Descartes wears Converse:
Liberal Arts for the Twenty-First Century Student

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0. **Abstract**

Students today have a different way of relating to information due to the new media channels that have arisen in the last decades. These have changed the way high-school and undergraduate students learn and they have altered the manner by which they perceive the world. Today’s Education Theory must take this fact into account in order to enhance the student’s learning process. The objective of this project is to give an example of how this enhancement may be achieved. First, it will give a brief overview of the relation between today’s young generations and the different channels of information; secondly, it will analyze the cognitive, psychological and educational theories that explain how the human brain learns and the important value that nonverbal information has for the memory system; afterwards, it will focus on this nonverbal information, looking at the possible effects that it may have on human memory and learning; finally, it will give an example of the practical implementation of this theory through the presentation of three animated instructional videos that have been created with the specific aim of enhancing the young generation’s understanding of some complex subjects of the Liberal Arts.
1. **Introduction: A new form of Education for a digital world**

The new media has changed the way we perceive information. Today’s students, their relation to information and the manner by which they process this information differ greatly from that of all previous generations. The internet, video-games, mobile phones and the bombardment of information given by all kinds of media, make today’s high-school and undergraduate students think and process information in a different manner from that of the past. There are no more taboos about gathering information: it is not locked in the teachers’ brain or hoarded by silent and intimidating libraries and museums anymore; information is everywhere. It is in being able to look at the Rosetta Stone with greater detail and quality than if standing in front of it in the British Museum; it is in receiving instant notifications (and visual coverage) of any important event in any part of the world; it is in knowing where you are and where you have to go in an unknown city; it is in watching a Nobel-prize winner give a lecture without having to leave your bed. Information is at the palm of anybody’s hand, and acting as if it were otherwise would be absurd.

For all these reasons, the relationship that a student in the twenty-first century has with information does not apply to what he would have had to do if he intended to receive the same information thirty years ago. These students are what the educator Marc Prensky calls “Digital Natives” (2001): a new generation of people who are “native speakers” of an information language that moves very fast and that communicates with them through channels that their predecessors did not have. Their relationship with the world is radically different and, when intending to educate them, one must take this fundamental fact into account; one must teach them through the channels that they understand.

This text does not intend to state that traditional instruction should be eradicated; the author affirms that it is important to teach students to process information through the traditional channels but, if one aims at engaging the students, if the goal is to motivate their intellects, o make them desire more and to learn to work with the same tools that they will
actually use in their future, one has to understand that making them read *Beowulf* or *El Cid Campeador* (depending on the country) when they are fifteen years-old will not increase their motivation to read. There is much value and great beauty in the Liberal Arts, but Mozart’s *Don Giovanni* has very few chances of winning a young mind’s attention if confronted with an Xbox or MTV. This is a fact, and there is absolutely nothing than one can do about it.

But this does not imply that the traditional art forms should be eliminated from the curriculum just because the younger generations are not able to grasp their value: the solution is to find ways to insert these classics into the channels that students understand easily and process efficiently. In this manner one can increase their motivation on the subject and make them desire for more of it.

Today’s world has replaced the traditional ways of receiving information with those brought up by the new media. E-mails have replaced written letters; news is being obtained through Twitter and RSS feeds; there is no book, movie or song that cannot be found on-line if one knows how to look for it. Furthermore, inside this new media, the quantity of text tends to be reduced so to give more space to visual representations: *emoticones* replace written words in chats; video and photo footage of an event are far more valuable than their written descriptions; and movies about books are seen by a far greater audience than their sources.\(^1\)

What to do, then, if one wants to open the lock that has kept information trapped in traditional media? As said before, the solution is to adapt this information into the channels that the young generations can process more easily, so to encourage them to study the original sources.

This is precisely the aim that this project has in mind. The Liberal Arts have far too much value and beauty for them to be trapped in libraries, museums and teachers’ brains. They have to be freed from their prisons and brought back to people’s lives. One can state that there are two fundamental steps for achieving this goal: the first is to render the information into a channel that can be more feasibly processed by the new generations (audiovisual material); and, secondly, uploading this newly rendered information into a media that the new generations actually use when searching for knowledge (the internet).

Even though this project will focus mainly on studying the first of the two steps, this is, explaining the arguments in favor of the use of audiovisual materials in an instructional

\(^1\) As a personal example, around 70% of the people that visit this author’s blog do it for the images or videos in it and not for the written texts, even though the blog’s goal is to share essays and not pictures.
environment, it is important to give a small glimpse of the remarkable opportunities that the internet offers to the learning process.

First of all, if a piece of information is not currently on the world-wide-web, it might as well not exist. Digital Natives’ first, and in many cases sole, source of information is the internet. When a teenager has to hand in a paper on the Second World War, his or her first impulse is not to go to the library and take out a book about it; the first action that they take is to type-in the paper’s topic in the Google browser and, in most of the cases, rely exclusively on the results that appear in the first page (even sometimes only on Wikipedia). Then, they go to video browsers (be it Google Videos or YouTube, among a few others) and search for information on their topic in the audiovisual media.

An average contemporary household does not have the old and reliable twelve-volumes Encyclopedia on the bookshelf for the children to do their homework with, simply because it has no way of competing against the almost infinite information that can be found in the internet (there is no doubt of why Encarta went broke); buying tapes or CDs for learning a language or having collections of “How-to” books is out of date when compared to the millions of web pages that offer free resources for language acquisition or podcasts and video tutorials that allow you to learn anything from any imaginable subject (from making cookies to “how to build your own gun with a 3-D printer”, passing through every digital or physical skill). Information has stopped being hoarded by the “gifted minds” and has been opened up to the masses. Keeping information secret has lost its sense completely; today, information is openly shared and that is precisely the reason why a YouTube video may arrive to a wider audience than any printed book may ever achieve to. The internet has penetrated faster around the globe than written text has in the last two thousand years\(^2\). This shows how powerful the use of internet may be for sharing information.

Another positive consequence is that most of the internet based learning experiences are a two-way communication channel just as a real classroom environment would be, in comparison to traditional materials such as textbooks. Using YouTube as an example, one not only uploads and shares information through this channel; it opens up the opportunity of receiving feedback. The audience can comment on what is being showed, they may ask

\(^2\) Another personal example, the video about Descartes (which will be presented for this project) has been seen more than 37.000 times in 88 different countries in only two years on-line, thanks to YouTube. One wonders how many people may see it if it were inside a CD on the back cover of a Philosophy schoolbook.
questions and solve doubts through on-line contact with the creator and they can openly show their “liking or disliking” of the material, aiding in the process of a democratic construction of the instructional tools. Books, television and tapes are a one-way channel of instruction; there is no way of asking a book to solve your doubts; there is no way of engaging on a personal and direct debate with millions of people around the globe through television; and it is a lot easier to share a song you liked with your friends by copying and pasting a link on Facebook, rather than by burning five hundred CDs and sending them by post mail to each of them.

The internet gives the possibility of receiving an almost infinite quantity of information from any part of the globe in any imaginable subject in just a few seconds. It allows one to share one’s own skills, thoughts and opinions with an audience bigger than ever imagined, having the opportunity of communicating with the audience and engaging in an open discussion that allows everybody to grow. For these reasons, today’s teachers must understand the whole range of possibilities that these tools offer to their students.

As mentioned before, the Liberal Arts have a lot to offer to today’s students, but the means by which these subjects are currently being taught do not motivate them enough and do not present themselves in a manner that the student may find and process more easily. For this reason, the author of this text has embarked in the quest to reach these young audiences’ interest. The Liberal Arts’ problem does not lie on the attractiveness of their content; it lies in the manner by which this content is presented to the students. This project will present some examples of audiovisual materials that have the sole objective of breaching this gap between the students and their schoolwork. They have been created specifically for their needs and motivations, as supporting material for their obligatory studies of some complex subjects of the different Liberal Arts. They do not aim at replacing their core resources, far from it. They must be seen as an aid that may, perchance, motivate them to looking at these subjects from another angle, helping them organize the complex elements into neat shelves in their memory so that their learning process may become more that merely memorizing facts, so to be able to understand what they are intended to learn.

In the author’s opinion, reading a book such as Don Quixote is an experience that everyone should have the chance of living. Furthermore, there is no possible way of enhancing or replacing this experience of reading the actual book. The problem lays in the
fact that high-school or even university students have not received the motivation that will allow them to actually open the book and enjoy it. Teachers must create the proper scaffolds that will drive the students to have a positive relation with the book, so to not see it only as dull homework.

The project that is being presented will propose a solution to the lack of motivation shown by young students in the study of the Liberal Arts. The materials and the channels used traditionally for teaching subjects such as Literature, Philosophy or History of Art, among others, are not engaging today’s young generations anymore. An average student who is connected to the internet most of the day and who is accustomed to receive information at a very high speed and mostly through the visual channel cannot be expected to have the innate motivation of going to the library and checking-out a book on Greek architecture for presenting the subject in class. He or she will not do it because a regular textbook does not motivate his or her curiosity and because the library is not his or her ordinary channel for retrieving information. It is important to make an emphasis on the fact that the author of this text is not intending to state that the student should not go to the library, on the contrary; what he is trying to explain is that, in order for the student to have the urge of learning, he must be appropriately motivated through the channels that he or she understands and enjoys.

This project intends to offer the scaffold that will allow the students to like what they are forced to learn by their curriculum so that they will not only memorize the facts, but so they can actually understand and get engaged with the subjects that they are being taught in school. This project presents, hence, an example of animated instructional videos designed specifically as a supporting source of information for the students’ core studies. Their goal is to stimulate the learner’s engagement with the subject, explaining the fundamental information in a clear and entertaining manner, so to motivate them to find out the hidden gems in the study of the Liberal Arts.

But the design of animated instructional material does not rely only on rendering the information into an audiovisual channel and sharing it with the world: the materials must be properly created in order for them to actually have a positive effect on the learning outcome. For this reason, the theoretical part of this project will focus on answering two fundamental questions that will structure the practical creation of the instructional materials.

First, it will explain “how the human brain learns”: supported by cognitive, psychological and educational theories, it will look at how the human memory works, how it is divided,
what are its limitations and which could be some possible ways of solving these limitations. Afterwards, it will analyze the subject from the opposite perspective, this is: having understood how the human memory learns, one may look at “how does one teach to this human memory”; it will study the positive and negative effects that an instructional material may have on the human memory, effects that will guide the instructional designer through the means that should be used or avoided in order to create materials that may enhance the learning process.

Finally, it will present the examples of the audiovisual instructional materials created for the project and it will justify and analyze them in relation to the theoretical background studied before. In this manner, the project will cohesively present a practical example of instructional materials created specifically for “Digital Natives”; it will give some empirical results that have been gathered from the instructional use of these materials; and it will structure it on a solid theoretical ground that intends to support it.
2. **How the human memory works: Cognitive learning theories.**

As previously noted, before being able to answer the question of “How should one teach?”, it is very important to analyze the mechanisms that allow the human brain to learn. There is no use in creating instructional material if one does not begin by understanding how the human mind works. Before even thinking about teaching, one must focus on the learning process. And, by having understood how this process works, the materials created afterwards will possibly have a more meaningful effect on the learner. This chapter, then, will give an overview of the main cognitive theories upon which the project will stand on. This will guide the reader through the process that will allow him or her to understand what is required in order to create meaningful instructional materials.

The project stands on five cognitive theories that complement each other in a way that all of them together give a complete picture of how the human memory works and how it affects the learning process. The first three focus on the structure and capacity of human memory, while the last two analyze the relevance of images in the learning process: 1) the Atkinson-Shiffrin memory model, which shows the basic structure and division of human memory into three different storage memory units; 2) the cognitive load theory introduces the concept of working memory’s limited capacity; 3) schema theory explains how the brain solves the problem of the above mentioned limitation by the creation of schemas; 4) dual coding theory divides the process of encoding information into two different channels (verbal and nonverbal codes); and 5) multimedia learning theory approaches the learning process from the multimedia’s point of view, through the unification of the above mentioned theories.

2.1. **Division of the human memory: Atkinson-Shiffrin Memory model.**

The selection of a memory model is the first fundamental step that has to be taken when designing instructional materials. All the future development will be based on this first step that explains how the human memory works. This project will use the longstanding Multi-
store model (Atkinson & Shiffrin 1968), which is based on a tripartite division of human memory: the sensory registers, the short-term memory (also called working memory) and the long-term memory. External information has to pass through these three stages in order to be able to be retained in the human brain. It is assumed that external stimuli pass from the environment to the brain through the sensory memory or registers (the visual, auditory and haptic) and from here into working memory. Here, the information may be rehearsed and encoded so to be retained in the long-term memory, or rejected and forgotten. It is stated that the longer quantity of time a piece of information resides in working memory, there is a higher probability for it to be retained permanently in long-term memory (Baddeley 2004: 1).

Working memory is ignited by one paying attention to the information that is received through the sensory registers (or internal thought) and it lasts for only a few seconds unless it is consciously repeated. This process of repetition allows the information to be encoded and stored in long-term memory. If so, it would lead to an enduring retention of information, which could last from minutes to a lifetime. The instructional designer has the obligation of understanding how each of these memories function and how they relate to each other in order to be able to create useful learning materials.

2.2. Working memory and cognitive load: Cognitive load theory.

The learning process is strongly affected by the way human memory functions; only by understanding how this system works one can develop useful educational material. The process of learning can be defined as a modification of long-term memory (Sweller 2005: 20), this is: the efficient integration of new information into the prior knowledge previously stored in long-term memory. One has to select and organize the new and relevant materials from all the possible external stimuli that arrive to working memory in order for it to adjust and alter the information that is already encoded in long-term memory (Mayer 2005b: 37).

A major inconvenient for the learning process is that working memory has very limited space. In contrast to the long-term memory’s huge capacity, which allows storing information maybe till infinity, working memory can process very few items at a time, limiting greatly the quantity of information that can be encoded in a given moment (Sweller 1994: 299). If the cognitive load —the amount of information being processed simultaneously in working memory— is higher than the memory’s capacity, then part of the information will not be processed or stored. Because meaningful learning may involve processing materials with a
heavy cognitive load, an instructional designer’s goal is to find ways of dealing with the limitations imposed by working memory and allowing the full understanding of the information that is intended to be taught. This is done by reducing or eliminating the unnecessary load so to allow the essential information to be processed smoothly (Mayer & Moreno 2003: 50).

The learning process involves three different kinds of cognitive load on working memory. Each of these alters the learning process in a different way. They are the intrinsic, the extraneous and the germane cognitive loads. The intrinsic cognitive load refers to the inherent density of the information being processed. It is fixed and can only be reduced by altering the same information that is to be learned (Sweller 2011: 57). The levels of intrinsic cognitive load are directly linked to the interactivity among the different elements: higher interactivity makes the intrinsic cognitive load rise. If one is teaching a very complex philosophical subject (Hegel’s *Phenomenology of the Spirit*, for example), it will lead to a very high load in the learner’s working memory, regardless of how clear one presents it due to its inherent complexity. The only possible way to decrease this load would be by reducing the information innate to the problem, which would lead to a more shallow exposition of the subject at hand.

Apart from the load created in working memory by a subject’s intrinsic complexity and interactivity, there is also the cognitive load produced by the methods and materials used to teach this subject. This is called the extraneous cognitive load and it is on this load that the instructional designer has to focus in order to develop useful learning materials. This cognitive load is imposed on working memory by the methods used to teach a given subject (how the information is explained, what format is used to explain it, etcetera). This affects all the materials and methods used by a teacher to present a subject, and it should always be reduced to the minimum possible in order to allow the greatest amount of working memory to focus on the processing of the information intended to be learned and not on the means by which it is presented (Sweller 2011: 63; Homer, Plass & Blake 2008: 787).

The third cognitive load that affects the learning process in working memory is the germane cognitive load. This is produced when the learner’s attention is directed to the same processes that allow him to construct meaningful structures in long-term memory. Cognitive load theory affirms that, when there is unused working memory due to low intrinsic cognitive load and properly reduced extraneous cognitive load, the learning process may be improved
by directing the learner’s attention towards the relevant learning processes (Sweller, Merrienboer & Paas 1998, p. 264). This means that, by making the learner conscious of the means by which he or she can meaningfully store information in long-term memory, it may aid the proper structuring of the information in long-term memory.

2.3. Mental model creation: Schema theory.

The process of storing new information in long-term memory is not only dependent on the correct encoding of the external sources of information in working memory; it also requires the development of linkages between this new information and the prior knowledge already stored in long-term memory. It is this prior knowledge that provides a framework into which the newly processed information may be introduced (Schnotz 2005: 56). The assimilation of new materials into preexisting knowledge is the fundamental step that allows meaningful learning (Baddeley 2004: 3); without linking the new material with the already stored information, one would only remember a chaotic accumulation of facts, names, dates and numbers (what could be called “rote learning”), but one would not be able to understand the relation between all these random items.

New information has to be altered in order for it to be properly assimilated into the learner’s prior knowledge on the subject. This is done by the construction of schemas, which are huge amounts of information that are processed by working memory as a single unit, reducing the load necessary for recovering them. Meaningful learning is achieved when one builds an increased number of complex schemas that allow very high quantities of information to be processed simultaneously in working memory without creating a high cognitive load (Kirschner 2002: 3). For example, when one sees a painting made by Salvador Dalí, one does not have to remember every detail of every painting made by this same artist in order to be able to categorize it in long-term memory: the newly seen painting is codified and classified depending on its inherent characteristics and the learner’s prior knowledge on the subject. The new painting is linked with what he or she already knows about Dalí and his paintings (be it the artist’s style, his recurrent images, his use of color, etcetera). This allows the new painting to be embedded into an already constructed schema of ‘Dalí’s paintings’.

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3 It is important to note that the schema theory has not been created by the authors quoted in this text. These are the secondary sources that the author has used due to their thorough and clear presentation of the theory.
This does not require a high cognitive load on working memory due to the fact that all the various and fundamental pieces of information required to understand the subject have been compressed into a single element, a *schema*, that allows the information to be retrieved without difficulty (Sweller 1994: 299).

2.4. **Verbal and nonverbal channels: Dual coding theory.**

In relation to the main objective of this project, it is important to look at the theories that have analyzed the linkage between human memory and the different sensory outlets. In other words, it is necessary to find an answer to the question: “How does the human memory system react to the diverse external stimuli during the learning process?” There are two theories, strongly connected with each other and with the above explained memory theories, that can be considered as fundamental for designing audiovisual instructional materials: Allan Paivio’s *Dual coding theory* and Richard Mayer’s *Multimedia learning theory*. The next two sections will give a brief review of these two theories, so to explain afterwards how these theories help as a guide in the creation of multimedia instructional materials.

The fundamental assumption made in Paivio’s dual coding theory (1986) is that working memory is divided into two separate systems for processing information: one specialized in the encoding of nonverbal information and a second one focused on dealing with language (Paivio 1986: 53). Each of these systems is independent of the other, this meaning that either one can be active without the other one having to do so. But, at the same time, activity in one system may lead to activity in the other. For example, hearing the word ‘tree’ not only activates the verbal system (the word ‘tree’) but it also creates in the nonverbal system an image of a tree that would also correspond to the external stimulus (Paivio 1986: 54).

In relation to creating schemas and meaningful learning, dual coding theory would suggest that one can create stronger memories and enhance the comprehension of any given information, if it is stored through the two codes instead of being processed by only one of them (Sadoski, Goetz & Fritz 1993: 291). This means that, by processing a piece of information with both images and language, it would have an additive effect on memory, reinforcing the creation of schemas through dual encoding.

The main point of Paivio’s thesis is that images have a more important role in the learning process than the one that has been given to them in the past. When learning solely through the
verbal system (be it with written words or orally), the information is processed only through the verbal code, making the recall of this information only available through language. On the other hand, if words are supported by related images, the same information will be dually processed in working memory, making the retrieval of the given schema available through both the verbal and the nonverbal codes. The reason why images are better remembered than words is that pictures are more likely to be processed through the two codes: an image comes with a verbal reference in most of its cases, while the contrary is not necessarily true (Paivio 1973: 179).

Many studies have shown that the use of images as an aid for memory has generally given more positive results in the recall of information than when information is tried to be remembered solely through the verbal system\(^4\). The main conclusion to which one can arrive is that, due to the fact that pictures can be dually encoded in working memory, this allows the creation of more easily retrievable schemas, which would lead to a more efficient learning process. Of course, it has to be noted that the use of images in instructional material does not directly imply an enhanced learning process; for meaningful learning to be achieved, as this text will show later on, instructional design has to take into account the above explained cognitive load on working memory. The mixture of verbal and nonverbal information can have positive effects on learning only if used properly; if misused, it could have a negative effect by unnecessarily increasing cognitive load on working memory and obstructing a meaningful learning process.

2.5. **Audiovisual materials and memory: Multimedia learning theory.**

Up till now, the studied theories have tended to relate to each other in a relatively harmonious manner: each of them constructing or complementing the other in some way or another; all of them find positive solutions, but somewhat evade the possible problems. The last theory that will be studied in this chapter intends to tie the loose knots among the above mentioned theories, aiming at constructing a well built structure upon which meaningful learning can be achieved through the use of multimedia instructional materials. It not only analyzes the possible advantages of learning through multimedia materials and how they can be enhanced, but it also looks at the disadvantages and limitations of multimedia, showing

\(^4\) See, for example, the studies by Anderson & Hidde (1971), Paivio (1973) and Pressley (1976).
that the learning process requires much more than only pictures and words; it requires an appropriate use of them.

Richard Mayer’s *Multimedia learning theory* (2002) stands on a very simple principle: that “People learn better from words and pictures than from words alone” (Mayer 2005a: 6). As stated before, Mayer will incorporate many of the elements from the other theories mentioned in this chapter in order to form a unified theory for multimedia instruction. But his contribution does not lie exclusively on unifying other theories; it lies on finding their limitations and the possible disadvantages of learning through this channel. This will allow him to create solutions that could surmount the obstacles of multimedia learning so to construct meaningful and useful materials. These effects of multimedia on the learning process will be studied deeply in the next chapter.

As mentioned before, *multimedia learning theory* states that the learning process can be enhanced and improved through the use of images. It stands on Paivio’s theory that information is processed in working memory through two different channels: one for verbal information and another for nonverbal information. Hence, when presenting material only through the verbal code, half of the potential capacity of working memory is being ignored by not processing information through the nonverbal channel; on the contrary, multimedia materials (that is, presenting information through both words and images) “takes advantage of the full capacity of humans for processing information” (Mayer 2005a: 4).

There are three basic assumptions upon which Mayer’s cognitive theory of multimedia learning is structured: dual coding of information (Paivio 1986), limited memory capacity (Baddeley & Hitch 1974; Sweller 1994) and the learners active role in processing (Mayer 2001). This is, 1) that humans posses two separate channels for processing visual and auditory information; 2) that there is a limited amount of information that can be processed simultaneously in working memory; and 3) that the learner is actively engaged in the selection of relevant information, organizing this relevant information into coherent mental representations and integrating these mental representations with the already constructed schemas of prior knowledge (Mayer 2005b: 32-37).

This leaves the instructional designer with more problems than solutions: because working memory has an extremely limited capacity and due to the fact that the learning process is carried out exclusively by an actively engaged learner, the material that aims at achieving a meaningful learning process has to be created following a very specific set of guidelines.
Multimedia instruction has to take advantage of the dual code’s full potential while, at the same time, understanding the limitations that working memory imposes on the learning process and the possible consequences of creating multimedia materials that could unnecessarily increase cognitive load instead of creating an ideal environment for instruction (Mayer 2005b: 37). As stated before, the following chapter will focus on analyzing the positive and negative effects that multimedia may impose on the learning process. It will look at how the positive effects may be enhanced and how the negative effects may be reduced through appropriately designed instructional materials.
3. **Teaching with audiovisual materials: Their effects on the learning process.**

The reason why this text has given a brief presentation of the main cognitive theories that explain the human memory’s structure and abilities to learn is so that the reader may understand the consequences that the above mentioned theories have on the actual creation of audiovisual instructional materials. This chapter will focus on studying the positive and negative effects that the audiovisual materials may have on the learning process, and it will look at the guidelines that an instructional designer may follow in order to create meaningful learning materials.

The effects of the audiovisual materials on the learning process will be divided by the type of cognitive load that they affect: 1) The effects on *intrinsic cognitive load*; 2) the effects on *extraneous cognitive load*; and 3) the effects on *germane cognitive load*. These conclusions have been taken mainly from the cognitive load theory (Sweller 2011) and the multimedia learning theory (Mayer 2002). But, instead of dividing them into the theories that gave birth to them, the author of this text has decided to unite them into cohesive categories. This will allow the reader to have a better understanding of how these effects may influence the learning process and what the instructional designer has to do in order to develop audiovisual materials that can actually improve the learning process, instead of deteriorating it.
3.1. Effects on Intrinsic Cognitive Load

The first effects that will be analyzed in this chapter are those caused by the audiovisual materials on the intrinsic cognitive load. This must be the first thought that one has to take into account when designing instructional materials due to the fact that it defines the information that will be taught and the information that will be excluded from a presentation. It does not concern the style of what is taught, but the subject that should be taught. There are two main effects on intrinsic cognitive load: the understanding effect, this is, the consequences that any given information may have on a learner depending on his or her degree of understanding of the subject; and the isolated elements effect, which focuses on how an instructional designer creates materials taking into account the level of complexity of a given subject and the learner’s level of expertise.

3.1.1. Understanding versus Rote Learning

There are basically two ways of storing information in long-term memory: by understanding the information through the creation of complex schemas; or by rote learning. Each of these two roads has its advantages and its disadvantages. Rote learning implies the elimination of interactivity among the different elements that are to be learned. For example, remembering the dates in which the different battles of the Second World War took place does not require understanding the reasons behind these different battles or how one battle affected on the development of the next one; the learner only has to repeat the names and dates of these events until they are lodged in his memory. This is what is considered rote learning. It has the advantage of reducing the complexity of the subject to its smallest degree, hence reducing the cognitive load during the learning process. But, as a negative consequence, it does not allow the learner to understand the subject; it only allows him or her to remember random dates and names through the creation of isolated schemas that cannot be linked with each other.

As shown in the last paragraph, the reduction of intrinsic cognitive load directly affects the information being processed. The instructional designer must aim at finding a balance between the complexity of the information taught and the cognitive load that it will create (Sweller 2011: 59-61). Giving very superficial and simplified information, with low
interactivity among the different elements, will not allow the learner to understand the relation between the different pieces of information on the subject; but, on the other hand, giving the whole information with all its inherent complexities to a learner who does not have a basic understanding of the essential concepts, will suffer an overload on his cognitive capacity and will not be able to understand what is being taught.

In relation to the project that this text aims to support, this is the first point that has to be taken into account. How these animated audiovisual materials could aid the students’ meaningful understanding of new information? The videos that are to be presented in this project have been thought of as a supplementary aid in the student’s learning process. This means that they are not to be used as the sole source of information on the subject but as a support for the main materials used. They have been designed so to aid the students with the creation of meaningful schemas that will allow them to understand the different elements of a given subject in an organized and simple manner.

3.1.2. The Isolated Elements Effect

As noted in the past section, there is an important conflict between understanding complex information and the cognitive load that this process represents. The instructional designer has to find a way to solve this ostensible opposition, and the isolated elements effect can be considered as a possible solution: it reduces the cognitive load required for processing complex information by segmenting the subject into isolated elements so that all the information does not have to be processed in working memory at the same time.

If a student is a beginner on the subject that is being taught, or if, simply, the material is intrinsically too complex with high interactivity among the different elements of information, it is improbable that working memory will be able to digest all the necessary information simultaneously (Pollock, Chandler & Sweller 2002: 64). In this case, it is suggested that the various elements should be initially presented in an isolated form so that each of them can be easily processed in working memory. Once the isolated elements have been fully processed individually, the interactivity among the different pieces of information may be presented, allowing the students to fully grasp their relations. This is allowed by the fact that the learners will have encoded the fundamental concepts that enable them to build a well formed structure on the subject (Sweller 2011: 63).
Richard Mayer calls this the *Pretraining effect* (2002: 125-128): he divides the schema construction process into two stages: first, building *component models*; and then, constructing a *causal model*. The first stage pertains the correct encoding of each of the elements of a given subject. The second one focuses on understanding the interactivity among these elements, the cause-and-effect that relates them to each other, making them in some way inseparable from that moment on.

This can be considered as a valuable instructional technique when the information is too complex to be processed simultaneously or when the students lack the basic schematic structures of concepts required for understanding the subject in its entirety (Bannert 2002: 143). When making use of this effect, a primal reduced understanding of the complexity of a given subject is counterbalanced by an increased probability of learning. Due to the fact that the working memory load is reduced, all the necessary elements will be encoded thoroughly (Pollock, Chandler & Sweller 2002: 66). So, afterwards, when the elements are presented in their full complexity, the student will have already processed the necessary structure, benefiting the codification of the new interactive information with a reduced use of the working memory’s capacity. This effect will also have positive consequences on the germane cognitive load, which will be explained later on in this chapter.
3.2. Effects on Extraneous Cognitive load

The effects presented in this section do not affect the information being taught, but they affect the way in which these materials are presented. These are the possible consequences on the learner’s extraneous cognitive load caused by the way the audiovisual material displays the information. It is a fundamental part of the project at hand because it directly concerns the positive and negative outcomes that animated instructional materials may have on the learning process.

There are five main effects of multimedia instructional materials on the extraneous cognitive load: 1) the modality effect, which concerns the outcomes of presenting material through two channels (audio and visual); 2) the split-attention effect, which shows the importance of spatial and temporal contiguity of the presented information; 3) the redundancy effect that analyzes the consequences of including unnecessary or redundant information; 4) the transient information effect, concerning the positive and negative factors of learning through an ephemeral channel of information; and 5) the personalization effect, which refers to the register that should be used in instructional materials in order to enhance learning.

The following sections will study each of these effects in detail, looking at how they may improve the learning process and, also, how they could deteriorate it if not properly accounted for.

3.2.1 The Modality Effect

The modality principle states, in few words, that learning is enhanced by the use of information transmitted through oral narration and images, rather than by printed text and images or than by printed text alone (Mayer 2005a: 6). It is based on the principles presented in Paivio’s dual coding theory (Paivio 1986) exposed in the former chapter. The modality effect assumes that if working memory has two different channels (audio and visual) for processing information, then the use of both of them would allow working memory to function at its full capacity without creating high levels of cognitive load (Kalyuga 2012: 148).
If information is given only through the visual channel (be it with pictures and written text or written text alone), all the elements would enter working memory through only one code. Due to working memory’s very limited capacity, only one piece of information could be processed in the visual channel at the same time. In the “image and written text” case, the processing of all the information would require more time because the learner’s eye and attention would have to switch back and forth between the picture and the words. This forces the visual channel of working memory to retain many elements of information at the same time, hence, increasing the cognitive load required for encoding all this material (Schnotz 2005: 60). In the “written text only” case, there would not be an overload of the visual channel’s cognitive capacity because only one source of information would be processed at the same time. In spite of this seemingly positive effect, half of the working memory’s full capacity (the auditory channel) would be unexploited, increasing the time of potential learning in relation to the use of both channels simultaneously.

Many studies have shown the positive outcomes of using the dual coding approach in an instructional environment. They have confirmed that the simultaneous use of the two channels (presenting information with both visual and auditory stimuli), divides the cognitive load required for a given task into the two independent processors, decreasing cognitive load and increasing the use of effective working memory (Sweller 2011: 67).

The modality effect can be included in audiovisual materials by two different methods: repetition or integration (Brunyé, Taylor & Rapp 2008). Repetition is the process by which the same information is given through both channels, aiming at reinforcing the information that is being learned; integration is used when different but interactive elements are given in each channel, so that they will be processed simultaneously, making it more feasible for working memory to create a unified schema of the two of them. The possible positive and negative consequences of the use of these two techniques will be analyzed further on in relation to other effects. Depending on specific situations they may be useful or adverse to the learning process, but studies have confirmed that, if used properly, both of them can be beneficial (Brunyé, Taylor & Rapp 2008).

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3.2.2. The Split-Attention Effect

When one intends to create instructional materials that can ameliorate the learning process, one has to take into account the importance of keeping the student’s attention focused on what is intended to be taught. Any information that disrupts this focused attention may have negative consequences on the student’s learning outcome. This is due to the fact that his or her working memory will tend to divide its capacity between the incongruent or irrelevant information and the valuable and relevant materials. It is important to note that this effect should not be taken as an unbendable law. In relation to the effects on the germane cognitive load, this text will intend to defend the inclusion of elements that may produce a split-attention effect on the instructional materials but that, nonetheless, will be justified due to the fact that they enhance the learning process from a psychological perspective, increasing the student’s motivation.

The split-attention effect affects the learning process in two ways: through the insertion of irrelevant information (Schnotz 2005: 60-61; Homer, Plass & Blake 2008: 788); and due to an erroneous spatial or temporal presentation of relevant information (Mayer 2002: 107-113; Sweller 2011: 66-67). As said before, keeping the student’s attention focused is one of the main objectives when designing instructional material and, if the split-attention effects are not taken into account, the instructional materials may not work as well as they could. This is due to the fact that they would force the student to encode useless information or would increase cognitive load in working memory due to the erroneous organization of relevant elements.

There are two principles in multimedia learning theory that have to be taken into account when creating audiovisual instructional materials: “Students learn better from words and pictures than from words alone, if the words and pictures are semantically related to each other (the coherence condition) and if they are presented closely together in space or in time (the contiguity condition)” (Schnotz 2005: 60). These principles have to be followed carefully in order to evade creating a split-attention effect with the instructional materials.

The contiguity condition concerns the spatial and temporal organization of the information in the instructional materials. This condition’s aim is to integrate the different elements inside the presentation so that the learner does not have to make an additional effort to integrate them by him or herself (Sweller 2011: 66). Semantically related information that is intended to be taught as a unified schema must be presented closely in space and time in order to allow
working memory to encode the information as a related whole: corresponding images and printed words must be placed close to each other so that they can be easily connected (Mayer 2002: 110); also, the simultaneous presentation of related elements should be done if it does not overload working memory (Mayer 2002: 112). These two principles are what is called “the contiguity condition”, which eludes a possible split-attention effect and should be taken deeply into account when creating audiovisual instructional materials.

The coherence condition is the second principle of multimedia learning theory in relation to the split-attention effect. It is fundamental not only to this effect in particular but also to others that will be presented later on. Audiovisual instructional materials should be designed taking into account the fact that the use of images, sounds or texts that are irrelevant to the core information may overload working memory. This is because their inclusion could divert the learner’s attention from the relevant information to secondary or decorative materials (Homer, Plass & Blake 2008: 788). It also has the negative consequence of creating a higher cognitive load than that which is actually required for the understanding of the subject; it makes the learner process information that he or she does not actually need to encode (Shu-Ling 2000: 199). In relation to this, Professor K. Alesandrini examines what type of images should be used in instructional materials, and proposes a system of how they should be presented in order to help the encoding process (Alesandrini, 1984).

She affirms that realistic, detailed and overloaded images are not effective as a learning aid, due to the fact that too much of the learner’s attention would be diverted to the extraneous and unnecessary details of the images, instead of being focused on their conceptual value (Alesandrini 1984: 64-66). Simple line drawings that provide only the fundamental information are more helpful in the learning process than their “baroque” counterparts (Alesandrini 1984: 66). This leads to the assertion that well-designed images are very important when creating instructional materials that depend strongly on them. The mental models are based on these images; hence, they should focus on providing the information that is required for the learning process so that they do not interfere with the mental model construction (Schnotz 2005: 63). This applies to all levels of expertise on a given subject.

As stated before, the split-attention effect created by wrongfully designed audiovisual materials must be avoided as much as possible in instructional design. The visual information must be reduced to the fundamental elements required for enhancing the learning process. So,
“designers of instructional material should resist the temptation to add irrelevant bells and whistles to multimedia learning environments” (Schnotz 2005: 65). The goal is to simplify the elements in order to allow the learner’s attention to focus on the relevant information.

3.2.3. The Redundancy Effect

The redundancy effect is in some points related to the above mentioned split-attention effect, in the sense that redundancy may occur when irrelevant or unnecessary information is presented in the instructional materials (Sweller 2010: 68). But, aside from this possible perspective on ‘redundancy’, this effect is mainly seen as the display of the same information through both the auditory and the visual channels (Mayer 2005a: 6). As mentioned before, repetition or redundancy of information through the two channels may have positive or negative effects on the learning process depending on the learner’s specific situation and on the complexity of the subject to be learned.

Some design principles that are reinforcing for novices may be detrimental for learners with a higher level of expertise (Mayer 2005a: 7). When a learner has high prior knowledge on the subject to be taught, then the use of both images and text may have negative outcomes. This is due to the fact that working memory would be required to encode the same information twice, even when only one channel would have been enough for the correct creation of complex schemas (Schnotz 2005: 63). On the other hand, a learner with low prior knowledge on the subject, or one who has not still constructed the fundamental schemas necessary for understanding the interconnected information would profit greatly from the repetition of information through both channels.

According to what has been seen up till now, an important question arises in relation to how to present information in multimedia instructional materials: is it better for the learning process to convey similar information on the two formats (auditory and visual) so to reinforce the information given in one by the other (repetition)? Or, is the use of complimentary material (different information in each channel) a better aid for integrating and organizing various elements into one complex schema?

Brunyé, Taylor and Rapp (2008) affirm that the two methods (repetition and integration) may have positive outcomes on the learning process. Repetition allows a novice to reinforce his understanding of one fundamental element through the use of his whole working memory’s capacity in only one piece of information. And, on the other hand, the integration
of different but interconnected elements provide benefits as a result of it allowing the learner (who already has the basic elements acquired) to integrate different pieces of information into a cohesive schema, leading to a better understanding of the subject (Brunyé, Taylor & Rapp 2008: 877).

As seen before in Sweller’s “cognitive load theory” (2011), repetition of information through the two formats produces a redundancy of information that makes the working memory load rise, allowing less information to be duly processed at the same time. There is, hence, both a positive and a negative outcome of using repetition on a multimedia presentation: it can be considered as negative because it increases cognitive load in working memory but, at the same time, it may be considered as beneficial due to the fact that repetition bolsters the codification by reinforcing the processing of the pieces of information given (Brunyé, Taylor & Rapp 2008: 879). So, Brunyé, Taylor and Rapp’s study suggests a contrary effect to that stated by Sweller (2011: 68) in relation to the redundancy effect: in spite of the fact that redundancy may induce high working memory load, it does give an advantage on the acquisition of adequate basic schemas for isolated elements (Brunyé, Taylor & Rapp 2008: 890). In relation to this, it may be said that when the information given in a repetitious multimedia mode does not have an extremely high intrinsic cognitive load, the redundancy effect would not have negative consequences but, on the contrary, it would enhance comprehension.

3.2.4. The Transient Information Effect

Another effect that may be considered as both negative and positive for the learning process through audiovisual materials is the transient information effect. This is: the consequences that the use of video (or any other ephemeral mode of instruction) may have on learning. It is important to understand clearly that animated materials are not necessarily better for the learning process than traditional textbooks and other materials that are stable in time (Mayer 2005a: 7). Because the information to be learned is ephemeral and disappears with time when teaching with audiovisual materials, previously permanent information (such as that of textbooks) could be considered to provide an easier access to all the elements that one intends to learn (Sweller 2010: 71). With audiovisual material, the learner has less control over the information, due to the fact that it disappears in time. So, he or she must hold in working memory the information that disappears in order to be able to integrate it with the
information that arrives afterwards (Ainsworth & Van Labeke 2004: 242). This can be considered as a negative consequence on the learning process because it would demand a higher load on working memory so to be able to integrate the information that comes and goes constantly through video or animation (Hegarty 2004: 346).

These arguments against the use of video in an instructional environment (such as a classroom) can be considered as absolutely undeniable. There is no doubt that audiovisual materials cannot evade the issue of presenting ephemeral information (it is its core characteristic). But the negative consequences of this effect only arrive when the learner does not have control over the audiovisual materials, as in the case of a video shown in a big screen to a group of students and controlled by the teacher. But when the material is accessed by the individual student and he or she has control on playing, stopping and rewinding the video, the transient effect would be as inexistent as in a textbook: the learner can access any piece of information at any given time, by moving the video forwards or backwards, in the same way that he or she could flip the pages of a book\(^6\).

Having seen that the negative effects of transience are eluded through the use of the new media and technologies, one may focus on looking at the positive effects that transience may have on the learning process. The inevitable movement and temporality of information in audiovisual materials has also the positive quality of being able to visually represent dynamic processes that cannot be easily explained with other instructional materials (Large 1996: 14). Changes over time or of direction and relations of cause-and-effect are easier to understand if presented in a transient mode rather than if taken from static material.

In the field of the Liberal Arts, one can take the presentation of a historical process as an example. Transience is so fundamental for its explanation that even textbooks try to imitate it with the use of directional diagrams, arrows and timelines; the same can be said of demographic studies, which are based on the analysis of changes through time. A less usual example would be that of the artistic creative process: many artistic movements may be easier to understand if explained by how the artistic work has been created, such as the process of deconstruction and reconstruction of reality done by Cubism.

\(^6\) This point shows the relevance that the media channel on which the material is presented has on the learning outcome. As stated in the first chapter of this text, designing instructional materials is only the first step of this process; where is this material being presented and how the student interacts with this material is the second fundamental step.
3.2.5. The Personalization Effect

The last of the effects on extraneous cognitive load presented in this text is the personalization effect. Unlike the effects mentioned before, this one is not precisely focused on cognitive factors per se but on the social or psychological issues that could affect the learning process in many ways. Studies done in the New York University by professors Homer, Plass and Blake (2008), state that “when information is presented in a way that increases social presence, it is more engaging and better remembered by learners” (Homer, Plass & Blake 2008: 788). This means that if an audiovisual presentation enhances the learner’s sense of social engagement, it may improve the learning process regardless of the fact that its use may increase cognitive load.

A more personalized and conversational style of narration enhances the social engagement between the learner and the material, leading to a deeper learning, rather than if a subject is presented in a more formal and non-personalized manner (Mayer 2002: 131). In other words, people learn more deeply when they are taught in their own language (be it their actual language or their own register of it) due to the fact that this creates a stronger link between the learner and the material. Also, apart from the psychological argument, the fact that the information to be learned is presented in a way that the learner understands instantly, allows working memory to focus on attaining the information and not on trying to understand what the words mean.

When one is reading Immanuel Kant, for example, one does not only have to understand the ideas that he is trying to explain (which may not be so overly complicated); to be able to achieve this, one must understand these ideas from the extremely complicated register that he uses to present them, which may actually require as much cognitive load as understanding the content itself. The situation is worsened if one tries to achieve this by reading him in his original language (assuming that one is not a German native speaker) because one would not only have to understand the content inside his formal register, but one would also have to use a big part of the working memory’s cognitive load to be able to understand the language. As a conclusion, most of the working memory’s capacity would be used in trying to understand how he is explaining the content and not in understanding what is the content.
The personalization effect has a positive outcome from the psychological and from the cognitive perspectives. It allows the learner to focus all of his or her working memory’s capacity in what he or she is intending to learn and not in the form that structures the content.
3.3. Effects on Germane Cognitive Load

The last effects that will be studied in this chapter are those that affect the *germane* cognitive load on working memory. As said before, the objective of a well-designed instructional material is to maintain a good balance between complexity and intrinsic cognitive load; also, reducing as much as possible the extraneous cognitive load; and reinforcing, as much as the working memory’s capacity allows, the positive effects of the germane cognitive load. When the unnecessary cognitive load has been successfully reduced from working memory, it is recommended for the learner to use his or her vacant cognitive capacity in reinforcing the proper creation of complex schemas so to structure a well-constructed learning process.

This section will study four main effects of multimedia instructional materials on the germane cognitive load: 1) the learner’s preconceptions effect, which concerns how the learner’s preconceived ideas of a medium of instruction may affect the outcome of the learning process; 2) the signaling effect, that analyzes the importance of organizing and structuring in a proper way the different elements of a subject in a multimedia presentation; 3) the transient and split-attention effects, looked at from the perspective of their positive consequences on the germane cognitive load; and, finally, 5) the concreteness effect, which underlines the value of concrete images in the presentation of abstract materials and concepts.

It is important to note that most of the conclusions arrived to in this section have not been defined in their entirety by the main cognitive theories, but they can be considered as a reinterpretation by the author of this text of some aspects of the multimedia instructional materials that have not been properly categorized into a specific group by the above-mentioned theories. In opposition to the effects mentioned in the other chapters, these effects cannot be considered as fundamental principles for the structural cognitive theories that support this project; they have been taken from academic studies aside from the main theories studied.

3.3.1. Learners’ Preconceptions Effect

The first effect that will be analyzed in this section will be that of the learner's preconceptions. It is stated that the medium and method of instruction used for teaching will have specific consequences on the learner's willingness to learn and in the mental effort that he or she will use to process the information given, regardless of how well or badly the
material is designed (Cennamo 1993: 34). In other words, the student's preconceptions on video animations will affect the outcome of his or her encoding process while learning through the mentioned medium.

In spite of the fact that it may seem, from what has been said, that these preconceptions will necessarily lead to negative outcomes, this is not necessarily the case. The symbol system (that will be studied at the end of this chapter) used by video instruction is said to be easier to process for students between 9 and 18 years old than the method of processing required for learning with written media (Cennamo 1993: 35). Still following Professor Cennamo, there are many researches and studies⁷ that have confirmed that preconceptions of the medium may affect the learning process but that the symbol system and the manner of presenting the material may balance the possible negative consequences of preconceptions (Cennamo 1993: 40).

Arguments against the use of animated videos for instructional purposes can be easily noted. But what may be considered as a negative effect could actually be beneficial for the learner’s learning process depending on how the effect is used by the instructional designer. In relation to the project at hand, one could state that the use of animated cartoons as instructional material for high-school or undergraduate instruction may be considered as too childish and probably too undemanding for the students. This is because it could have a negative effect on the students who feel that their knowledge is being unappreciated due to oversimplifying the information with cartoon animations. In other words, the student’s preconceptions on the medium would close them intellectually to the information that is to come. But, it is not irrational to affirm the opposite statement: that the same preconception could actually have a positive effect on the learning outcomes.

Cartoon animations simplify the material that is going to be studied; it aids in processing complex information through the use of analogies and easy-to-digest images. Due to this, it can be considered that it would reduce intrinsic cognitive load, having the negative consequence of giving more shallow information, but with the positive consequence of presenting the basic principles in a way that they are easier to digest, hence, easier to process and encode. The results acquired by the college professor Larry Juchartz (2003) with his methodology of using Dr. Seuss’ and Shel Silverstein’s books (poetry written for children) in his theoretical classes for teaching basic philosophical concepts before entering into the

⁷ See Cennamo (1993) for a full list of studies on the subject.
complex information, show how extremely useful this technique can be. Not only because it motivates the students to learn complicated information with the use of didactic and simple examples, but also due to the fact that it prepares them with easy-to-digest material that work as a solid structure for the complex information that will come later.

Short, concise and entertaining animations act as a useful synthesizer of all the complex information studied, enhancing the probability for proper encoding and schema construction. The aim of this project is to create animated videos that will help the student to organize the complex elements of information into a cohesive mental model of the subject.

3.3.2. Signaling Effect

When presenting new or very complex material, it is very important to have in mind that the students probably do not know anything or only know very little about the subject that is being taught. For this reason, when designing instructional materials, one has to take this matter into account. If the goal is to enable the learner to fully understand the information, then one must think on how to surpass the simple explanation of random concepts, in order to arrive to a holistic comprehension of the subject. The instructional material must guide the student through the information, underlining the links among the different elements and leading to a well structured understanding of the subject as a whole.

As noted by Richard Mayer (2002: 128-130), the signaling effect is produced when the instructional material achieves to give a proper introduction, outline and highlights of what is going to be presented. Doing this will aid the student to process the different pieces of information before they are actually explained and it will prepare him or her for the new information that is to come. In some way, it constructs the student’s mental model beforehand, so that when the new information arrives, it will only have to be organized into the structure that has already been built.

The signaling effect is in many ways related to what David Ausubel would call the advance organizers (Ausubel 1960). These can be defined as the elements that guide the learner through the new material, linking the different pieces of information together and allowing an appropriate understanding of the subject. The advance organizers may be phrases that point towards the matter that is going to be presented next; or, thinking more visually, a diagram that indicates the connection between the different elements; or the use of color and size in the images to highlight specific pieces of information that are considered as more
relevant. In few words, the signaling effect created by the use of advance organizers provides what is called the “mental scaffolding” that enables the student to understand new information in a way that does not overload his or her working memory’s capacity.

3.3.3. Positive use of the Transience and Split-Attention effects

In former sections it has been noted that the transience and split-attention effects may have negative consequences on the learning process. Transience does it due to the fact that it generates an ephemeral flow of information, which complicates the effortless retrieval of past elements. Split-attention creates it by distracting the learner’s attention from the relevant materials with the inclusion of unnecessary and irrelevant elements. These two statements are undeniable, but this does not mean that they are always true. This section will analyze these two effects from a different perspective: aiming at finding exceptions to the “rule” that defines them as negative consequences on the learning process.

As seen before, the coherence principle of multimedia learning theory affirms that the student’s probability of achieving meaningful learning from multimedia instructional materials is enhanced when any information that is not required for the comprehension of the subject (be it words, pictures or sounds) is eliminated (Mayer 2002: 117). But there may be positive outcomes for this seemingly negative effect: when it becomes difficult to motivate the students on the subject that is to be taught, it may be useful to cautiously increase the extraneous cognitive load on working memory by including attracting and entertaining details that will stimulate the students’ interest.

When a given subject is intrinsically very complex and, one may say, tedious to understand, the student’s motivation to learn decreases, creating a reticence to the subject that is intended to be taught. In cases such as this, it may be better to create a more welcoming and motivational atmosphere (even if it has negative effects on cognitive load) than not motivating the student at all. A small distraction inside the instructional material (such as background music, the use of jokes or attracting images) is better for the learning process than the student’s objection to learn.

Another positive outcome, in this case of both the transience and split-attention effects, may be seen in the encoding and schema creation processes. The right use of time and transience may have positive outcomes on the student’s elaboration of schemas. “Music, explanatory examples, and other mentally undemanding content may be used to allow the
learners time to prepare to elaborate on new content information” (Cennamo 1993: 42). What Cennamo is intending to say is that the use of repetitive explanations, recapitulation of information explained before and long pauses with background music that reduce cognitive load enables working memory to focus its capacity on the correct processing of the information that has been already given. Also, it does not overload working memory with the processing of new information that arrives at a speed that it may not be able to reach. For this reason, it would be recommended to include the new information in the instructional materials in a pace that will not overflow working memory, leaving enough time for the student to integrate and fully comprehend the already presented elements.

3.3.4. The Concreteness Effect: Learning abstract concepts.

Most of the fields in the Liberal Arts and the Social Sciences are based on an extremely abstract structure. Many of the subjects taught float on a sphere of ideas that is rarely linked to the perceptual world. Because of this, the effort required from the students in order to understand this metaphysical spider web of abstract concepts is hardly ever a simple one. For this reason, this last section will study the means by which concepts are learned, and will focus specifically on the methods that promote the learner’s meaningful understanding of abstract concepts.

Concepts are stored in long-term memory through a classification process that includes or excludes a specific item into or from a concept group depending on its relatable attributes. Working memory identifies the perceptual, functional and relational characteristics of the new item and includes it into a bigger group of various elements that may be considered to have similar characteristics to the newly acquired information (Newby & Stepich 1987: 20-21). This creates what could be called a “prototype” for the group of interrelated items. This prototype combines the relevant attributes of the different items in the group, creating one single representation of all the interrelated elements.

As Newby and Stepich affirm, “concepts can be defined along a continuum according to their concreteness or abstractness” (Newby & Stepich 1987: 22). They are not all the same: their intrinsic characteristics and the way the brain remembers them differ radically depending on how abstract or how concrete they are. This will have important implications on the methodology required for teaching and learning them. According to Paivio’s before
mentioned dual-coding theory, concrete concepts are learned faster than their abstract counterparts because concrete concepts have higher imagery (are more visually perceptible) than the more abstract concepts which are less likely to be visually represented in the brain (Paivio 1986: 206). Following Paivio’s argument, one can affirm that when a concept is easily perceived through the visual channel its recollection from long-term memory will be faster.

This is due to the fact that concrete concepts may be accessed through both hemispheres of the brain. Concrete concepts are stored in long-term memory through two channels: through the verbal and the non-verbal systems. This leads to a broader chance for recollection of the concept because there is a wider contextual support for one sole element in long-term memory, resulting in a faster processing of information in working memory (Jessen, Heun, Erb, Granath, Klose, Papassotiropoulos & Grodd 2000: 103). When one reads a concrete word with high-imagery, such as ‘tree’ or ‘chair’, the concept required for understanding what is being read will be recovered through both the semantic (the verbal definition of the word) and the image (a visual prototype of the concept) systems. On the other hand, when reading a more abstract word, ‘ontology’ for example, the concept cannot be easily recovered through the visual system due to its low-imagery, and working memory has to rely solely on its semantic recovery. Doing this simple exercise of recollection shows how much faster the concept of ‘tree’ or ‘chair’ comes to mind than that of ‘ontology’. The studies done by Jessen and his colleagues (2000: 110) conclude that concreteness activates both the verbal (left frontal and parietal associative areas of the brain) and the non-verbal (right hemispheric areas) systems, using a higher processing capacity of the brain so that retrieval is faster and more probable.

The higher chances of comprehensibility and recall of concrete concepts has been confirmed from all sides: following Paivio’s dual coding theory, this is due to the simple fact that high imagery concepts are available through both hemispheres (verbal and non-verbal systems), while more abstract or low-imagery concepts are retrievable almost exclusively from the left hemisphere (verbal system)\(^8\).

The before mentioned problem that arises when learning complex information (such as that of philosophical theories) is that these rely almost exclusively in an extremely abstract

\(^8\) For more information on the neurological approach to dual coding see: Paivio (1986: 123, 261); Sadoski, Goetz & Fritz (1993: 291); and Jessen, Heun, Erb, Granath, Klose, Papassotiropoulos & Grodd. (2000).
structure; the higher the abstractness of the concepts is, the less likely that they could evoke non-verbal retrieval, leaving the brain to work only at half capacity, making it more difficult for the learner to recover the required information from long-term memory (Paivio 1969: 243).

Having analyzed the difference between the encoding process of abstract and concrete concepts and its consequences on the learning process, it seems reasonably clear what should be the goal when teaching abstract concepts: to introduce a wider context of concrete content in the presentation of abstract elements so to make it more comprehensible and easier to process for the student (Sadoski, Goetz & Fritz 1993: 299). The research done by Sadoski and his colleagues (1993) proved that the inclusion of concrete and relatable information before introducing new and abstract concepts promoted a higher rate of recall than when the abstract material was presented alone in their presentations (Sadoski, Goetz & Fritz 1993: 292-297). A practical example of this may be the before mentioned use of Dr. Seuss’ books in college classrooms as advance organizers for teaching more complicated literature (Juchartz 2003): give concrete examples of what is intended to be taught so that, when the new and abstract information is presented, the students will already have a sufficient understanding of the underlying structure so to process more easily the new and complex information.

This by no way means that the abstract terminology and content should be deleted from the instructional materials: the exclusion of the abstract and complex materials would lead to an oversimplified and shallow exposition of the subject and would not allow the learner to actually understand what is intended to be taught. This project’s goal is not to erase what is difficult from complex subjects, but to work as a scaffold that guides the student through this complicated information. It is considered that the use of analogies is possibly one of the most beneficial methods to introduce new abstract concepts in a concrete manner that will promote the meaningful processing and encoding of new information (Newby & Stepich 1987: 23; Alesandrini 1984: 68). The ambiguous, intangible and invisible characteristics of an abstract concept may be transformed into high-imagery attributes that will create a link between the abstract and the concrete worlds, boosting the learner’s visual perception of the information.

The analogy uses information and terms that are familiar to the learner in order to define new concepts in a relatable way. This transformation of the abstract concept into a concrete and familiar analogy works in a similar manner as the prototype does when learning or
recalling a concrete concept: it creates a bridge between what is already known and what is to be known; it eliminates the gap that obscures the learning of new, abstract and complex information by finding a middle point which can connect the familiar with the newly acquired information (Newby & Stepich 1987: 23-24). By presenting the analogy contiguous to the abstract definition [following Mayer’s contiguity principle (2002: 110)] the two will be processed simultaneously in working memory, allowing the learner to create a mental schematic model that will unify both the abstract and the concrete into a sole schema (Newby & Stepich 1987: 25). This will not only make the complex information easier to understand for the student, but it will actually present the information as a whole, without oversimplifying it or trivializing it.
4. The practical implementation of the theory in animated videos and their analysis.

All of the above explained theory has been presented in order to show a possible implementation of the theory in actual instructional materials. This project will present three instructional animations and will intend to analyze and explain them in relation to the different effects that have been presented before. The videos have been created to be used as a supporting source of information for the subjects that are to be taught, and their aim is to synthesize the core information into a simple and entertaining format. The objective is not only to allow the students to learn from the materials, but also to show them traditional subjects from a different angle. As said before, the Liberal Arts have many wonders to be discovered, but if the materials used for teaching them are not presented in a way that will attract and motivate the students, all of those wonders will stay hidden for the eyes of the young generations.


4.1.1. Production process and content

This video was created as a presentation of René Descartes’ “evidence for the existence of God” for the class of “Modern Philosophy” in the Pompeu Fabra University (2011). The script was based on Descartes’ Meditations on First Philosophy10 and on the objections and answers that this text received by thinkers such as Thomas Hobbes, Pierre Gassendi and Marin Mersenne.

The images were adapted to the video’s needs and animated with Adobe Photoshop CS2, using the stop-motion technique for turning still images into moving figures. The voices were recorded and edited using Adobe Soundbooth CS2 and then taken into Adobe Premiere Pro for edition and unification with the images.

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9 See the video in the annexed CD: Vídeo 1- Descartes y las pruebas de la existencia de Dios.

The script goes back and forth between Descartes and his retractor, allowing the development of a dialog between Descartes’ own explanations for each of his evidences for the existence of God and the answers by each of his retractor. Even though these conversations did not actually take place, the structure of the text and its responses gave way to a dialectic possibility when approaching the subject. This allowed the video to include more dynamism into a possibly lifeless subject.

4.1.2. Analysis and justifications

The first point that has to be taken into account in relation to this video is that this material was created before the actual development of the whole project; it can be considered as the first idea that gave way for the rest of the project to be created. This means that it was not designed having in mind the above mentioned theory. While, due to this, it may break some of the "rules" explained before, it actually follows the main guidelines that structure the theory, as will be seen in this section’s analysis. Furthermore, the fact that it has been available to the public for the last two years has allowed the author of this text to analyze the positive and negative consequences more thoroughly from an empirical point of view. In the end, one will be able to see that the positive outcomes have been greater than the negative ones.

In relation to the video’s implementation of the cognitive effects explained before, the first subject that must be treated is the importance that the video gives to understanding the material in opposition to rote-learning. It intends to explain Descartes’ thoughts from a more ample point of view, not focusing exclusively on what he thinks on the subject, but also including the thoughts and reasoning of other philosophers. This creates, hence, a higher interconnectivity among the different elements inside the video. This allows the student to link what he or she is learning about Descartes to other philosophical subjects and ideas, reinforcing the connections between philosophical thought in different times.

But for the goal of “understanding” to be achieved, the instructional material must be designed in a certain pace that allows the student to have enough time to process the various elements that are being presented. This can be considered as the isolated-elements effect of this video. The different “proofs” and responses are given in a progressive manner, beginning with the most basic information and allowing it to grow in complexity at a slow pace, so that
the learner may be able to efficiently create mental models that will allow him or her to include the consequent arguments into the same complex schema.

The material also takes highly into account the value of the image in opposition to that of written words: text is barely used in order to allow the images to speak for themselves. Even though, at a first glance, it may seem that the video includes too many unnecessary elements (that would lead to a split-attention effect), all the images included are in some way part of the visual explanation of Descartes’ ideas. Due to the fact that this subject is, by nature, so serious and possibly dull for young learners, the inclusion of seemingly secondary elements becomes fundamental if the goal is to attract the learner’s attention and make them desire to know more about the subject. In this case, hence, the social engagement produced by the personalization and split-attention effects boost the learner’s motivation, justifying the possible increase in extraneous cognitive load.

According to the theory presented in the past chapter, most of the redundant, unnecessary or distracting information should be reduced in the multimedia instructional materials in order to not overflow the learner’s cognitive load. It can be stated that this video includes elements that could be deleted while leaving the fundamental information untouched, but these small details (the foreign accents, Descartes sneakers, the various jokes, etcetera) are the precise reason why the video works. Thanks to the many comments received on YouTube\(^\text{11}\), the author was able to analyze the actual effects that the video had on its viewers. It seems, at least from the non-scientific conclusions that can be taken from the feedback received, that it was the humorous and amusing approach of the material the one that motivated the audience to actually watch it and learn from it. It may be that the cognitive load on working memory is increased in some manner due to these extraneous elements, but it does not reach the point of overloading working memory, hence, it not only allows the learner to properly process and encode the information but it also increases the social engagement of the material with the audience.

As stated in the beginning of this section, the most important reason why this video was included in this project is because it can be analyzed not only from the theoretical perspective that has been thoroughly explained in previous chapters, but also from the empirical results that it has gained in the past two years on-line. In other words, the author intends to affirm

\(^{11}\) The video and comments may be found on YouTube, http://youtu.be/jF1m92HDO1Y.
that this video is appropriate as instructional material not only because it follows a set of pre-established theoretical “rules”, but because it has been empirically proven that it is useful. Aside from the positive comments and the more than 37,000 views it has received in the last two years, this video is currently being used by high-school teachers as a supporting source of information for their students and as an example material for the class “Enseñanza de la filosofía” (Teaching Philosophy) in the Faculty of Philosophy and Letters at the UNAM in Mexico.

4.2. Video 2: “Platón y la teoría de las ideas”

4.2.1. Production process and Content.

Based on Plato’s texts, the script was written with the explicit goal of condensing Plato’s theory to its core information. Some of the examples and metaphors used were taken directly from Plato and the rest were created by the author of this text. Adobe Photoshop CS4 was used for adapting the created images (be it photographs, hand-made drawings, or clipart) to the specific needs of the animated video. The voices were recorder and edited in Audacity 2.0.3. The images where then taken to Adobe After Effects CS4, where the animation process took place. Consequently, the prepared animations were edited and put together in Adobe Premiere Pro CS4 so that the encoding procedure could take place. In opposition to the video explained in the past section, this one was designed taking meticulous account of the theoretical framework and, because of this, it follows the “guidelines” in a more detailed manner.

4.2.2. Analysis and justifications

The “theory of Ideas” is fundamental for understanding Plato’s whole philosophical theory and it is strongly connected to a great variety of his other propositions. In the same texts in which he presents his theory of Ideas he also analyzes the soul’s immortality, the emotional, physical and cognitive capacities of the human anatomy, and the creation of an ideal State.

12 See the Annex 1 (p. 49) for the full list of teachers and schools that use the video as a supplementary source of information for their studies of Descartes.

13 See the video in the annexed CD: Video 2 – Platón y la teoría de las ideas.

among others. For this reason, it is crucial to avoid the dangers of digression when presenting this subject because one may end up accumulating too much secondary information that does not directly affect the matter at hand.

The isolated-elements effect on intrinsic cognitive load has been applied to the animation’s content as a scaffold that will allow the learner: first, to construct *component models* that encode the elements of the theory in isolation; secondly, to construct *causal models* that present the interactivity between the isolated elements that have been presented before, so to enable the learner to understand the theory as a unique complex schema.

This effect has been reinforced by the use of *advance organizers* that create a positive *signaling effect* on the germane cognitive load. This can be considered as a fundamental part of the animation because it is the one that creates the links among the different elements and because it highlights the basic concepts that are being presented. It can be seen in the first part of the video (as an introduction and outline); in the constant use of arrows and directional organizers that create links between concepts; or in the spatial division of the scenes that are presenting a relation of opposites (clearly seen in the opposition between body and soul).

The carefully chosen written words that have been used in the video can also be considered as advanced organizers for the material. In spite of the fact that the *redundancy and modality effects* on extraneous cognitive load, announce the negative consequences of using written text in a multimedia composition, the fact that they are being used in this animation as conceptual images and not as descriptive explanations erases all possible negative effects on the learning process. Written words have only been used to allude to an abstract concept that cannot be represented visually; to highlight the important concepts that are intended to be learned; or to indicate the specific subject that is being explained. Written text has negative effects on extraneous cognitive load when it diverts the learner’s attention from the dynamic images and the narrated words into itself. But this video is not the case: the written words in this material can be considered as part of the visual animation and as reinforcement to the narrated words; they function more as images than as written words.

Plato’s theory structures itself on the opposition between the concrete and the abstract; between what is visible and what is only thinkable. For Plato, “ideas” are impossible to perceive with the physical senses, which makes it highly complicated to create a visual representation of them for their appropriate display in the video. Even Plato was conscious of this difficulty, reason why he created the “Allegory of the Cave” to explain his conception of
the human condition in relation to knowledge. So, this video has intended to create a similar structure, by analyzing the “theory of ideas” through a series of analogies and practical examples that recreate Plato’s abstract meditations in a concrete manner. This produces a concreteness effect on the germane cognitive load, which will enable the learner to relate the metaphysical world created by Plato with tangible experiences and examples taken from everyday life. Ironically, this is the same process that Plato presents in his theory, stating the dangers of believing that the concrete objects are the same as the abstract ideas that they represent.

Before concluding, one must make a remark on the consequences of two effects on extraneous cognitive load that have been mentioned before in relation to the video about Descartes. As with the previously analyzed animation, this video includes background music and sound effects, regardless of the split-attention effect that they may produce. Their objective is to create an atmosphere that will motivate and soothe the learner, while giving more volume to the images. It may increase cognitive load, but its negative consequences are counterbalanced by the fact that it keeps the learner interested in a ten minutes oral presentation that could turn out to be very dull if not enhanced by a motivating atmosphere.

Also, as with the previous video, this animation has taken into account the importance that the personalization effect has on increasing the social presence in the presentation. The information is given in a more personalized and conversational style (using the plural first person conjugation of verbs) and the narrator looking at the screen and talking directly to the audience, in order to increase the social and emotional engagement of the learner with the character in the animation.

This animation is still lacking an empirical study with actual learners, which would allow understanding its possible positive or negative outcomes on a real instructional environment. In spite of this unresolved matter, it seems correct to state that, following the theoretical guidelines presented in the previous chapter, the material has been designed in a manner that will enable it to be used as a supporting resource for the study of Plato’s “Theory of Ideas”.
4.3. Video 3: “Picasso y Braque explican el Cubismo”\textsuperscript{15}.

4.3.1. Production and content.

This video intends to give a brief and entertaining explanation of the fundamental characteristics that structure the Cubist art. Pablo Picasso and Georges Braque present the most important traits that will allow the audience to understand how a Cubist artwork functions. Its intention was not to give a fully detailed explanation of Cubism’s whole theoretical framework; instead, it focuses on the visual representation of the creative process. The material gives a brief overview of the influences that inspired this art movement and it presents its main characteristics in a brief and dynamic manner: the elimination of the Renaissance’s focal perspective, the creation of the multiple perspective, the decomposition and fragmentation of the image, the geometric simplification of the figures and the use of collage.

The video is composed almost exclusively of photographs that were edited and reconstructed into sets using Adobe Photoshop CS4. As with the previously presented material, the stop-motion animation of the still footage took place in Adobe After Effects CS4, where the voices (previously recorded and edited in Audacity 2.0.3) were included and united with the moving images. The complete animations where taken, then, to Adobe Premiere Pro CS4, where they were edited, rendered and encoded into a video format.

4.3.2. Analysis and justifications.

This material, in relation to the previously presented videos, has been created with the aim on a completely different target. The information has not been presented in its full complexity and interconnectivity, but more as an outline presentation of Cubism’s most basic characteristics. The objective of doing this was to show a different perspective of the possible counterbalance between the different cognitive loads on an audiovisual material. The video is focused on two points: the value of the transience effect for the representation of the visual dynamism of an artistic creative process; and the personalization effect, which concerns mostly the psychological and motivational factors that affect the learning process. The video aims at exploiting the most of these two effects with dynamism and motivation as their main objective.

\textsuperscript{15}See the video in the annexed CD: Video 3 – Picasso y Braque explican el Cubismo.
As mentioned in the previous chapter, the instructional designer must learn to balance the different cognitive loads on working memory in order to achieve an actual learning experience: the intrinsic cognitive load created by a subject’s innate complexity is counterbalanced by the extraneous and germane loads and, to maintain the equilibrium among them, one load must be reduced if one intends to increase the load created by another one. In this case, the intrinsic cognitive load was reduced in order to allow the instructional designer a higher degree of freedom in the inclusion of elements that could increase the extraneous and germane cognitive loads. In other words, the complexity and depth of the theoretical information about Cubism was reduced to its more basic points, so to have enough capacity in working memory for the incorporation of motivating and dynamic elements into the video.

The material, hence, has not been made for an audience with a high prior knowledge on the subject, but for beginners who do not have a deep understanding of it and who would be more interested in a simple and entertaining explanation. Intrinsic cognitive load, then, has been reduced in order to allow more space for inducing motivation and social engagement. The characters of Picasso and Braque have been caricaturized; they have been taken away from their position of serious and important artists in order to make them seem closer to the audience. They are put in uncomfortable positions, speaking with jocular voices and relating to each other and the audience in a very informal manner, so to increase their social engagement with the viewer and make them more attractive to the young learners.

As mentioned before, this video has focused on increasing the germane cognitive load by the use of transience and split-attention as positive effects. In order to do this without overloading working memory, it has had to reduce the intrinsic complexity of the subject: it explains verbally only what is fundamental for understanding Cubism and it uses written text as advance organizers as little as possible. In this manner, the audience can concentrate all of their attention on the visual dynamism of the representation. This methodology allows the learner to understand the artistic movement from the visually represented creative process, which makes him or her understand it visually and not from the theoretical framework. The learner will not have to use working memory’s capacity to process and encode abstract concepts, which, as has been explained before, induce a very high cognitive load; he or she will process, encode and remember almost exclusively nonverbal information so to understand art as it is in itself and not as it has been theoretically translated.
It is evident that for a wholesome understanding of a subject (be it as visual as it may be) it requires a theoretical explanation in some degree. Even more so if one is conscious that an avant-garde artistic movement such as Cubism may be utterly incomprehensible if not properly introduced through its main theoretical structure. But, in this video’s case, one must take careful account of how much is being explained and how complex the explanation will be so not to overload working memory, due to the fact that the visual representation already requires a high cognitive load. For this reason, the author has carefully introduced, be it orally or with the use of written text as advance organizers, the minimum required theory that will allow the learner to acknowledge the essential abstract concepts, but still allowing the images to speak for themselves.

As with the latter video, this one has not had the chance of being studied from an empirical point of view. In an experimental case such as this one, this point would be the next important step to take, due to the fact that an empirical study would be the best way to confirm that its motivational and dynamic objectives are not only achieved, but also that they are not detrimental to the understanding of the subject, be it due to overload of working memory or due to an insufficient explanation of the theoretical framework.
5. **Annex 1: List of schools that use the video about Descartes as a supplementary source of information.**

This is the list of teachers who have shared the video on their educational blogs and who the author of this text has been able to contact in order to confirm that they have actually used the video as a supplementary source of information for their classes. This means that the material may have been used in a wider range of instructional environments, but the author just states those that he has been able to find and contact through their blogs and web pages.

- Francisco Barrón, professor of the Philosophy and Letters Faculty at the National Autonomous University of Mexico (UNAM), uses the video as an example of instructional material for his class “Teaching Philosophy” at the above mentioned university. The video can be found on his blog: http://ensenanzadelafilosofia.wordpress.com/2012/11/19/descartes-y-las-pruebas-de-la-existencia-de-dios/, (24th of May, 2013).

- Victor Bermúdez Torres, Philosophy teacher at IES Santa Eulalia de Mérida (Spain), uses the video for his Philosophy classes for Secondary Education. The video can be found on his blog: http://filosofiacavernicolas.blogspot.com.es/search/label/Descartes, (24th of May, 2013).


- Anay Simón González, teacher at the Santo Domingo de Silos School, Pinto (Madrid, Spain), uses the video for her 4th ESO “Philosophy” class. The video can be found on her blog:
Francesc Llorens Cerdà, PhD in Education and TIC, uses the video in his History of Philosophy classes for 2º Bachillerato. The video can be found in the webpage he has created for sharing information with his students: http://francescllorens.wordpress.com/2012/02/07/video-descartes-y-las-pruebas-de-la-existencia-de-dios/ (24th of May, 2013).

José Benito Seoane, Philosophy teacher at the IES Ruiz Guijón, Utrera (Seville, Spain). Uses the video for his “History of Philosophy” classes for 2º Bachillerato. The video can be found on his blog: http://lalechuzadeutrera.blogspot.com.es/2013/01/descartes-y-las-pruebas-de-la.html, (24th of May, 2013).

The video is used as a supplementary source of information for the “History of Philosophy” classes at the IES Las Musas, Madrid (Spain). The link can be found at the school’s web page: http://www.ieslasmusas.org/historia-de-la-filosofia/, (Taken the 24th of May, 2013).
6. Bibliography


