Artigo Original

ISSN 2177-8310
DOI: 10.18264/eadf.v11i1.1378

The Support of Some Technologies in the Review of Physics Concepts 1

O Aporte de Algumas Tecnologias na Revisão de Conceitos de Física 1

Keli Cristina Maurina [1*]
Tarliz Liao [2]

[1] Universidade Tecnológica Federal do Paraná/Campus Pato Branco. Via do Conhecimento, s/n - KM 01 Pato Branco - PR -Brasil.

*kelimaurina@utfpr.edu.br

[2] Universidade Federal do Estado do Rio de Janeiro. Avenida Pasteur 296. Rio de Janeiro. RJ. Brasil.

Abstract

The article presents the theoretical contributions that guided a proposal for the use of some digital technologies (TD) in relation to the deficit of knowledge in basic Physics of students entering the Engineering courses at the Federal Technological University of Paraná. The retention rate in this discipline causes a problem called "pocket", characterized by a high number of students who need to retake the discipline and are on a waiting list. Thus, the (Re) course aimed at Physics was developed, on the Moodle platform, in order to contemplate the main contents that make up the previous knowledge of the discipline of Physics 1. from the assumption of digital wisdom, it counted on the contributions of Connectivism and the principles of Cognitive Theory of Multimedia Learning (TCAM) that are carefully examined and associated through conceptual maps. It was considered, therefore, that the use of these theories in synergy offers a theoretical basis that allows the teacher greater security in the development of his digital didactic resources.

Keywords: Physics teaching. Technological education. Initial teacher training.

Recebido 10/02/2021
Aceito 30/08/2021
Publicado 02/09/2021

COMO CITAR ESTE ARTIGO

ABNT: CRISTINA, K. M.; LIAO, T. O Aporte de Algumas Tecnologias na Revisão de Conceitos de Física 1. **EaD em Foco**, v. 11, n. 1, e1378, 2021. https://doi.org/10.18264/eadf.v11i1.1378

O Aporte de Algumas Tecnologias na Revisão de Conceitos de Física 1

Resumo

O artigo apresenta os aportes teóricos que nortearam uma proposta do uso de algumas tecnologias digitais (TD) em relação ao déficit de conhecimento em Física básica de alunos ingressantes nos cursos de Engenharia da Universidade Tecnológica Federal do Paraná. O índice de retenção nessa disciplina acarreta um problema denominado "bolsão", caracterizado por um número alto de estudantes que precisam refazer a disciplina e encontram-se em uma lista de espera. Assim, desenvolveu-se o curso (Re)visando Física, na plataforma Moodle, de modo a contemplar os principais conteúdos que compõe os conhecimentos prévios da disciplina à disciplina de Física 1. A formatação do curso pensada em um viés das tecnologias digitais, a contar do pressuposto da sabedoria digital, contou com os aportes do Conectivismo e dos princípios da Teoria Cognitiva de Aprendizagem Multimídia (TCAM) que são examinados detidamente e, associados por meio de mapas conceituais. Considerou-se, portanto, que o uso dessas teorias em sinergia oferece um embasamento teórico que possibilita ao professor maior segurança no desenvolvimento de seus recursos didáticos digitais.

Palavras-chave*: Ensino de física. Educação tecnológica. Formação inicial de professores*

1. Introductory notes

When the visitor sat on the sand
from the beach and said:
"There's nothing more to see,
I knew it wasn't like that [...]
You have to restart the trip.
Always.
(Saramago)

This article is guided by the proposal for the use of digital technologies (DT) in Physics Teaching at a higher level, considering the possibility of consolidating learning or reconceptualizing high school contents, which are essential for further studies.

The Federal Technological University of Paraná (UTFPR – Pato Branco Campus) has four Engineering courses: Civil, Computing, Electrical and Mechanics, which have in their curriculum of basic cycles, the subject of Physics 1, on time in the first semester of each mentioned graduation, and worked without the need for the concepts of derivative and integral from Calculus. Over the years, this discipline has shown a significant and worrying number of failures, indicated below in Table 1 (data extracted from the UTFPR1 Corporate Systems, in the Analytical Management Reports). The indicatives refer only to the regular classes, that is, extra classes (dependence) are not included.

Time course	Students enrolled	Pass	Cancelled	Fail	Passing Index
2013/1	191	74	8	109	40,4
2013/2	167	38	14	115	24,8
2014/1	168	58	15	95	37,9
2014/2	173	53	17	103	34,0
2015/1	168	87	10	71	55,1
2015/2	173	45	18	110	29,0
2016/1	164	98	5	61	61,6
2016/2	166	53	15	98	35,1
2017/1	171	78	8	85	47,9
2017/2	169	54	11	104	34,2
2018/1	170	82	4	84	49,4
2018/2	147	47	10	90	34,3
2019/1	168	89	16	63	58,6
2019/2	185	36	27	122	22,8

Chart 1: Physics 1 subject data (FI21NB)
Source: Analytical Management Reports UTFPR (2021).

One of the consequences of this situation characterizes what has been called the "pocket problem", that is, a high number of students who need to complete this course and who find themselves on a sort of waiting list. This is because the number of places offered by the university is not enough to cater to students who fail.

Some actions have been adopted as palliatives to alleviate this problem, which must be treated from different perspectives due to its degree of complexity. The main action refers to one of the elements that imply that issue: the deficit of knowledge in High School Physics. Thus, an online course was designed, on the Moodle platform, in order to review basic physics content. We aim, therefore, to present the theoretical elements that underlie the structuring of the course.

Thus, the proposed course was anchored in Connectivism and Multimedia Learning theories, seeking to consider characteristics of digital wisdom present in that group of students. Thus, it was possible to illustrate, through examples from a course content unit, the presence of the principles of these theories.

Bring Transition references: Guzmán et al, Gueudet (These are in the area of mathematics, there must be in the area of Physics or Education in general).

Answer: In this space, we are referring to the transition that does not occur for the teaching of physics, in general.

Nasser et. al. (2017) present an investigation on the transition from High School to Higher Education and what would be the actions to improve the performance of students in Calculus I, from the point that these difficulties are generally attributed to gaps in the learning of Mathematics in Basic school. In the perception of these authors, some appropriate approaches to some topics should be addressed from High School onwards. However, in this article, the action to get around this situation is pointed out and not the discussion that should be carried out in high school in order to get around the problem.

Figure 1 presents a conceptual map – a resource of significant relevance for the characterization and articulation of the underlying ideas – containing the essential objective, the theoretical basis and its articulation, thus allowing a holistic view of the work.

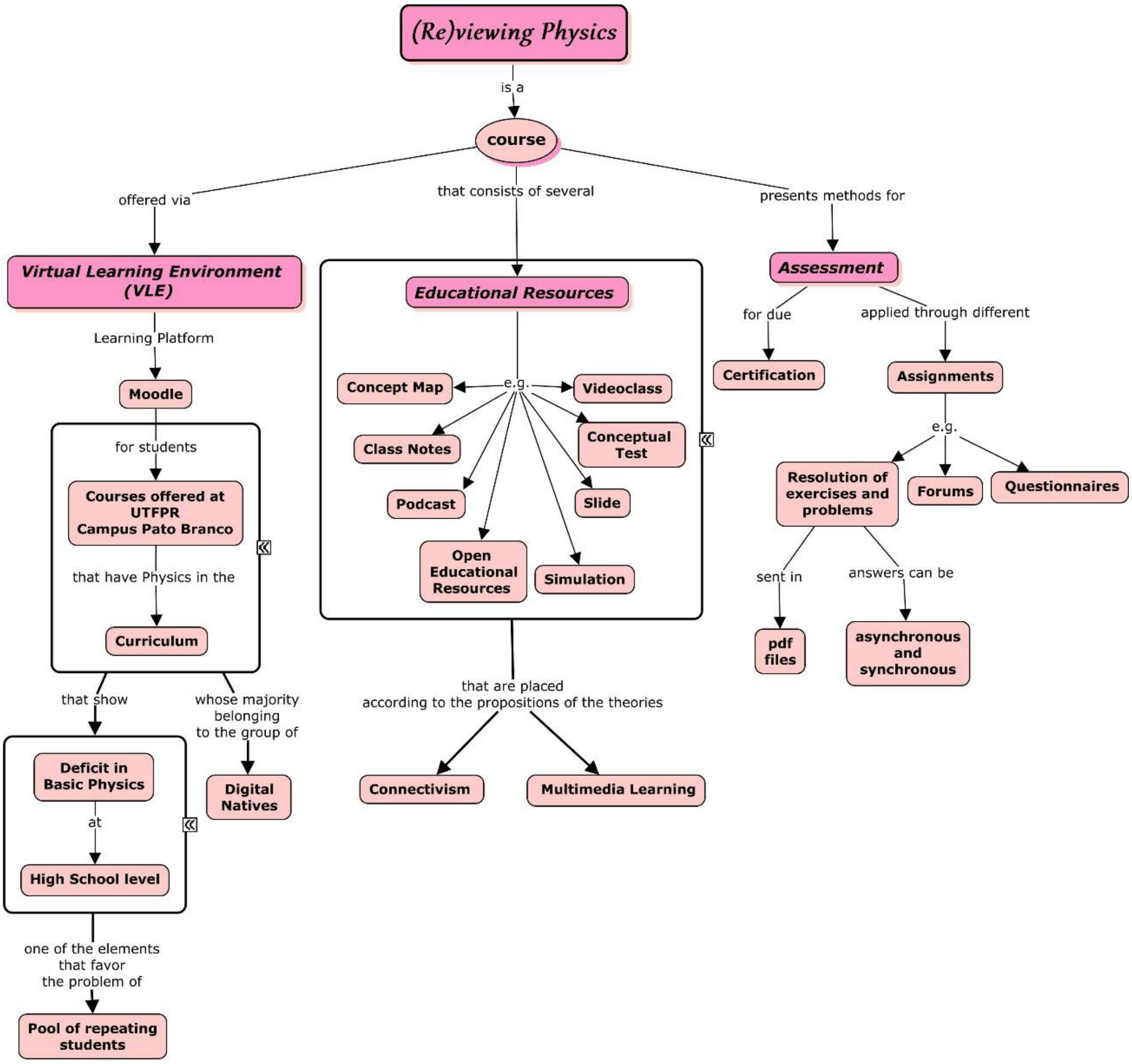

Figure 1: Concept map of the work
Source: The author (2019).

Given the situation regarding the high retention rate indicated in Table 1, there is a mobilization on the part of the institution to address the problem and propose actions that can minimize its dimension. In this sense, it is worth highlighting the Forum of Disciplines of the Basic Core (FORbas) that has been taking place, with representatives from all campuses, in order to analyze the problem and discuss possible actions. In the Forum, there are many variables observed.

We note that traditionally undergraduate professors consider that most of the contents of Physics 1 have been worked on/studied during High School, being, therefore, a review with depth in higher education.

However, given the current context of Physics classes in public high school (small number of weekly classes, shortage of teachers trained in the area, lack of environment for practical/work activities, among other factors), several Physics contents are seen by first time in graduation.

About the teaching of physics, the author warns that:

> [...] is in crisis. The weekly workload, which reached 6 class hours per week, is now 2 or less. Laboratory classes are practically non-existent. There is a lack of Physics teachers in schools and those that exist are obliged to train students for tests, for the correct answers, instead of teaching Physics. Interdisciplinarity and transdisciplinarity are confused with non-disciplinarity and take away the identity of Physics. The curriculum contents do not go beyond Classical Mechanics and are approached in the most traditional way possible, totally centered on the teacher [...] The result of this teaching is that students, instead of developing a predisposition to learn Physics, as would be expected for significant learning, generate an indisposition so strong that they even metaphorically say that they "hate" Physics (MOREIRA, p.1, 2018)

We also reflect on the paradox that points to the need for students in Physics 1 to use concepts and operations with derivatives and integrals, even before they learn it in Differential and Integral Calculus I and II courses. These disciplines take place simultaneously with Physics 1 and, by a didactic sequence, should precede the first one. It should be noted that the curricula have not changed since the implementation of the undergraduate courses at that institution.

We also considered some other possible factors that could also affect failure in this subject: the lack of the habit of studying effectively (the student did not learn to study and was not prepared for this either); the lack of persistence of these new academics; the excessive volume of content in a short period of time considered sparse by them; and, one of the most recurrent ones, the deficit of knowledge in Basic Physics.

It is not uncommon to notice the scarcity of both qualitative knowledge (essential concepts of physics such as Velocity, Acceleration, Force, Work, Energy, Vectors) as well as quantitative knowledge, such as basic mathematical tools (equations, functions, proportionality, operations with numerical sets, notions of geometry, among others).

Thus, it is clear that due to the complexity of the situation, the actions taken to reduce the failure rate can be carried out gradually, under different aspects. From this perspective, an action aimed at the deficit in Basic Physics was proposed: a course via the Virtual Learning Environment (AVA). More specifically, on the Moodle platform, which had some basic Physics content important to newcomers to these courses.

The offer of this type of course not only helps to reduce the failure rate in Physics 1, but also meets the new profile of students belonging to Generation Z, who did not know the world without the Internet.

It is worth considering that DTs have a close relationship with students, as they are mostly "[...] truly "Z" people, they did not know and cannot conceive of a world without remote controls, smartphones and high-end internet connections velocity" (KUCHARSKI, 2019, p. 6).

Thus, it is necessary to "[re]think our pedagogy so that the teaching-learning process aimed at this audience respects and takes advantage of their skills, abilities and interests." (KUCHARSKI, 2019, p. 8). Garutti and Ferreira (2015) continue to indicate that DTs contribute to students and teachers in promoting a learning perspective in which they must "be used creatively and critically, bringing the educational process closer to the reality of students, making the pedagogical practice more dynamic, rich and contextualized." (GARUTTI; FERREIRA, 2015, p. 365).

Therefore, even though the course has been called "(Re)vising Physics", a name that indicates that it is only a content review, it aims to meet the main needs to start, review and reconceptualize studies in the discipline of Physics in graduation via TD, as described in the next section.

2. Theoretical Reference

The target audience with which we seek to work is represented by freshman undergraduate students. They belong to a generation that, in general, is familiar with Digital Information and Communication Technologies (DICT), immersed in the perspective of digital wisdom (PRENSKY, 2012). Thus, we will define in this text as "digital natives" those born after the 1990s, with access to digital technologies and the skills to use them.

Palfrey and Gasser (2011) indicate that:

> Digital Natives will move markets and transform industries, education and global politics. These changes can have an immensely positive effect on the world we live in. Overall, the digital revolution has already made this world a better place. And Digital Natives have all the potential and capacity to drive society much further, in any number of ways – if we let it. (PALFREY; GASSER, p. 17, 2011).

We point out that even though digital natives and immigrants share knowledge, the second group tracks the potential of the digital universe with less ease. The first group was born immersed in this digital age and, consequently, permeated by digital culture.

Thus, we have different generations living together at the same time. Due to the characteristics of each group, which evidently entails different views, actions are taken influencing the teaching-learning process – whether positively or not so much.

In this article, we will adopt this conception of digital natives, despite the discussion promoted about the polysemy of this term. We exemplify this situation through access to information. Accessing the web and thus obtaining a huge amount of information does not exactly reverberate in knowledge and, it is also known that digital natives do not necessarily choose their information sources properly. Many even consider all the information on the web as correct, trusting all search sources and not caring about the veracity of the data. Thus, faced with a multiplicity of options, they tend to overestimate information, without a careful discernment of what can effectively help them in terms of learning. In this direction, Prensky (2012) coins the term Digital Wisdom, which will indicate that regardless of the native status versus digital immigrant, the most important are the uses and reflections made from DT.

In this sense, we seek to make the course (Re)visando Physics an online and specific space that includes various resources organized for the study of a particular subject.

It is noteworthy that one of the main advantages of Moodle over other platforms is the foundation in Social Constructionist Pedagogy, proposed by Seymour Papert (1986). She adapted Piaget's Cognitive Constructivism principles by elaborating a set of premises to be used when applying computer technology to the knowledge construction process. Thus, the term "constructionism" suggested by Papert (1986, apud LIMA, 2009) designates the modality in which a student uses the computer as a tool by which he builds his own knowledge.

This educational philosophy:

> [a]states that knowledge is constructed in the student's mind, rather than being conveyed unchanged from books, lectures, or other traditional instructional resources. From this point of view, courses developed in Moodle are created in a student-centered, not teacher-centered environment. The teacher helps the student to build this knowledge based on their own skills and knowledge, rather than simply publishing and transmitting this knowledge. (SABBATINI, 2007, p. 73).

Thus, we can see Papert's pioneering role in the role of technology in education, which highlights the role of the student in the teaching-learning process. Regarding this aspect, we also consider Connectivism in Siemens (2004) as one of the supports of the course (Re)vising Physics, because:

> [he] presents a learning model that recognizes tectonic shifts in society, where learning is no longer an internal, individual activity. The way a person works and functions changes when using new tools. The field of education has been slow to recognize both the impact of new learning tools and the environmental changes in which learning has meant. Connectivism provides insight into the skills and learning tasks needed for learners to flourish in the digital age. (SIEMENS, 2004, p. 29).

Thus, Connectivism incorporates the issue of technologies; it is based on principles of theories: chaos, network and in general, "provides an awareness of the skills and learning tasks necessary for learners to flourish in the digital age" (SIEMENS, 2004).

Below, Figure 2 presents a conceptual map on the subject, emphasizing that this is a form of visual representation of knowledge based on Ausubel's theory of Meaningful Learning (apud MOREIRA, 2011a; 2011b). Furthermore, as we will see, it has convergence and correlation with the ideas of Connectivism, as it presupposes the (inter)linking of concepts through semantic propositions.

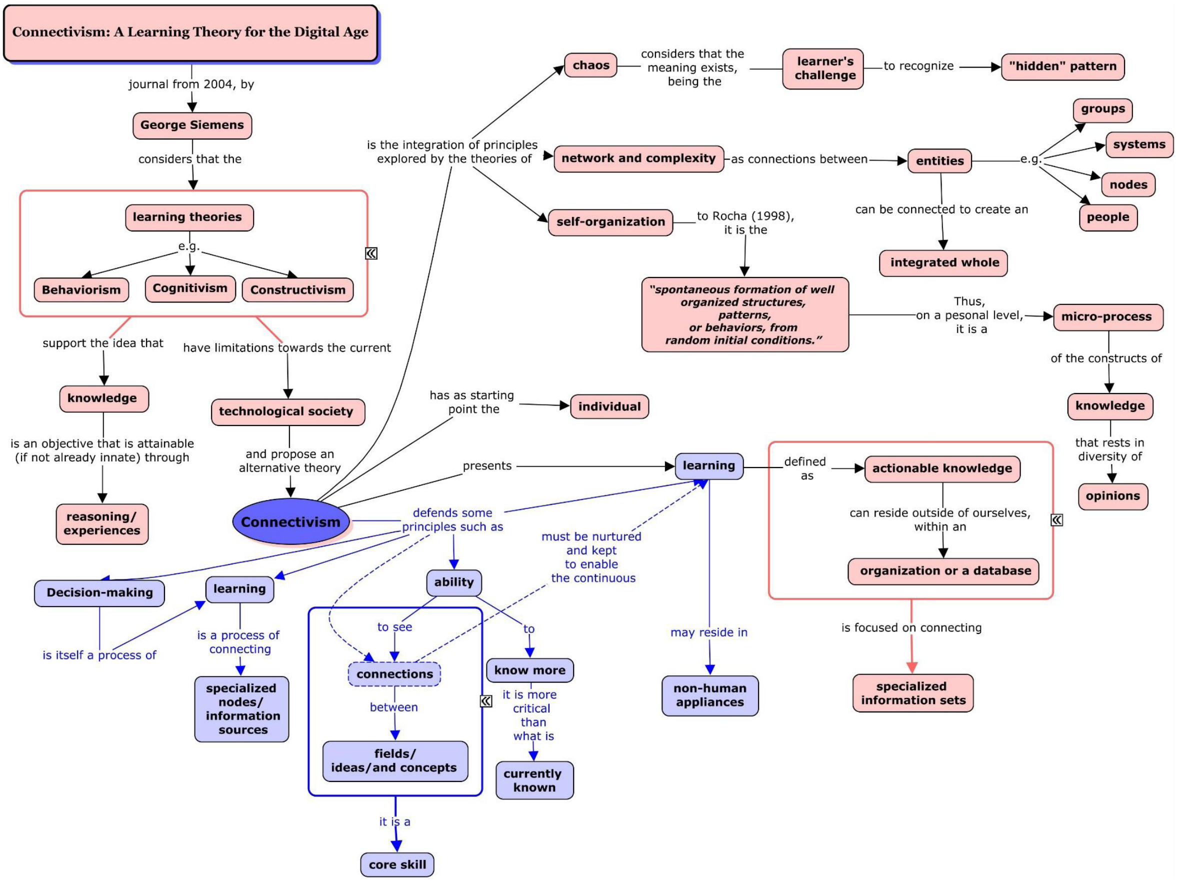

Figure 2: Conceptual map on Connectivism

Source: The author (2019).

It is observed in the conceptual map that connection(s) is one of the most present words in the principles of Connectivism, which illustrates its importance for the learning process. When we return to the situation exemplified above about the excess of information, it is possible to see the learner's difficulty in making good choices, verifying that chaos is used as one of the concepts underlying Connectivism, reporting it as a desirable ability of the learner to recognize standards and in making decisions.

We will consider in this article as theoretical contributions that support the development of the proposed course: Generation Z (digital natives), virtual learning environment, Constructionism and Connectivism.

We used the contribution of the Cognitive Theory of Multimedia Learning (CTML) by Mayer (2008) to better organize the media in Moodle. As illustrated in the CTML conceptual map in Figure 3, the model argues that information processing is primarily determined by the sensory channel, with its own processing in the sensory memory, which through a selection, passes to the short working memory deadline; thus, it is organized and integrated in the long-term memory, when it brings new or relevant information to prior knowledge (ILLERA, 2010).

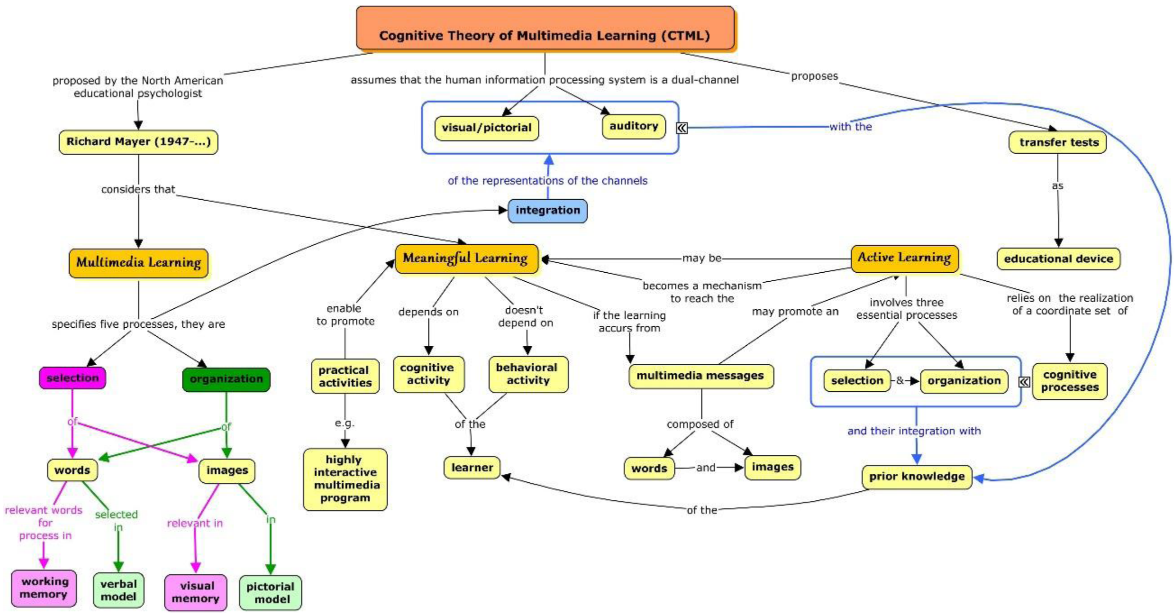

Figure 3: Conceptual map about CTML.
Source: The author (2019).

As for the production of teaching resources, Mayer (apud SILVA, 2017) differentiates two types of approaches: one centered on technology and another on the learner, which is defended by the author. Therefore, it is proposed an adaptation of the technologies to the learners' needs regarding learning, which would entail the production of a mental model.

This way:

> [to]learn would imply remembering, that is, being able to reproduce and recognize the content, and understanding, that is, building a coherent mental model for the content. Consequently, multimedia learning would be the construction of knowledge (as something personal, non-transferable) from the interaction with a multimedia resource. (SILVA, p.2, 2017)

The conditions for multimedia learning to occur, according to Mayer (2008), must take into account that the interaction with the multimedia resource would need to trigger a series of processes, as shown in the conceptual map in Figure 3, which involves the selection and organization of words and images.

In order to further explain CTML, we present another conceptual map (Figure 4) about the theory, now showing the elements that Mayer recommends for the production of multimedia resources. This is so that they are potentially more effective in terms of learning. These elements are based on the twelve principles of Multimedia Design that the author classified into three subgroups according to the main function.

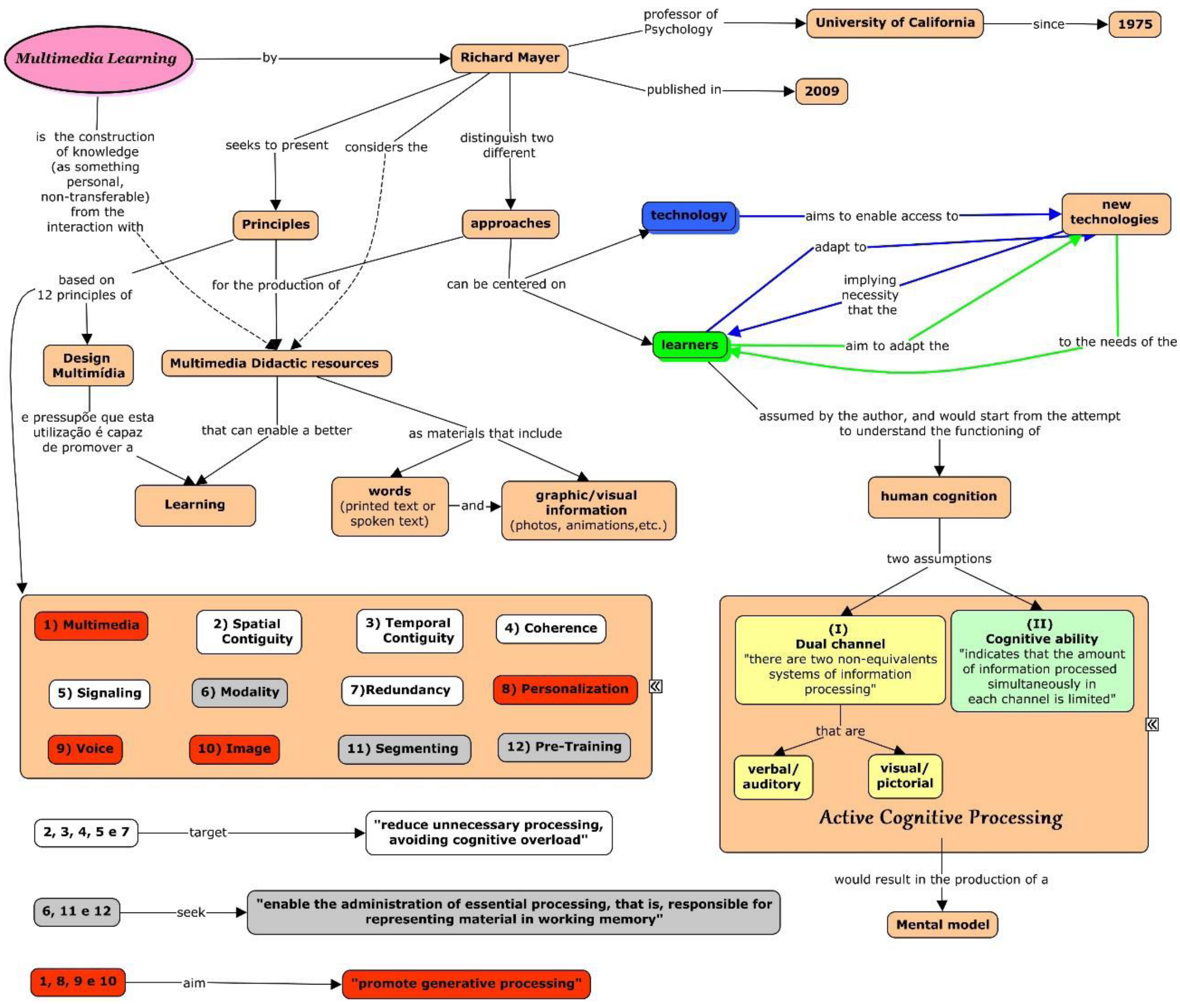

Figure 4: Conceptual map about CTML with the principles of Multimedia Design
Source: The author (2019).

3. Methods and materials

It remains evident that the intention that moved the construction of the proposed course (via DT) has its theoretical foundations synthesized in the form of a conceptual map (Figure 6) that seeks to explore, describe and generate such perspectives.

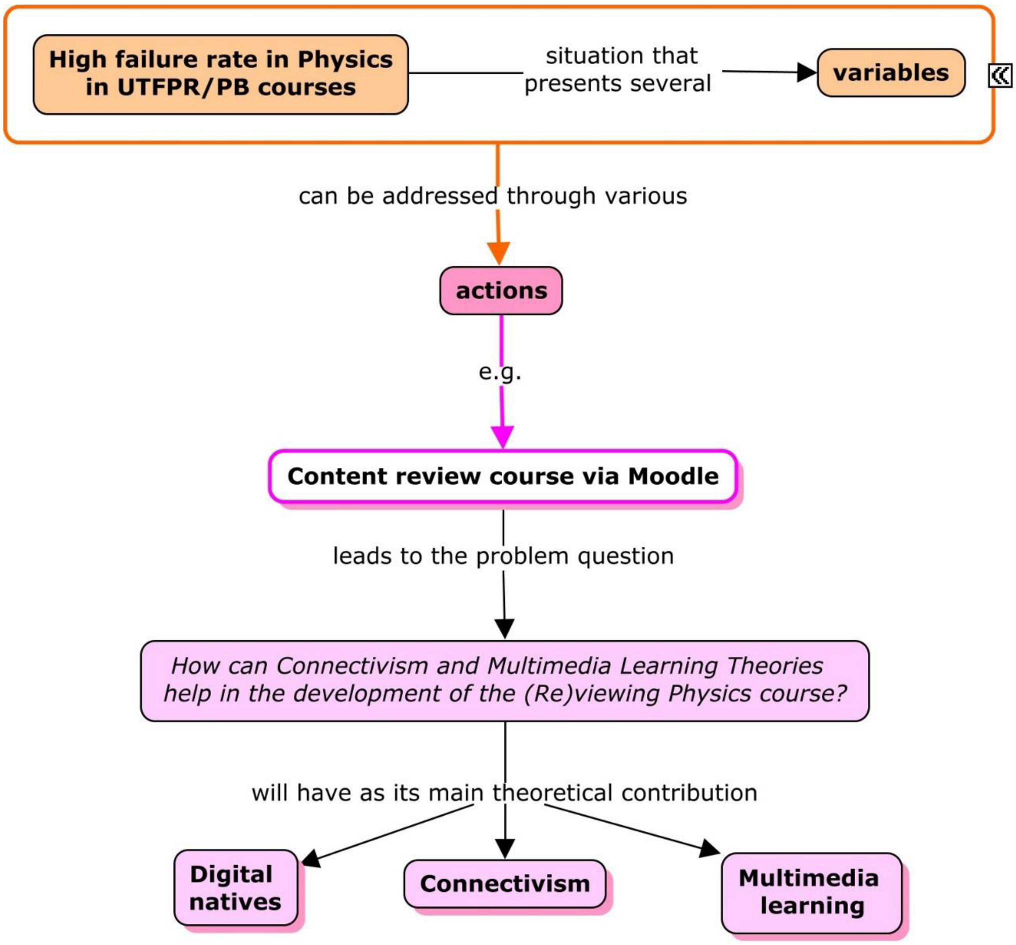

Figura e:' Conceptual map with the central idea of the course.

Source: the author (2019).

Below, we will point out the measures in which Connectivism and Multimedia Learning theories are articulated in the (Re)targeting Physics course.

3.1 Connectivism

One of the assumptions defended by Connectivism is the ability to perceive connections between concepts/ideas as an essential skill. And, along with that, learning as a connection process between specialized nodes/information sources. Thus, since the beginning of the course, we have sought to highlight the idea of connection, mainly using the concept map resource.

In the course presentation topic there is a video entitled "Advantages of studying Physics" (mp4 format, duration of five minutes) in which, based on the authors Guimarães, Piqueira and Carron (2016), we illustrate through a conceptual map the importance of Knowledge in physics.

Novak and Cañas, advise on using the free CmapTools program[1]:

> sources from the internet and other digital resources prepares a powerful New Model of Education, leading to the creation of individual knowledge portfolios capable of recording meaningful learning and infor-

1 In the topic "Tips for studying Physics" of the course, we present the link to access the program, which is available at <https://cmap.ihmc.us/>.

> ming any future related learning. The CmapTools program also offers extensive support for collaboration, as well as for publishing and sharing knowledge models. (NOVAK; CAÑAS, p.9, 2010).

As CmapTools contains a tool that allows the presentation of the map, making the concepts appear on the screen as desired, we use the oCam program, which makes it possible to record directly from the computer screen. To illustrate, we can see in Figure 7, the concept map “Advantages of studying Physics”, which had the presentation recorded and transformed into video.

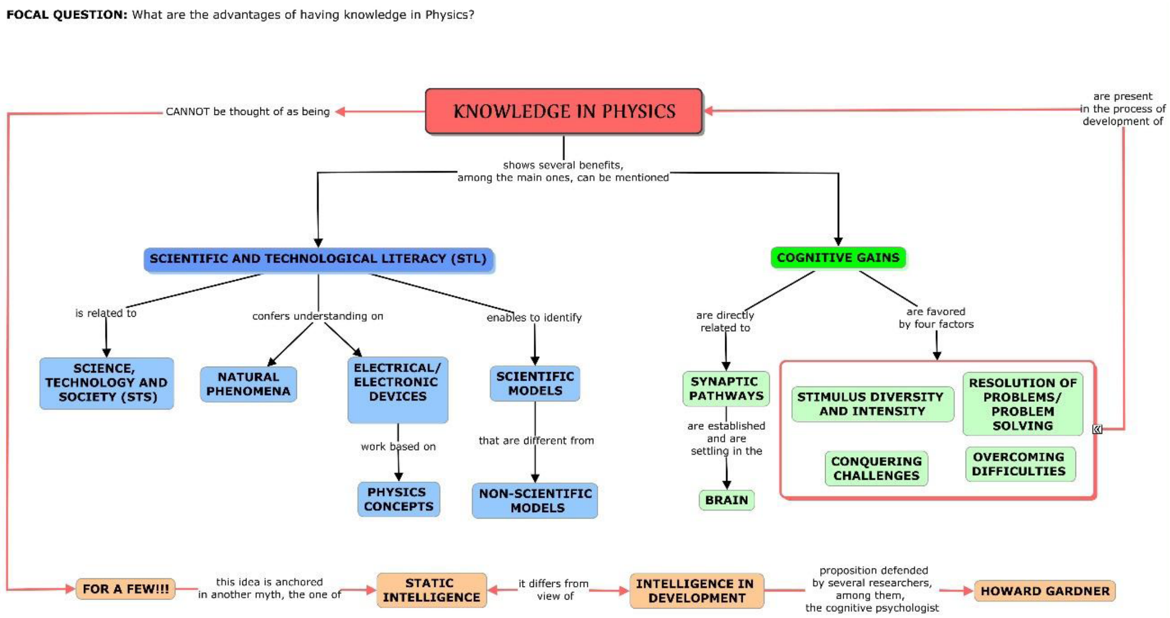

Figure 7: Concept map “Advantages of studying Physics”

Source: The author (2019).

3.2 Multimedia learning

CTML (MAYER, 2008) exposes twelve principles of Multimedia Design (Figure 4) as a suggestion for creating multimedia didactic resources with greater learning potential. The authors indicate that “[are] consistent with the functioning of cognition and human learning and are supported by the results of several empirical studies focused on transference tests.” (SILVA, 2017, p. 2).

Thus, we present below some examples of how these principles were included in the course, emphasizing that the principles are distributed and present in several resources and that a resource can contain several of them.

As the principle indicates, the communication process takes place through multiple means, such as sounds, images, texts, videos and animations, and thus, we endorse the idea that the course is promoted by various resources. In the topic “Understanding the resources used”, there is a video that illustrates the main resources used – Concept Map, Lecture Notes, Slides, Simulation, Open Educational Resource (OER) and Conceptual Test – and a brief explanation of each one.

Below, we follow with a brief summary of each of the principles of CTML (Mayer, 2009):

- Spatial and Temporal Contiguity – deals respectively with the suggestion of presenting corresponding words and images more closely and simultaneously;

- Coherence – refers to the care to avoid placing unnecessary information and not relevant to the subject, which would become a visual/conceptual pollution; Signaling - highlighting important content information;

- Modality – proposes that words presented as spoken text express information better than printed texts; Redundancy – relating to the indication to use animation and narration instead of animation, narration and text, which was also used to the extent throughout the course;

- Personalization – regarding this principle that recommends more informal words to bring the student closer to reality, we opted for a balance, as we must remember that they are higher education students and must develop, among other skills, vocabulary;

- Voice – highlights that narration in multimedia classes spoken in friendly human voice is better than in 'machine voice';

- Image – under the recommendation to place the image of the speaker added to the screen, for the sake of approximation/humanization, we chose an avatar that appears in several of the resources;

- Segmentation – the content is presented in a segmented way, by units with subdivisions, in which the user can set the pace;

- Pre-formatting – it is considered that you learn best from a multimedia lesson when you have knowledge about the names and characteristics of the main concepts.

In physics, particularly, this is very important. The understanding of physical concepts is essential for an effective practice of solving problem situations, exercises and other activities.

3.3 Materials

In this topic, we present in a general way how Connectivism and Multimedia Learning theories are present in the course (Re)vising Physics, that is, how they are articulated throughout the set.

As exposed, CTML presents twelve principles of Multimedia Design (Figure 4) as a suggestion for creating multimedia didactic resources with greater learning potential. To begin with, we covered the Image principle, which recommends using the speaker image added to the canvas. In this case, for the sake of approximation/humanization, we chose an avatar that appears in several of the resources, as shown in Figure 8. To access the Moodle platform, it is necessary to register with a profile. The subject teacher chose a real photo so that students could correctly identify it.

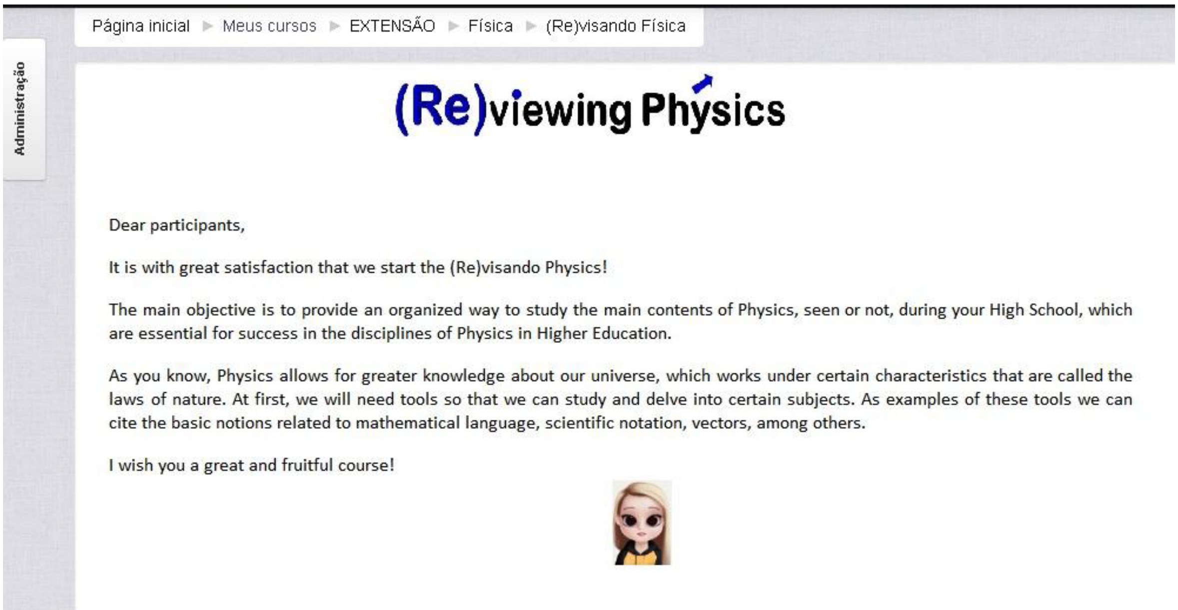

Figure 8: Course presentation topic (Re)vising Physics
Source: The author (2019).

The Multimedia principle indicates that the communication process must occur through multiple media such as sounds, images, texts, videos and animations. In the topic "Understanding the resources used" there is a video that illustrates the main resources used – Concept Map, Lecture Notes, Slides, Simulation, Open Educational Resource (OER) and Conceptual Test – and a brief explanation about each one. To illustrate, despite being in video format in the course, we present here in image form, in Figure 9, the part that corresponds to the Simulation feature.

In this same figure, we illustrate the suggestions of the principles of Spatial and Temporal Contiguity (which respectively deal with the suggestion of presenting corresponding words and images more closely and simultaneously), and of Coherence (which refers to the care to avoid placing unnecessary information and not relevant to the subject, which would become a visual/conceptual pollution). Thus, it can be seen that the word Simulation is close to its representational image and, in the video, the speech of the word and image occurs simultaneously. In addition, there is care with the exposure of ideas, avoiding excesses of information.

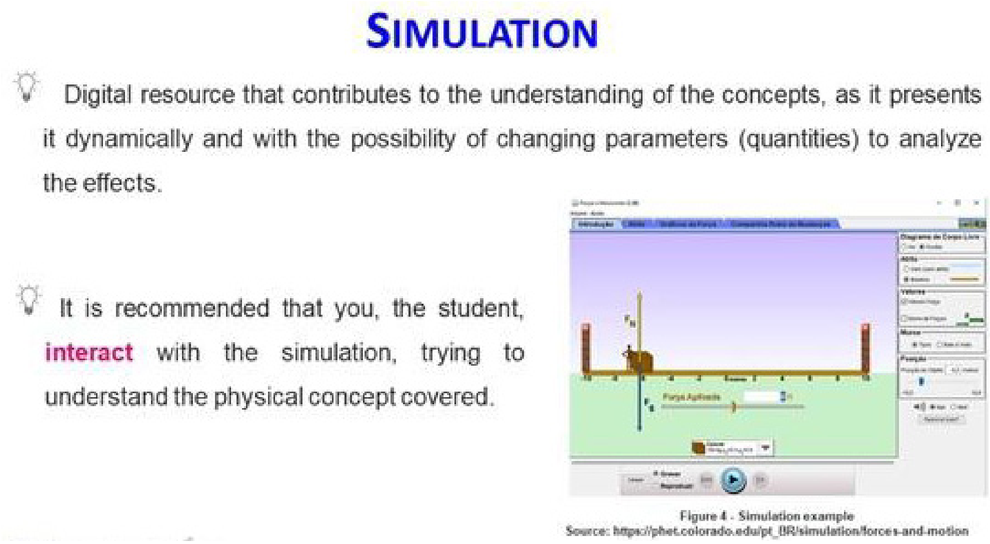

Figure 9: Part of the video about the resources used in the course
Source: The author (2019).

As for the Modality principle, which proposes that words presented as spoken text are better than in printed text, we exemplify through the REA, Unit Conversion, which was designed so that the student could have access to a step-by-step explanation about the transformation process of the main units used in Physics. In this OER, which was developed based on the Microsoft Power Point program and later saved in video format, there is spoken text explaining the unit transformation technique "chain conversion", and verification is possible through the link in the note of footer.

Regarding voice, narration in multimedia classes spoken in a friendly human voice is better than in a mechanical voice. As an example of this principle, we present the resource "Conceptual Map - Quantities and Units" in video format, just illustrated in Figure 10.

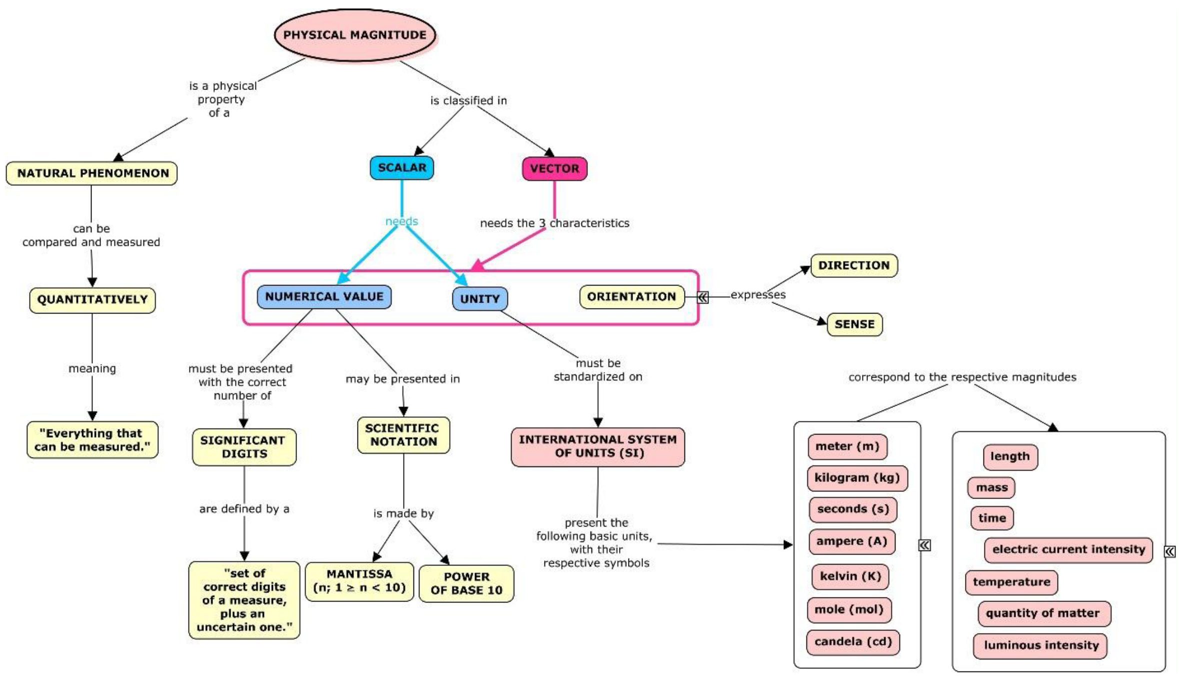

Figure 10: Conceptual map "Quantities and their units"
Source: The author (2019).

4. Results analysis

In order to develop our analytical considerations about the course "(Re)vising Physics", we recommend again the visualization of Figure 1 (Conceptual Map about the work). Through this conceptual map, we perceive the context that originated the idea of the work; the action proposal, as well as its articulation with the theoretical foundation. As explained above, the use of concept maps throughout the course, as well as the exposition of ideas in this text, is of high conceptual and practical relevance. This, therefore, we consider it to be in addition to an excellent graphic instrument – 'of the knowledge organizer type –, a resource that combines theory and practice, demonstrating in a relatively easy way, the power of (inter)linking concepts. As this feature is very influential in the construction of knowledge by the student, allowing the student to appreciate their strengths and weaknesses.

The use of this resource, together with others – video class, podcast, slide, class notes, developed by the teacher/coordinator of the course, following notes from Connectivism and CTML theories, allow us to estimate positive perspectives in terms of functionality and learning. In addition to meeting an important demand - action aimed at the problem of deficit in Basic Physics of newcomers to Engineering at UTFPR / Campus Pato Branco - the course "(Re)visando Physics" may also provide data that will subsidize future research related to the theme of teaching and learning Physics via a virtual learning environment and its aspects, with the potential to become an official action of the institution.

Through the theoretical foundation and experience in the area, we believe that this course presents real conditions to be able to collaborate to improve the approval rates in the subject of Physics 1, of the basic core of Engineering, which so burdens students (and their families, as it often , are young people who come from other states if they increase their expenses by having to stay longer to complete the course), teachers and administrators.

In terms of perspectives, we believe that from the first classes onwards, we will be able – through student feedback – to evaluate the course and, if necessary, make possible adjustments.

5. Endnotes

Much has been reflected, discussed and even put into practice thought/planned actions for the teaching and learning process of Generation Z. For that, educational institutions will need teachers who are trained in this perspective of cognitive appropriation, or who adapt to these new paradigms.

It is necessary that there is, in an almost utopian way, mutual help, in the sense that "everyone teaches everyone" how to apply technologies in teaching, without always resorting to continuing education courses, even though these are necessary. In this way, since educating is to favor development and that, in light of all the theories that indicate that digital natives think and process knowledge differently, it is necessary that there is a greater interest in relation to cognitive appropriation in a technological bias.

In other words, it is necessary that the subjects involved (professors, students and their peers) become aware that it is necessary to learn and teach how to handle technological artifacts, without financial cost, as a process of mutual assistance, legitimate, natural and continuous in this contemporary society, immersed in this paradigm.

Therefore, we seek to establish, from this article, the dissemination of these contributions to education professionals who have plans in the area of developing multimedia materials aimed at teaching and learning. In this, through a relatively recent and quality theoretical framework, we present the foundation in a way to add and contextualize resources, such as concept maps, making the exposition of ideas, of the work as a whole, more elucidating and concrete.

By portraying through examples with images or links referring to the course, we ended up further enriching the theory-practice articulation, which we see as an encouragement to colleagues in the area to develop their teaching resources.

The design principles shared by CTML, despite not being universal rules, proved to be relatively easy to apply. From the moment the needs point out, there is justification for it to be done that way and, thus, professionals can feel stopped and safe in the process of developing multimedia educational material.

As explained in the rationale, CTML promotes the creation of a mental model (Figure 4) as a consequence of multimedia learning. From this perspective, we infer that the formatting of the course (Re)vising Physics, exemplified in section 5, favors the development of this type of resource by the learner. Such inference is based particularly on the aggregation of conceptual maps, present since the beginning of the course, well-articulated, not only promoting specific content, but also from other contexts, such as those in the field of study and learning, tips in general.

The characteristics of Connectivism are aimed at individuals with aptitude for autonomous learning, who perceive and take responsibility for managing their learning. This does not mean that individuals who do not have these characteristics cannot learn, but they will face more difficulties.

Finally, we consider that the articulation between Connectivism and Multimedia Learning was extremely enriching, enabling us to incur didactic resources in a virtual learning environment, in a satisfactory way and with an increase in the learning potential. We believe that even though this experience is a power vector for rethinking the issue presented, the problem of reconceptualization in Basic Physics extends to most institutions in the country and should be carefully observed.

References

GARUTTI, S.; FERREIRA, V. L. Uso das Tecnologias de Informação e Comunicação na Educação. **Revista Cesumar Ciências Humanas e Sociais Aplicadas**, Cidade de publicação, v.20, n.2, p. 355-372, 2015.

GUIMARÃES, O.; PIQUEIRA, J. R.; CARRON, W. Capítulo 3. *In:* **Física Mecânica** – Manual do professor. 2. ed. São Paulo: Ática, 2016. p.297-298.

ILLERA, J. L. R. Os conteúdos em ambientes virtuais: organização, códigos e formatos de representação. In: COLL, C.; MONEREO, C. (e col.). **Psicologia da educação virtual:** aprender e ensinar com as tecnologias da informação e da comunicação. Porto Alegre: Artmed, 2010. p. 136-154.

LIMA, M. R. de. **Construcionismo de Papert e ensino-aprendizagem de programação de computadores no ensino superior**. 2009. Dissertação (Mestrado em Educação)–Universidade Federal de São João Del-Rei, São João Del-Rei, 2009.

KUCHARSKI, M. V. S. **Fundamentos de Inovação e Tecnologia na Educação.** 2019. Especialização em Inovação e Tecnologias na Educação– Universidade Tecnológica Federal, 2019. Available at: https://moodle.utfpr.edu.br/course/view.php?id=10512. Access in: may 20, 2020.

MAYER, R. **Multimedia Learning.** 2. ed. Cambridge. CambrigdeUniversity Press, 2008.

MOREIRA, M. A. **Aprendizagem significativa:** a teoria e textos complementares. São Paulo: Editora Livraria da Física, 2011a.

MOREIRA, M. A. **Metodologias de Pesquisa em Ensino.** São Paulo: Editora Livraria da Física, 2011b.

MOREIRA, M. A. Uma análise crítica do ensino de Física. **Estudos Avançados**, São Paulo, v.3, n.94, Set./Dec., 2018. Available at: https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-40142018000300073.

Access in: may 20, 2019.

NOVAK, J. D.;CANÃS, A. A teoria subjacente aos mapas conceituais e como elaborá-los e usá-los.**Práxis Educativa**, Ponta Grossa, v.5, n.1, p. 9-29, jan./jun., 2010. Available at: https://www.revistas2.uepg.br/index.php/praxiseducativa/article/view/1298. Access in: nov.6 2017.

PALFREY, J.; GASSER, U. **Nascidos na era digital:** entendendo a primeira geração dos nativos digitais. Porto Alegre:Artmed, 2011.

SABBATINI, R. M. E. **Ambiente de Ensino e Aprendizagem via Internet** - A Plataforma Moodle.[S.l],2007. Available at: http://www.ead.edumed.org.br/file.php/1/PlataformaMoodle.pdf. Access in: may 05, 2019.

SIEMENS, G. **Conectivismo**: Uma teoria de Aprendizagem para a idade digital. [S.l], 2004. Available at: http://wiki.papagallis.com.br/George_Siemens_e_o_conectivismo. Access in: june 15 , 2019.

SILVA, A. C. da. Resenha do livro Aprendizagem Multimídia. **Revista Ensaio**, Belo Horizonte, v.19. 2017.