.66%	46.66%	66.66%	
3 °	60.00%	66.66%	46.66%	
4 °	46.66%	53.33%	46.66%	
5 °	53.33%	66.66%	53.33%	
6 °	66.66%	66.66%	66.66%	
Average	56.66%	61.11%	55.55%	
Standard deviation	0.091	0.088	0.091	

Table I and II show an average considered in process, in terms of the answers to knowledge questions using the videos without subtitles through the excel and E-Commerce topics.

TABLE IV: Percentage of Success Post Test Video Excel

	Post Test Results: Video Excel			Visual and textual questions
Question	***Group 1***	***Group 2***	***Group 3***	
1 °	86.66%	66.66%	100.00%	
2 °	100.00%	73.33%	80.00%	
3 °	73.33%	60.00%	100.00%	
4 °	100.00%	66.66%	86.66%	
5 °	100.00%	73.33%	86.66%	
6 °	100.00%	66.66%	93.33%	
Average	93.33%	67.77%	91.11%	
Standard deviation	0.111	0.050	0.080	

TABLE V: Percentage of Success Post Test Video Excel

	Post Test Results: Excel Video			Knowledge Questions
Question	***Group 1***	***Group 2***	***Group 3***	
1 °	86.66%	66.66%	86.66%	
2 °	86.66%	73.33%	86.66%	
3 °	100.00%	73.33%	93.33%	
4 °	93.33%	66.66%	86.66%	
5 °	86.66%	73.33%	86.66%	
6 °	86.66%	73.33%	93.33%	
Average	90.00%	71.11%	88.88%	
Standard deviation	0.055	0.034	0.034	

TABLE VI: Percentage of Success Post Test Video e-Commerce

	Resulted Post Test: Video E-Commerce			Knowledge Questi
Question	***Group 1***	***Group 2***	***Group 3***	

1 °	93.33%	73.33%	73.33%	
2 °	80.00%	66.66%	86.66%	
3 °	86.66%	73.33%	93.33%	
4 °	93.33%	66.66%	93.33%	
5 °	93.33%	73.33%	93.33%	
6 °	86.66%	73.33%	93.33%	
Average	88.89%	71.11%	88.89%	
Standard deviation	0.054	0.034	0.080	

In the Tables IV, V and VI, a difference should be made between knowledge questions (explore knowledge) and visual and textual questions (schematic questions). Therefore, it is recommended that if one of the sources adds nothing new, it should be eliminated. However, if it is essential to include both sources, they should ideally be physically integrated (e.g. texts and diagrams combined). This way, extraneous cognitive load is reduced and working memory capacity can be used for intrinsic and germane cognitive load instead.

TABLE VII: PORCENTAJE DE ACIERTO POST TEST VIDEO E-COMMERCE

	Resulted Post Test: E-Commerce			
Question	***Group 1***	***Group 2***	***Group 3***	
1 °	100.00%	66.66%	100.00%	Visual and textual questions
2 °	93.33%	53.33%	100.00%	
3 °	100.00%	73.33%	86.66%	
4 °	100.00%	66.66%	100.00%	
5 °	93.33%	66.66%	93.33%	
6 °	86.66%	53.33%	93.33%	
Average	95.55%	63.33%	95.55%	
Standard deviation	0.054	0.082	0.054	

In the Table VII, you can see the percentage of success in both videos, both in the pre-test and in the post test, at first glance you can see in general the difference that exists between the samples taken for the first and second experimentation that contemplated the video of the topics: Excel and E-Commerce, where in principle a significant difference can be observed in terms of final learning, however it can be highlighted with the following graphs that the difference obtained when contrasting between the three test groups points to distant conclusions.

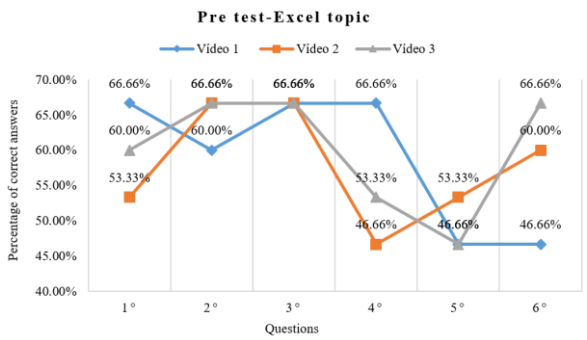

Fig. 2. Comparison of successes in pre test (excel video).

In Fig. 2 you can see a comparison of the performance of the students in the Pretest, there is no considerable difference between the three videos used by the students.

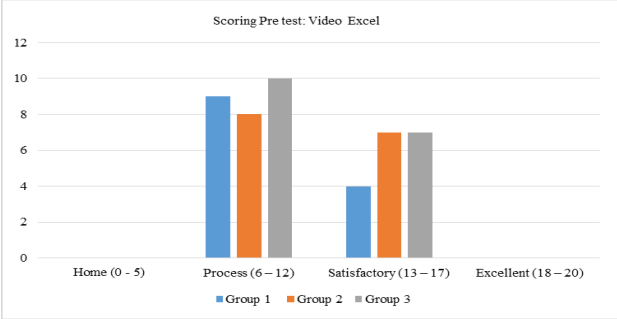

Fig. 3. Comparison of results on the vigesimal rating scale in the pretest.

In Fig. 3 an average of 58.8% of successes is observed that denotes a partial knowledge about the subject, however it is observed that the number of students who have achieved a satisfactory score, in this stage an average of 40% is observed representing 18 of the 45 students who participated in this stage have knowledge about the subject of Excel.

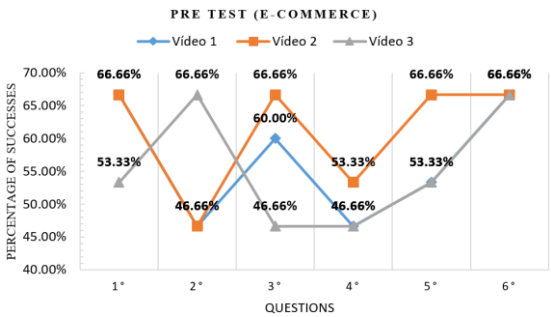

Fig. 4. Comparison of pre-test hits (e-commerce video).

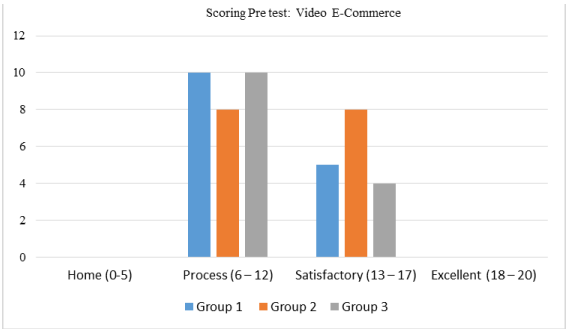

Fig. 5. Comparison of results on the vigesimal rating scale in the pre-test video 2.

In the Fig. 4 and Fig. 5, it is observed that the results are similar, on average to the level of success of 57.7% that denotes a partial knowledge of the subject in general, and 37.7% of the students who applied to this stage have obtained a satisfactory score representing 17 students who have a significant knowledge in the subject of electronic commerce.

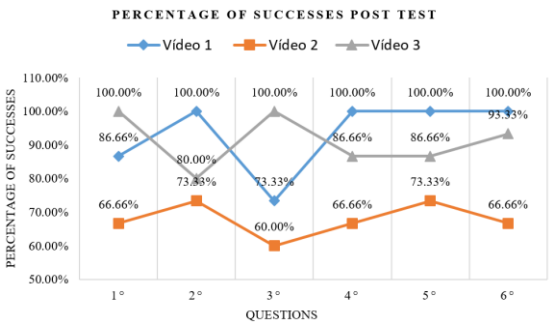

Fig. 6. Comparison of post test results (excel – formulas).

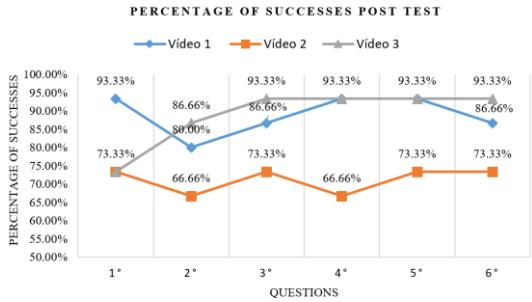

Fig. 7. Comparison of post test results (e-commerce).

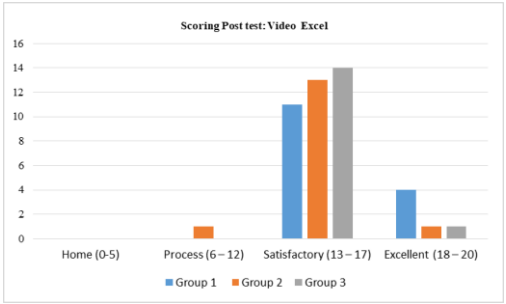

Fig. 8. Comparison of results on the vigesimal rating scale in the post test video excel.

Fig. 6, 7 and 8 show a comparison of success is made with respect to the results obtained and averaged of the post test where in the first instance you can observe in a general way the difference that is observed in the knowledge questions where on average the observed difference is 18.33%, difference that is found in the application of subtitles, where group 2 was subjected to partial subtitling, in this situation 2 groups were subjected to subtitles The processing of information in this working memory is related to the activity we are performing unconsciously [25]. This is how a decrease in learning can be due to the unconscious reading that our brain performs in addition to the phrases that it tries to autocomplete when capturing all the inputs of information provided by the multimedia material.

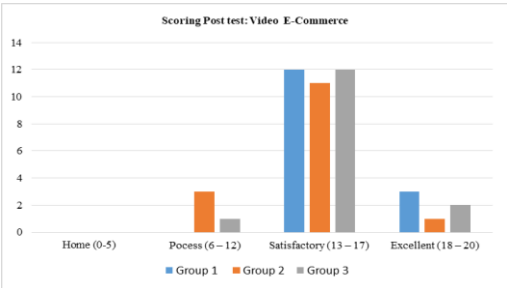

Fig. 9. Comparison of results on the vigesimal rating scale in the post test video e-commerce.

Fig. 9 shows at this stage the students who have achieved a satisfactory achievement represent 84.4% and 77.8% for the first and second video respectively, this represents those 38 and 35 students respectively of the 45 students have achieved significant learning.

TABLE VIII: PERCENTAGE OF SUCCESS IN OVERALL AVERAGE

General Comparison Pre and Post TEST			
	Video 1	Video 2	Video 3
Pre Test	58.88%	57.77%	60.00%
Post Test	91.66%	69.44%	90.00%

Table VIII shows the difference between both the learning obtained between the pre-test and the post-test that favors what is expected through the application of new technologies in education, and the difference that is denoted between the three groups, where the group that was subjected to a partially subtitled video denotes a lower learning reflected in the test, this according to the ideas proposed in the Cognitive Theory of Multimedia Learning [6], Theory of cognitive load, multimedia design and learning: a state of the art [11] and the Theory of Cognitive Load [5] where providing information to working memory will support us to process information in a complex way as shown in graph 1 (Structure of human cognitive architecture), however the overload of processes generates a mental overexertion that leads to forgetfulness, such is the case of our second group (partial subtitling) of test where according to what it affirms [25] it is about unconsciously analyzing both subtitles and sound and image, the detail at this stage is that the subtitles have not been completed and inevitably our mind tries to fill in the blanks, devoting more attention to this task, leaving aside other channels of information that are more relevant to the task to be performed.

In relation to what was experienced during this stage of research and what was observed in the Technology sessions, the best option to optimize learning through multimedia support and subtitles specifically must be a pre-selection of videos, in order to identify the best situations where to apply subtitles in general and what type of subtitles.

In the case of the presentation of videos in another language, it is essential to use linguistic subtitles that will directly favor the understanding of the information in the video; however, there are situations where intralinguistic subtitles generate both support and a distraction factor, so their application is evaluated by the educator and the nature of the multimedia material.

IV. DISCUSSION, INTERPRETATION AND COMPARISON OF COGNITIVE LOAD

A. *Data Collection Using the Fred Paas Rating Scale*

Table IX presents the data obtained using the Fred Paas scale [26] in the three groups, where the maximum value that can be obtained is 20 and the overload is considered from 15, in this case values lower than estimated as overload are presented.

TABLE IX: GENERAL COMPILATION OF COGNITIVE LOAD VALUES

	Sample															Average
Video Subtitling	10	11	9	11	9	10	10	9	9	9	8	9	12	10	10	9.73
Video partiallysubtitled	13	14	12	10	10	10	12	10	13	12	12	12	12	10	11	11.53
Video without subtitles	8	9	9	9	7	10	10	9	11	11	10	11	10	10	9	9.53

Chandler and Sweller [27] found evidence of the split-attention effect. This occurs when different sources of information discussing the same topic are separated by time or space, such as a diagram with a key that corresponds to

separate text next to it. When information is presented in this way, it is left to the learner to attempt to amalgamate it, which generates extraneous cognitive load. Therefore, it is recommended that if one of the sources adds nothing new, it should be eliminated. However, if it is essential to include both sources, they should ideally be physically integrated (e.g. texts and diagrams combined). This way, extraneous cognitive load is reduced and working memory capacity can be used for intrinsic and germane cognitive load instead.

TABLE X: GENERAL AVERAGE OF THE VALUES OBTAINED DURING THE EXPERIMENTATION STAGE

Cognitive Load		
Group	***Stocking***	***N***
Group 1 (Fully subtitled)	9.73	15
Group 2 (Partially subtitled)	11.53	15
Group 3 (Non-subtitled)	9.53	15
Total	-	45

As can be seen in the Table X, a higher average is required when the partially subtitled video was presented to the students, denoting that they have generated a greater cognitive demand in the valuation scale, on the other hand it could be said that there is a scarce influence of the subtitles in the videos applied at this stage, because the averages between the group that watched the video without subtitle seems to have the same demand as the group subjected to the video subtitled totally because the difference is negligible, however the average with respect to the second study group rises considerably, in principle due to the partial subtitling however the question arises of why we cannot avoid reading the subtitles, according to what is stated by [25] the processes analyzed and that generate a cognitive demand are also related to what is analyzed unconsciously, in addition to it and related from the same forma to automatic reading [24] that our mind produces involuntarily, that is to say in the case of this test the mind was in a constant attempt to complete the missing sentences what was reached become a factor to analyze or a distraction, on the other hand the videos that were subtitled and subtitled respectively denote a lower demand and an optimal learning result that is expected at the time of applying this kind of educational material during the sessions of the TISG course, which is why the best option to support learning would be the subtitled videos, because even if it demands a greater cognitive load than the non-subtitled ones, they demonstrate greater support for the student due largely to the involuntary reading that is made of them where they can receive more support for the understanding of the video.

B. *Hypothesis Validation Using ANOVA*

To validate the proposal, the data collected for the ANOVA evaluation were subjected to analysis, the results are presented below:

- Alternate Hypothesis: The difference in cognitive load generated by the subtitles is significant in relation to the Fred Paas Scale.
- Null Hypostasis: The difference in cognitive load generated by subtitles is not significant in relation to the Fred Paas Scale.

C. *Results Obtained from the Analysis of Variance*

In Table XI you can see the analysis based on the ANOVA analysis, where according to the value of F obtained from the data is 13,553 is greater than the critical F for the degrees of freedom that supposes 3.22, so the alternative hypothesis (Ho) is accepted, affirming that the observed difference is significant with 95% reliability in relation to the averages which means that the subtitles in general influence in the results of cognitive demand, and specifically the partial subtitling is the factor that determines the cognitive load presented in the second graph, since the unconscious factor insists on reading incomplete information, which means a greater demand for attention and processing than is needed to perform the task, as observed during this stage it can be said that if a large difference is generated reflected in the significance of the analysis of variance.

TABLE XI: ANOVA ANALYSIS OF VARIANCE (GENERAL DATA)

Origin of variations	**Sum of squares**	**Degrees of freedom**	**Average of the squares**	**F**	**Probability**	**Critical value for F**
Between groups	36.4	2	18.2	13.553	0.00003	3.22
Within the groups	56.4	42	1.342	-	-	-
Total	92.8	44	-	-	-	-

The emergence of technology as an educational resource brought with it different problems in terms of the disparity of its uses, in the first instance it was considered a distracting agent, today it has become the frontline support both in education and in training of international scope, used in conferences either as visual multimedia material, text or sound. In this area, subtitling emerges as support material, because as mentioned in the Multimedia Learning Theory, the information that comes from a single channel is limited, but by adding more information income the processing and retention of it increase [28], the implementation of multimedia material to education has meant a new stage in the forms of teaching and learning.

Subtitles have positive effects on other aspects of the teaching-learning process [29], in these cases as it investigates, [30] part of the responsibility for learning lies with the student, because in any situation there is a method of support for the student, in the case of multimedia resources has resources to support all types of students.

Currently Learning Management Systems (LMS) store a large amount of data about student interactions in log files, these files generally contain variables in the data, such as the number of logins, the number of accesses to elements of an online course, the number of completed assignments, the number of days in the online course, the activity grades, the period grade, the course grade [31].

V. CONCLUSION

- The application of subtitles means a potential proposal of education due to the increase in learning; Approximately 30% between the pre and post test score, in addition to equality education giving importance and

support to people with sound disabilities, on the other hand it represents a constant support material due to the information with which the student is provided during the learning process.

- The use of multimedia material arises as a potential proposal in the educational area due to the great difference in learning that is represented by the score obtained between the pre and post test, this proposal being of potential for different areas of learning especially areas where visual support is a necessity for learning.
- The integrity of the subtitles and the information presented in them is paramount and of complete responsibility of the one who develops them because these are not integral how they are developed in the experimentation stage of the present research, can generate havoc during learning, it denotes a fall in the score obtained by 21.56% on average and an overload in the cognitive demand expected for the task being developed, 2 points on the scale approximately.
- The application of subtitles is evaluated by the student and the developer, because not in all videos it is productive to apply those existing videos where subtitles of an intralinguistic, bilingual and other nature are required; except for situations where the learning condition warrants it.
- Finally, to reduce the cognitive load when presenting multimedia material, it is recommended: Break down subject content when introducing new topics and pause regularly to check understanding. Present instructions clearly without using too many sources of information at the same time. Be wary of reducing cognitive load too much the learning process should be manageable, but not overly fragmented.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Benjamin Maraza-Quispe has carried out the methodological design, Olga Alejandro-Oviedo has reviewed the background, Luis Cuadros-Paz has performed the statistical analysis, Walter Fernandez has intercepted the data and Eduardo Rodriguez-Zayra has contributed with the discussion and conclusions.

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