DIGITAL INFORMATION AND COMMUNICATION TECHNOLOGIES COMBINED WITH AN INVESTIGATIVE APPROACH TO HEALTH EDUCATION

https://doi.org/10.56238/sevened2024.031-082

Khristyanne Aparecida Moutim Ferreira[1], Iasmin Rabelo de Queiroz[2], Tânia Mara Segatelli[3], Juliana Carvalho Tavares[4], Pollyanna Souto Fonseca Viana[5], Luciana de Pinho Tavares Sousa[6], Fernanda Aparecida da Mata Abreu[7] and Janice Henriques da Silva Amaral[8]

[1] Master in Biology Teaching
Federal University of Minas Gerais
E-mail: moutimkhris@gmail.com
ORCID: 0000-0002-9986-6001
LATTES: 8907490191704625
[2] Master in Neurosciences
Federal University of Minas Gerais
E-mail: iasmini.r@gmail.com
ORCID: 0000-0001-9374-4284
LATTES: 0982414263612057
[3] Post-Doctorate in Cellular and Molecular Biology
Federal University of Minas Gerais
E-mail: segatellitm@gmail.com
ORCID: 0000-0002-3717-0711
LATTES: 4492420667052931
[4] Doctor in Molecular Biology and Physiology
Federal University of Minas Gerais
E-mail: julianact2015@gmail.com
ORCID: 0000-0002-5504-505X
LATTES: 1526778796118109
[5] Master in Biology Teaching
Federal University of Minas Gerais
E-mail: pollyanna.fonseca@educacao.mg.gov.br
ORCID: 0000-0001-7834-8718
LATTES: 6596505118576750
[6] Master in Biology Teaching
Federal University of Minas Gerais
E-mail: lucianapinhotavares@gmail.com
ORCID: 0000-0002-9981-3508
LATTES: 3068519882521183
[7] Doctor in Education
Federal University of Minas Gerais
E-mail: fmata22@icloud.com
ORCID: 0000-0002-7589-0680
LATTES: 5136820948676865
[8] (Advisor and corresponding author)
Doctor in Biochemical and Molecular Pharmacology
Federal University of Minas Gerais
E-mail: janicehs.amaral@gmail.com
ORCID: 0000-0001-8930-8869
LATTES: 3220505504503017

ABSTRACT
Contemporary society has experienced a new way of relating to others and the environment. The speed of information propagation has provided different perspectives for education. Both the way of learning and teaching have been impacted by the digital age. Therefore, the restructuring of pedagogical practice has become a necessity. The use of digital technologies as teaching strategies can provide the development of a student with the ability to solve problems and reflective and critical capacity (VIDAL; MIGUEL, 2020).

Keywords: Digital Information and Communication Technologies (DICT). Artificial Intelligence (AI). Personalized education. Pedagogical innovation.

INTRODUCTION

Contemporary society has experienced a new way of relating to others and the environment. The speed of information propagation has provided different perspectives for education. Both the way of learning and teaching have been impacted by the digital age. Therefore, the restructuring of pedagogical practice has become a necessity. The use of digital technologies as teaching strategies can provide the development of a student with the ability to solve problems and reflective and critical capacity (VIDAL; MIGUEL, 2020).

The teaching of Science in Brazil has also undergone a significant evolutionary process since its inclusion in school curricula through the Law of Guidelines and Bases, in 1961 (Law No. 4,024), until the creation of the new Law of Guidelines and Bases of National Education (LDB), in 1996 (Law No. 9394) and subsequent educational policies such as the National Common Curriculum Base (BNCC), in 2018. Science teaching has gone from a traditional content-based panorama to a teaching based on the relationship between science, society, technology and the environment (SILVA-BATISTA; MORAIS, 2019).

Within this new perspective and according to the LDB (Law No. 9394), it is up to the school and the teacher to implement an education supported by new pedagogical practices that make teaching more attractive and contextualized. In addition, the Federal Constitution proclaims that teaching strategies must meet subjects with different educational needs (BRASIL, 1988).

DIGITAL INFORMATION AND COMMUNICATION TECHNOLOGIES (TDIC)

According to Kesnki (2012), Digital Information and Communication Technologies (DICT) promote student involvement, communication, motivate and facilitate learning. Both the BNCC and the National Curriculum Parameters (PCN), guiding documents for Brazilian education, advocate the use of DICT as motivating elements in the formation of an autonomous student in the search for knowledge (SILVA *et al*., 2021).

DICT have become part of students' daily lives and, according to the BNCC, their use in the school context can help teachers stimulate interest and protagonism. The incorporation of digital technologies in pedagogical practices can stimulate participation and creativity, promote autonomy and digital literacy. In addition, DICT fosters dialogue between different areas of knowledge, providing training for life (BRASIL, 2018).

In view of the technological insertion in the daily lives of students, the need for innovation and diversification of teaching and learning methods has become imminent (ZÔMPERO *et al*., 2019). Social changes and new educational demands required a teacher

who transcended the limits of the traditional classroom. Zômpero et al. (2019) point out that the teacher who manages to overcome the barriers imposed on teaching and learning leads the student to learn how to learn. With this new perspective, it was necessary to look for ways to encourage a questioning student with the ability to solve problems (ZÔMPERO *et al*., 2019).

On the other hand, the use of Digital Information and Communication Technologies (DICT), combined with Artificial Intelligence (AI), has also proven to be a powerful tool in the educational context, allowing the teacher to enhance the teaching-learning process and make classes more dynamic and personalized. It is worth knowing that Artificial Intelligences (AIs) can be considered a subcategory of Digital Information and Communication Technologies (DICT), but with a specific and distinct focus within this universe. While DICT encompasses a broad set of digital technologies used to process, store, and communicate information (such as the internet, educational software, social networks, and digital devices), AI refers to systems that simulate human intelligence, performing tasks such as data analysis, learning, and decision-making based on advanced algorithms (CARVALHO, 2021). In other words, AI is a tool within DICT, but it has unique characteristics that expand the possibilities of personalization and automation in education.

The integration of Digital Information and Communication Technologies (DICT) with Artificial Intelligence (AI) in education can occur through various tools and strategies that enhance teaching and learning. One form of integration is the use of adaptive learning platforms, which use AI algorithms to personalize content according to each student's performance and needs. These platforms analyze data on students' interaction with the system, adjusting the level of difficulty of the activities and suggesting complementary materials, promoting more individualized learning (CAMPOS, 2018).

The implementation of AI in the classroom can transform pedagogical practice by facilitating the analysis of data on student performance, enabling more accurate monitoring and targeted pedagogical interventions (MORAN, 2015). In this way, the teacher starts to play a more efficient mediating role, using technology to identify difficulties and adjust the content according to the needs of each student (GATTI, 2019).

For students, the impact of using DICT associated with AI is significant, providing a more interactive and personalized learning environment. In addition to increasing engagement, this combination of technologies enables students to develop skills such as critical thinking and problem-solving. (RUSSEL & NORVIG, 2018).

Thus, the combination of Digital Information and Communication Technologies (DICT) with Artificial Intelligence (AI) represents a substantial advance in education,

providing a more interactive and adaptive learning experience. By offering personalized content and immediate feedback, AI DICT promotes greater student engagement, allowing each student to learn at their own pace and focusing on the areas in which they most need development. By receiving recommendations and additional resources in an automated way, students have the opportunity to explore complementary content and reinforce areas of interest or difficulty (VICARI, 2018). Thus, DICT associated with AI not only helps to improve academic performance, but also prepares students to face challenges in an increasingly dynamic educational scenario, where this integration becomes essential to form individuals able to deal with an uncertain and technologically advanced future.

Even pointing out benefits, on the other hand, the implementation of AI in education, aiming to promote meaningful learning, presents significant challenges that need to be addressed carefully and strategically. One of the main challenges is the resistance to change and the adaptation of teachers to new technologies (SANTOS & LIMA, 2022). Many teachers may feel overwhelmed by the need to integrate AI tools into their pedagogical practices, especially if they have no prior experience with such technologies. To overcome this challenge, it is crucial to offer continuous training and adequate supports, which not only introduce the technological tools, but also explain how to integrate them effectively with existing teaching methodologies. Training should be practical and results-oriented, allowing teachers to develop confidence and skills in using AI to create more personalized and engaging learning experiences (OLIVEIRA & SANTOS, 2021).

Another key challenge is the need to ensure that AI technologies are used ethically and equitably. This includes protecting student data privacy and ensuring that AI tools do not reinforce existing biases or inequalities (SILVA & OLIVEIRA, 2021). To address these challenges, it is necessary to establish clear guidelines and data protection policies, as well as promote transparency in the use of technologies.

In view of the above, it is essential to involve teachers in the selection and customization of AI tools, ensuring that they are adapted to the specific needs of students and the educational context. In this way, the integration of AI in education can be carried out in a way that maximizes the benefits for all students, promoting meaningful and inclusive learning, seeking an increasingly interactive and transformative school environment.

HEALTH EDUCATION

Health Education is a pedagogical process that requires the construction of knowledge and skills that promote autonomy and critical awareness for the realization of healthier choices, individual and collective, taking into account the context of the subjects

(LEITE, 2014). Therefore, the theme aims to lead subjects to autonomy, self-knowledge, and self-regulation over their organism through the acquisition of knowledge. This allows discernment in decision-making that corroborates health promotion (BRASIL, 2006).

In this context, Ponte and Maldarine (2019) emphasize that understanding the integrated functioning of the human body can promote the internalization of healthy attitudes and habits. This knowledge awakens in learners more conscious choices related to lifestyle. According to the BNCC, it is:

> It is essential that students are able to take the lead in choosing positions that represent self-care for their bodies and respect for the bodies of others, from the perspective of comprehensive care for physical, mental, sexual and reproductive health (BRASIL, 2017, p. 325).

Thus, schools must implement transversal pedagogical actions that integrate knowledge (BRASIL, 2017). In addition, Cardoso et al. (2008) suggest that teaching practices should prioritize the context and involvement of the school community.

Santana and Mota (2022) highlight the need to provide opportunities for Biology teaching that meets social demands and dialogues with the reality of the subjects, making them active in issues involving health and the environment. Thus, the use of contextualized and interdisciplinary pedagogical strategies that offer an integration of knowledge and foster dialogue between knowledges is increasingly justified (BRASIL, 2010).

Interdisciplinarity is necessary as it overcomes the fragmentation of knowledge of school contents. Nascimento et al. (2020) highlight interdisciplinarity as an integrating tool for knowledge and emphasize that the process needs to be mastered by the teacher. According to Ruas and Araújo (2017), in interdisciplinarity there is a transposition of disciplinary limits, promoting integration of knowledge. The relationship between disciplines, the dialogue between parties, and the contextualization of teaching are pointed out by Nascimento et al. (2020) as characteristics that promote interdisciplinarity. From this perspective, integrative, problematizing, questioning and contextualized didactic strategies can contribute to student learning.

The premise of a democratic and good quality education guaranteed by national legislation requires, according to Libâneo (2013), the appropriation of a set of strategies, resources and spaces. Jacobucci (2008) already discussed the use of non-formal spaces of education as "allies of the school" in the dissemination of scientific knowledge.

TEACHING BY INVESTIGATION AND DIDACTIC SEQUENCE

For Sasseron (2015), teaching by inquiry values student-centered activities, enabling the development of autonomy, the ability to make decisions, evaluate and solve problems. In this way, the teaching of Biology by investigation can appropriate strategies that allow learners to relate scientific knowledge to everyday situations (SANTANA; MOTA, 2022).

Sasseron (2015) points out that teaching by inquiry unites science and school and that inserting students in problem situations, which involve scientific concepts, can stimulate them to create solutions to everyday challenges. Pedaste et al. (2015) propose that teaching by inquiry comprises interconnected phases, translating into the investigative cycle, with guidance, conceptualization, investigation, conclusion and argumentation.

The interaction of the phases of the investigative cycle provides conditions for the use of student-centered teaching methodologies, so that he is the main responsible for the construction of his knowledge and the teacher is an adjunct to the process. This interconnection of the phases allows the teacher to develop pedagogical strategies, such as Investigative Didactic Sequences (SDI), which encourage students to solve problems. SDI offers means to bring students closer to scientific knowledge (SCARPA; CAMPOS, 2018).

According to Carvalho (2018), an investigative teaching sequence consists of pedagogical activities that provide means to propagate scientific knowledge on a given topic. The activities are built around a problem-situation and Carvalho (2013) emphasizes that the phenomenon to be investigated must be inserted in the student's daily life. Lima (2019), in turn, emphasizes that investigative activities should be increasingly articulated, involving the solution of the problem, in order to provide the development of skills and meaningful learning.

MEANINGFUL LEARNING

Meaningful Learning (SA) occurs, according to Ausubel et al. (1980), when new information and concepts are related and incorporated into pre-existing structures, the subsumers. Thus, SS occurs when the student relates the content studied to previous knowledge (AGRA *et al*., 2019).

According to Agra et al. (2019), learning will be mechanical if new knowledge does not interact with subsumers. Moreira (2012) reiterates that there may not be adequate prior knowledge and, therefore, the teacher has a crucial role in attributing meaning to the new content. According to the BNCC (BRASIL, 2018), for there to be meaningful learning, the information provided must make sense in the learner's experience.

Brum and Schuhmacher (2015) highlight problem solving, sequential didactic activities and Concept Maps (MC) as tools to assess meaningful learning. According to Moreira (2012), CM can be used to represent the relationships between concepts in a given theme, starting from broader concepts to more specific ones.

In attention to the different social demands that reaffirm the need for an increasingly democratic education, accessible to all and that uses varied resources to promote a connection between the student and knowledge, we seek contextualized pedagogical strategies, supported by digital technologies, teaching by investigation and in a non-formal space of education that can motivate and to awaken the student's protagonism in the search for scientific knowledge, in contemporary themes of relevance in the field of health education.

NON-FORMAL EDUCATION SPACE

Non-formal education spaces gained prominence as an educational tool in the 70s, when teachers realized how much these spaces could add to pedagogical practice. Areas such as ecological parks, museums, zoos, science centers, botanical gardens, among others, were designated as non-formal spaces for education and considered to promote scientific knowledge (CAZELLI, 2005; ROCK; TÉRAN, 2010).

Vieira (2005) and Souza (2021) clarify that non-formal education is carried out in a systematized way and with the intention of achieving objectives outside the environment of the educational institution. Rocha and Terán (2010), on the other hand, conceive the process as systematized or not, with established objectives, but with a certain malleability in relation to factors such as time and learned contents. Back et al. (2017) understand

> the formal spaces as schools, the school context itself; informal spaces for spontaneous socializing, with friends, theaters, readings without the purpose of teaching, and the non-formal space includes walks, visits that have the intention of teaching, with activities developed in a targeted way, but outside the classroom (BACK *et al.*, 2017, p. 2).

According to Jacobucci (2008, p. 56), a non-formal space of education "is any space other than the school where educational action can take place". For Silva and Santos (2021, p. 5), non-formal education spaces are "all those spaces that can also be used for teaching and learning, but without following the systematization that occurs with the teaching promoted by formal spaces". Silva and Santos (2021) also point out that non-formal spaces can contribute to teachers' pedagogical strategies, bringing an interdisciplinary and contextualized perspective.

According to Guerra (2011), one learns what is necessary in daily life, what provides pleasure and the environment is a generator of stimuli that favors brain connections for this process. In this sense, exciting and motivating pedagogical strategies, such as the use of non-formal spaces, can contribute to student learning. Hennemann (2015) highlights that motivation can underpin learning and the emotions aroused lead to the development of motivation.

In this motivating context, non-formal education spaces emerge, as well as other strategies that enhance teaching and learning, such as Digital Information and Communication Technologies (DICT), which, according to the BNCC, arouse interest and promote student engagement (BRASIL, 2017).

In the next paragraphs of this chapter we will present a study proposal where the application of an investigative didactic sequence elaborated from the perspective of Meaningful Learning and the use of DICT on the theme "The influence of physical exercise on the human body" was analyzed. The research provided students with an autonomous construction of knowledge and understandings about important concepts of science in the field of health education and provided conditions for meaningful learning.

METHODOLOGICAL PATH

The qualitative study consisted of the analysis and interpretation of data produced and collected during the elaboration and application of an investigative didactic sequence (SDI), with the participation of 30 students, from the 3rd year of High School, from a public school in Belo Horizonte. To deepen the understanding of the effects and efficacy of the didactic sequence, the study comprised the following steps: (1) elaboration and descriptive analysis of the application of SDI; (2) analysis of the students' conception; and (3) analysis of the students' perception of the application of the SDI (Chart 1).

Chart 1 – Presentation of the stages developed in the research

STAGE	INSTRUMENTS	PARTICIPANTS
1) Elaboration and descriptive analysis of the application of SDI	Bibliographic research, elaboration of activities with an investigative approach, implementation of free tools for the use of Digital Communication and Information Technologies in SDI, research of tools based on Meaningful Learning to be implemented in SDI and incorporation of non-formal education space.	Not applicable
	Survey on the possession and use of DICT by students through a questionnaire	30
	Diagnosis of students' previous knowledge through questionnaire and word cloud	30
	Didactic activities developed throughout SDI	30
2) Analysis of the students' conception	Application of semi-structured questionnaires and didactic activities developed throughout the SDI.	30
3) Analysis of students' perception of the application of SDI	Application of semi-structured questionnaires	30

Source: The authors (2022).

ELABORATION AND DESCRIPTIVE ANALYSIS OF THE APPLICATION OF THE SDI

In order for the SDI to be properly elaborated, it was necessary to investigate the use and possession of digital technologies by students. The survey was carried out through a questionnaire. Such investigation provided the verification of the feasibility of carrying out SDI's activities, which used digital technologies. The questionnaire used in the survey of digital technologies was made through the *Google Forms* tool and answered by the students in the school's computer lab. "Do you have a smartphone or tablet?" and "Do you have quality internet access?" were questions listed.

The research participants made a diagnosis of previous knowledge about the topics addressed in the study. For Ausubel (2000), relating previous knowledge to new information can promote Meaningful Learning (SA). The investigation about previous knowledge was carried out by means of a semi-structured questionnaire and/or word cloud. The questionnaire was made through *Google Forms* and the word cloud through *the Mentimeter.com* application.

The activities of the didactic sequence were built in a systematic way, according to the phases proposed by the investigative cycle of Pedaste et al. (2015), namely: guidance, conceptualization, investigation and conclusion, with the discussion going through them. A visit to a non-formal education space was incorporated into SDI's activities, with the aim of motivating students in the construction of knowledge. The students visited the Center for Education and Communication in Life Sciences (NEDUCOM), at the Institute of Biological Sciences (ICB) of the Federal University of Minas Gerais (UFMG). This space

encompasses several extension projects related to Health Education and fosters scientific dissemination practices at the university-community interface.

The data produced during the study were collected from the observation of the teacher-researcher, records produced by the students participating in the research in didactic activities developed throughout the SDI, images and semi-structured questionnaires.

ANALYSIS OF THE STUDENTS' CONCEPTION AND ANALYSIS OF THE STUDENTS' PERCEPTION OF THE APPLICATION OF THE IDS

The understanding of the participating students about concepts related to the theme worked on and their perceptions about the activities developed during the SDI, including perceptions about the visit to NEDUCOM, were collected by questionnaires (Chart 2). Within the scope of the students' conceptions, the didactic activities developed throughout the SDI, such as concept maps, videos, booklets, were also considered.

Chart 2 – Guiding questions of the semi-structured questionnaires

QUESTIONS
What do you mean by "integrated functioning of the human body"?
Can you identify the structures of the locomotor system and their respective functionalities?
Do you identify the components of the cardiovascular system and their respective functionalities?
Can you identify the changes caused by physical exercise in the systems of the human body?
Do you understand the difference between physical exercise and physical activity?
Do you understand the relationship between physical exercise and health?
Did you enjoy participating in the activities of the didactic sequence? Why?
Can you see if the activities contributed to your learning?
What was the importance of the activity carried out for you?
What did you like the most during the completion of the didactic sequence?
After having participated in this investigative activity, contribute by leaving your criticisms and suggestions to make the process more interesting, fruitful and enriching.
Can you identify the structures of the locomotor system and their respective functionalities?
Do you identify the components of the cardiovascular system and their respective functionalities?
Can you identify the changes caused by physical exercise in the systems of the human body?
Do you understand the difference between physical exercise and physical activity?
Do you understand the relationship between physical exercise and health?
Did you like the mediated visit? Point out at least one reason.
Can you see if the visit contributed to your learning? In what way?
What was the importance of the activity developed during the visit for you?
What did you like the most during the visit? Why?
Did the visit to the non-formal educational space contribute significantly to your learning about the human body and health?
About the topic studied during the visit, what did you learn most relevant?

Source: The authors (2022).

RESULTS AND DISCUSSION

The didactic sequence had as its main focus the insertion of students in an investigative learning process on the theme "The influence of physical exercise on the human body". The idea of the approach came from situations experienced with the group of

students in the classroom. Taking advantage of the context, joint activities of Biology and Physical Education were developed to arouse the curiosity of students in relation to the effects of physical exercise on organic systems and health promotion. The SDI was organized in 8 moments, distributed in 7 classes (Chart 3).

Chart 3 – Organization of the SDI in moments of application

MOMENTS	OBJECTIVES	DURATION	DEVELOPMENT
First	To ascertain the profile in relation to the possession and use of DICT and contextualize the theme	1 lesson (50m)	Survey on the possession and use of DICT and conversation circle.
2nd	Diagnosing prior knowledge	1 lesson (50m)	Word cloud, diagnostic questionnaire and discussion.
Third		1 lesson (50m)	Presentation of the guiding question (*Why do we breathe for breath after physical exercise*?), raising hypotheses and discussion.
4th	Explore, analyze, discuss, and interpret data	2 lessons (1h 40 min)	Interdisciplinary practical class, data exploration, discussion and orientation to consult the scientific literature to confirm or refute hypotheses.
5th	Stimulate scientific and critical argumentation	1 lesson (50 min.)	Discussion and argumentation about hypotheses with scientific basis.
6th	Motivate the student in the construction of scientific knowledge	Extra-class activity	Guided tour of the non-formal education space (NEDUCOM/UFMG).
7th	Promote understanding of the changes caused by physical exercise in the human body	Extra-class activity	Preparation of digital resources (video, MC and educational booklet).
8th	Verify and evaluate the knowledge stimulated	1 lesson (50 min.)	Presentation of the final product and final questionnaire.

Source: The authors (2022).

1st moment: The scientific research project was presented to the students and a survey was carried out on the possession and use of DICT, through the *Google Forms* tool. The students participated in a conversation circle to contextualize the topic addressed. In the survey of possession and use of digital information and communication technologies,

97.8% of the students reported having a smartphone or tablet and 70.8% had a computer at home. Regarding the difficulty of using DICT, 61.8% said they had no difficulty, 34.8% had little difficulty and 3.4% had difficulty. The information collected suggested feasibility in the application of SDI activities.

During the conversation circle, the teacher-researcher showed images of people adept at the practice of regular physical exercises and asked the students to observe and physically describe such people. During the discussion, the students highlighted the well-defined muscles of the individuals and discussed the importance of physical exercises in the prevention of diseases such as diabetes and hypertension. According to Luan et al. (2019), regular physical exercise is a potent non-pharmacological device in the prevention and treatment of diseases and the World Health Organization (2014) also attributes to this practice the prevention of diseases such as high blood pressure, diabetes, strokes, depression, among others.

2nd moment: The students participated in the construction of a word cloud, in which they were challenged to express in three words what "Physical Exercise" represents to them. The teacher presented the results and mediated the analysis and discussion carried out by the class. Pagliarini and Sepel (2022) recommend that the implementation of tools that collect prior information allows the teacher to qualify pedagogical actions.

As a result of the word cloud performed by the students, health, gym, effort, food, well-being and weight training were terms that appeared more frequently and that, corroborated with the discussion among peers, suggest that most students related physical exercise to health promotion. However, it is interesting to note that the students also associated physical exercise with other concepts such as self-esteem, determination, willingness, responsibility and learning, that is, they demonstrated a relationship between exercise and mental well-being. Freitas (2019) highlights that physical exercise is an important tool with undeniable biological and psychological benefits that prevents the onset of various diseases and reduces stress.

The students answered a questionnaire, made on *Google Forms*, to assess their conceptions about the human body, physical exercise and health. The results in relation to the questions investigated show that more than 60% (19) of the students fully agreed with the statement "The systems of the human body work in an integrated manner". However, they demonstrated that they did not have previous knowledge for this, as they stated that they did not identify the structures and respective functions of these systems. According to Moreira (2012), there may not be adequate prior knowledge, and in this case, the role of the

teacher is fundamental to attribute meaning to the information to be incorporated into the cognitive structure.

The results also show that approximately 50% (15) of the students understand the difference between physical exercise and physical activity and about 80% (24) consider that they understand the role of physical exercise in the prevention of diseases. It is important to emphasize that this stage of the research, diagnosis of previous knowledge, provides information to direct pedagogical actions and achieve an SSA (AUSUBEL, 2000). In addition, it was possible to perceive, through peer discussion, a curiosity of the students in relation to the performance of physical exercise in the functioning of the human body. From this, it is understood the importance of the teacher planning pedagogical actions that make sense to the student (BRASIL, 2018).

3rd moment: The guiding question was presented to the students who, in groups, wrote down their initial hypotheses (Chart 4) about "Why do we breathe after a physical exercise?" and brought it for general discussion with the class.

Chart 4 – Hypotheses presented by the students

GROUPS	CHANCE
1	"*We get out of breath after physical exercise, because the body needs more oxygen; heartbeat is accelerated; adrenaline increases; There is a lack of air and the respiratory system becomes unbalanced. So all these factors contribute to panting after physical exercise.* "
2	"*We get out of breath because to carry out our functions we need oxygen, which varies according to our activities. In a more accentuated exercise or physical activity, we need a greater amount of air, if we are not prepared (in good health), breathing is altered and we are panting.* "
3	*"We were gasping for breath because of the increase in respiratory and heart rate, because we are sedentary and because of the action of adrenaline.* "
4	"*We gasp because as the exercise is performed the muscle fibers require more oxygen from the blood, causing the lung to work at an accelerated pace, along with the heart that needs to pump blood faster. For this reason, we get out of breath after physical exercise.* "
5	"*This is due to the increased speed at which the heart pumps blood because of exercise. The cardiovascular system has to operate faster, so it interferes with the respiratory system.* "
6	"*Because when we exercise, the blood circulates faster through the body, due to the stimuli (nervous system) caused by the muscles.* "

Source: The authors (2022).

The groups associated the difficulty in breathing, after physical exercise, with changes in the cardiovascular and respiratory system and some mentioned the action of neurotransmitters such as adrenaline, but none of them clearly addressed the events that lead to this shortness of breath, in an integrated sequence.

Vanzela et al. (2013) point out that the organic functions of the human body are traditionally addressed by Biology in a compartmentalized way. This approach makes it difficult to understand this content and translates into the need for pedagogical strategies that integrate this knowledge.

4th moment: the students participated in an interdisciplinary practical class with the Biology and Physical Education teachers. Divided into groups, the students chose two representatives, one female and one male, to measure vital signs, heart rate (HR) and blood pressure (BP). The measurement was carried out by the Physical Education teacher, who, in addition to being a physical educator, is a physiotherapist, and had the help of an automatic arm sphygmomanometer.

Data collection took place in three moments: before the exercise (rest), immediately after and ten minutes after the end of the physical exercise. The students recorded the collected data and discussed the results in their respective groups. The students observed the following questions: "Was there a change in HR and/or BP after physical exercise? If so, why did it occur? ", "Was there any difference in the data obtained in relation to the collection times? If so, why? ", "Was there any difference in the data regarding gender? If so, why? ". The groups analyzed the results, proposed and recorded their hypotheses (Chart 5). Then, they presented and discussed their findings and hypotheses with the class.

Table 5 – Initial hypotheses about changes in BP and HR

GROUPS	CHANCE
1	*"There was an increase in HR and BP due to the increase in the levels of adrenaline stimulated by the nervous system. It may also be due to the pumping of blood during exercise. "*
2	*"There was an increase in HR and BP after exercise due to the release of adrenaline and respiratory control. "*
3	*"Females increase HR more because of hormones and the colleague who had lower BP and HR than at rest may be due to regular physical exercise. "*
4	*"There was an increase in HR and BP due to the need for oxygen generated by the muscles and thus the blood has to be pumped faster. The difference in relation to sex is because a woman's heart is smaller, having to pump blood faster. "*
5	*"There was an increase in HR and BP, because when physical activity is practiced, the body needs more oxygen and so the heart makes more effort to pump the necessary blood. Regarding gender, there was variation due to weight, height, and whether or not they do regular physical activity. "*
6	*"There was an increase in BP and HR because of the increase in respiratory rate and blood flow, increasing muscle contractions, due to the effort. There was a difference between the sexes, due to the physical issues of men and women. "*

Source: The authors (2022).

The teacher-researcher advised that, for the next class, students should consult the scientific literature to confirm or refute hypotheses both in relation to the guiding question and the measurement of vital signs. Students should argue about their records, corroborated by the scientific literature. To guide the students' consultation, support materials were posted on the *Google Classroom* and *WhatsApp* platforms, already known and used by them.

This stage of the SDI showed great engagement and motivation of the students when carrying out practical activities that encouraged them to collect, explore, analyze data and formulate hypotheses to solve the proposed problems. Carvalho (2013) points out that activities should be built around problem situations inserted in the students' daily lives and Lima (2019) emphasizes that they should be planned in a growing dynamic, in order to develop skills and promote SS. In addition, the students showed enthusiasm by carrying out the activities in a physical space different from the traditional classroom. According to Guerra (2011), the environment generates stimuli that can favor learning. In addition, the emotions aroused by these stimuli develop motivation (HENNEMANN, 2015).

5th moment: After consulting the scientific literature to confirm or refute hypotheses, both in relation to the guiding question and the measurement of vital signs, the students presented their findings and arguments (Charts 6 and 7).

Chart 6 - Arguments presented to explain the guiding question

GROUPS	ARGUMENTS
1	*"We get out of breath after physical exercise, because the more muscle fibers strive to perform a task, the more they consume oxygen brought by the bloodstream. This forces the lungs to work at a fast pace, since they are responsible for oxygenation. The heart also speeds up, as it needs to pump blood more vigorously. And that's why, during exercise, the heart rate and respiratory rate increase. "*
2	*"We get out of breath after a physical exercise because when you start a physical exercise the muscles start to work harder than normal and for that they need energy in the form of ATP. For ATP to be produced, there needs to be oxygen. This oxygen is carried by the blood that is pumped by the heart. Hence the change in respiratory rate and heart rate. "*
3	*"Physical exercise stimulates the brain and activates the frontal cortex. There is release of neurotransmitters and increased respiratory rate, increased heart rate, and increased volume of blood pumped by the heart per minute. That's why we get out of breath after physical exercise. "*
4	*"Physical exercise leads the nervous system to inject adrenaline into the bloodstream, consequently increasing the heart rate, pumping more blood to the body. One of the direct consequences of this event is the increase in lung activity, generating the sensation of panting. "*
5	*"The breathing pattern depends on variables related to respiratory volume and timing, and its control is influenced by cortical and peripheral mechanisms, as well as respiratory and limb muscles. During and after physical exercise, there is an increase in muscle bioenergy functions, increasing physiological reactions responsible for gas exchange, such as respiratory and cardiac rates, enabling greater oxygen supply to tissues and increasing the removal of carbon dioxide. "*
6	*"The changes in the breathing pattern at the end of the exhaustive exercise are due to changes in the muscles of the lower limbs (lower limbs) compared to changes in the respiratory muscles. Therefore, changes in the breathing pattern during and after exercise can be generated by fatigue of the muscles of the rib cage, more than that of the diaphragm, or by fatigue of the muscles of the lower limbs, leading to wheezing. "*

Source: The authors (2022).

Chart 7 – Some of the arguments used by the students to explain the variation in BP and HR after physical exercise

GROUPS	ARGUMENTS
2	*"The increase in heart rate and blood pressure is due to the action of the sympathetic autonomic nervous system that has the ability to increase cardiac activity, thus increasing the heart's ability to pump blood. On the other hand, there is the action of the parasympathetic autonomic nervous system to stop this action, slowing down the heart rate during recovery from exercise. In addition, the size of women's hearts, smaller than men's, influences the volume of blood pumped and consequently a greater oscillation of heart rate. "*
3	*"There was a difference between the sexes, as women have a smaller body surface area and a smaller heart than men. The heart in women has a smaller stroke volume (volume of blood ejected from the heart with each beat) the geometry of the left ventricle in women is different. In physical stress, women respond differently, there is a lower increase in peripheral vascular resistance and less impact on BP. On the other hand, there is a greater elevation in heart rate, but all of this can vary depending on body mass, glycemic index, and other factors. "*
5	*"One of the main adjustments observed after the practice of physical exercise is the response of systolic blood pressure to diastolic blood pressure, which tends to reduce below the levels found in pre-exertion. This effect is called post-exercise hypotension. This may, for example, explain why some colleagues had a reduction in BP ten minutes after the end of the exercise. Aerobic exercise has a hypotensive effect and its magnitude depends on the intensity, duration, muscle mass involved and gender of the practitioners. The nervous system, during physical exercise, increases the release of neurotransmitters such as serotonin, noradrenaline and dopamine. It stimulates the release of neurotrophins, stimulates neuroplasticity that causes a decrease in the feeling of stress and anxiety, which causes post-exercise hypotension. "*

Source: The authors (2022).

The groups argued about the initial guiding question, bringing integrated information about the activation of the nervous system by physical exercise, the release of neurotransmitters and the associated systemic responses. Azevêdo et al. (2019) corroborate that physical exercise stimulates cortical and subcortical areas of the central nervous system, decreasing parasympathetic action and increasing sympathetic activity. Stimulation of the sympathetic nervous system leads to the release of neurotransmitters that lead to increased heart and respiratory rate.

During the interdisciplinary practical class (Physical Education and Biology), the groups noticed that there were changes in the data recorded (HR and BP) after physical exercise, when compared to the resting situation. All individuals measured had an increase

in HR and BP immediately after exercise, but they noticed that some colleagues showed a decrease in HR and BP values 10 minutes after the end of the physical exercise, when compared to the resting data.

The muscle work performed during physical exercise leads to a greater energy demand and causes changes in the body's homeostasis. To meet this demand, the body makes use of immediate adjustment mechanisms that promote an increase in HR and BP (BRUM *et al.*, 2004). According to Laterza et al. (2007), there may be a reduction in blood pressure levels, after physical exercise, lasting for several hours and trained individuals have efficient autonomic and hemodynamic adaptations.

Some students highlighted that female colleagues had a greater elevation in heart rate when compared to male colleagues. Some studies mention differences in autonomic control, hormonal issues, body mass, among others that corroborate these results (SAMORA *et al.*, 2020).

6th moment: The students visited the NEDUCOM/UFMG laboratory, where they participated in the approach carried out by the "Interact Project" with the theme "Physical exercise". The students had the opportunity to visit laboratories of the Department of Morphology of the Institute of Biological Sciences (ICB/UFMG) and participate in a practical class on the systems of the human body, with real anatomical parts. During the visit, and especially on the way back to school, the students mentioned how interesting it was to participate in the activities at NEDUCOM. The integration of a non-formal education space in the SDI aimed to motivate students in the construction of scientific knowledge in a contextualized and playful way. Guerra (2011) highlights that the environment can stimulate learning and emotions lead to the formation of memories. So, exciting experiences, such as those offered in these spaces, can contribute to the student's teaching and learning process.

Therefore, the importance of the visit to the NEDUCOM/UFMG laboratory to awaken the students' motivation to learn was notorious. They were curious and involved throughout the approach. In addition, the visit gave rise to a sense of belonging to the University, a desire to be part of that academic context. Consequently, all this transposition of the limits of the traditional classroom can lead the student to learn how to learn (ZÔMPERO *et al.*, 2019). Therefore, the demand for pedagogical practices that meet a changing society goes beyond the walls of the classroom, seeking contextualized spaces that promote exchanges of experiences with students.

7th moment: As SDI products, the groups made a digital concept map, a digital booklet and a video, in which they revisited the guiding question, addressing the action of

physical exercise on the systems of the human body. The choice of technological tools was made by the students themselves. In this way, each group researched and used the applications of their interest. The use of ICTs was also thought of as a motivating and student engagement strategy, since these technologies are part of students' daily lives and, as recommended by the BNCC, can help teachers in the search for student protagonism (Brasil, 2018). Thus, the students produced well-prepared materials, in a creative way, using different applications and based on the scientific knowledge they sought, in a totally autonomous way, during the stages of SDI.

8th moment: The groups organized a digital exhibition and presented the materials produced to the pairs and, later, the presentation was extended to the school community, through the school's social networks and those used by teachers in other projects that promote knowledge. According to Sasseron (2013), the dissemination of ideas is part of science and new perspectives can be added to the previous view. Knowledge is constantly changing, and peer-to-peer exchanges can enhance ideas. At the end of the 8th moment, the students answered the questionnaire to assess their conceptions about the human body, physical exercise and health.

The results of the analysis of the questionnaires, applied to diagnose previous knowledge and to verify the final conceptions, showed that there was an increase in the number of students who considered to have knowledge about the concepts addressed in the proposed statements. Regarding the statement "The systems of the human body work in an integrated manner", more than 85% (26) of the students considered that they understood this integration and, according to the results shown in chart 4, there was a significant increase in the number of students who considered identifying structures and functions of the systems involved. This suggests that the SDI participants added information about the topic studied to the repertoire they previously had. For Moreira (2012), new information can be incorporated into that already existing in the cognitive structure. When this new information is able to establish relationships with previous knowledge, it is cognitively added to the learner's repertoire. Ausubel (1980) highlighted that SSA occurs when there is substantial interaction between existing information and new information.

At the end of the SDI activities, the students answered a questionnaire, made on *Google Forms*, to evaluate their perceptions or experiences regarding the activities developed and applied in the didactic sequence and regarding the visit to the NEDUCOM/UFMG laboratory. The questionnaire to assess the students' perception of SDI included questions such as "Did you enjoy participating in the activities of the investigative didactic sequence? Why? ". The percentage of students who answered affirmatively was

93.3% (28). The reasons listed by them were the acquisition of knowledge about the human body (19 students), a different form of learning (8 students) and the acquisition of scientific knowledge (1 student). Only two students reported not having liked it, as they found the activities too laborious and difficult.

It was possible to perceive, through the students' reports (Chart 8), important aspects proposed by the SDI developed, such as, for example, the integrated understanding of the concepts addressed by the theme, the curiosity aroused by the investigative context, the interest in using DICT in activities and in seeking scientific information to explain phenomena experienced in everyday life.

Chart 8 – Students' reports about what they liked most during SDI

STUDENT	REPORT
1	*"Learning in a relaxed way, since we are always very used to the teacher explaining the theory, but we never have the practice. "*
2	*"The proposed work, the explanatory video, concept map and etc... Especially the visit to the ICB. "*
3	*"Making the digital concept map, because it was the activity I learned the most. "*
4	*"When it clicked and I realized I was really learning."*
5	*"Of how one thing connects to another in our body, which works all together, and with each question aroused more curiosity. "*

Source: The authors (2022).

Thus, the reports suggest an increase in the students' motivation to learn. According to Guimarães and Boruchovitch (2004), motivation promotes the involvement of students in activities that challenge them, provides the development of strategies for solving problems, generates enthusiasm and acquisition of skills. Consequently, the investigative approach, placing students at the center of the learning process, encouraging them to discover concepts related to their daily lives, promoted more meaningful learning.

The questionnaire to analyze the students' perception of the visit to the NEDUCOM/UFMG laboratory included questions such as "Did you like the visit to the NEDUCOM/UFMG laboratory?". All 30 participants (100%) said they enjoyed the visit. The students also listed reasons why they liked it. Of the 30 respondents, 19 pointed out the acquisition of knowledge, 7 pointed out the contact with the anatomical specimens, 2 highlighted the welcome of the NEDUCOM team, 1 of the students said that he liked it because it was the university he wanted to study and another highlighted that the topic addressed was the one he liked the most.

When we evaluated the students' perception of the visit, we realized that they were impacted by the differentiated pedagogical activities, with the contact with the anatomical

specimens and with the scientific knowledge provided by the academic environment. Through the reports, we found a feeling of belonging of these students in relation to the university. The visit to NEDUCOM/UFMG was pointed out by the students as an enriching moment and a lot of learning. The pedagogical activities, carried out by the NEDUCOM team, aroused interest, curiosity, attention and motivation of the students. Hennemann (2015) highlights this motivation as a foundation for learning.

Several authors reiterate that teaching can take place outside the classroom environment and that making classes more interesting and attractive contributes to the acquisition of knowledge and the formation of a student with the capacity for scientific and critical argumentation (Rocha and Fachín-Téran, 2010; Jacobucci *et al.*, 2009; Marandino, 2009; Praxedes, 2009). For Santos (2018), non-formal spaces of education are important means of scientific dissemination because they arouse curiosity and interest.

FINAL CONSIDERATIONS

The study developed allowed us to conclude that the insertion of students in contextualized, motivating pedagogical practices that make sense to the learner can arouse interest in science. The incorporation of the visit to the University's NEDUCOM space to SDI's activities contributed to motivating students and fostering the construction of scientific literacy. The interaction between basic education and higher education created perspectives for the teaching and learning process.

The use of DICT during the SDI activities provided a contextualized approach to the themes worked and the involvement of students in the stages of the construction of scientific knowledge. Involving students in everyday themes provided an integrated knowledge of their own bodies and elucidated the importance of organism-environment interaction for health promotion.

The practices based on the investigative cycle aroused curiosity in the students to solve problem-situations inserted in their daily lives. The contemplation of the investigation, discussion and sharing of ideas in the activities developed brought fluidity to the construction of knowledge.

Therefore, this entire process elaborated from methodologies focused on the needs of the learner and that takes into account their cognitive baggage may have contributed to significant learning.

ACKNOWLEDGMENT

To the professors and students participating in the research and to the Coordination for the Improvement of Higher Education Personnel (CAPES) for the financial support.

REFERENCES

1. Ausubel, D. P., Novak, J. D., & Hanesian, H. (1980). *Psicologia educacional*. Rio de Janeiro: Interamericana.

2. Ausubel, D. P. (2000). *The acquisition and retention of knowledge: a cognitive view*. Boston: Kluwer Academic Publishers.

3. Back, D., Radetzke, F. S., Gunzel, R. E., & Wenzel, J. S. (2017). Educação em espaços não formais no Ensino de Ciências. In *Encontro Nacional de Pesquisa em Educação em Ciências, 11.* Anais... Disponível em: https://www.abrapec.com/enpec/xi-enpec/anais/resumos/R1066-1.pdf. Acesso em: 15 fev. 2024.

4. Brasil. Ministério da Educação. (2017). *Base Nacional Comum Curricular: Educação Infantil e Ensino Fundamental*. Brasília: MEC.

5. Brasil. Ministério da Educação. Conselho Nacional de Educação. Câmara de Educação Básica. (2010). Resolução nº 4, de 13 de julho de 2010. Disponível em: https://normativasconselhos.mec.gov.br/normativa/view/CNE_RES_CNECEBN42010.pdf?query=AGR. Acesso em: 19 out. 2023.

6. Brasil. Ministério da Saúde. Secretaria de Gestão do Trabalho e da Educação na Saúde. Departamento de Gestão e da Regulação do Trabalho em Saúde. Câmara de Regulação do Trabalho em Saúde. (2006). Brasília: MS.

7. Brum, W. P., & Schuhmacher, E. (2015). A engenharia didática como campo metodológico para o planejamento de aula de matemática: Análise de uma experiência didática para o estudo de geometria esférica. *Jornal Internacional de Estudos em Educação Matemática, 6*(2), 1-13. DOI: [10.17921/2176-5634.2013v6n2p%p](https://doi.org/10.17921/2176-5634.2013v6n2p%p).

8. Campos, L. F. A. A. (2018). Inteligência Artificial e instrumentalização Digital no Ensino: a semiformação na era da automatização computacional. Disponível em: https://repositorio.unesp.br/handle/11449/157281. Acesso em: 06 nov. 2024.

9. Cardoso, V., Reis, A. P. D., & Iervolino, S. A. (2008). Escolas promotoras de saúde. *Journal of Human Growth and Development, 18*(2), 107-115. DOI: [10.7322/jhgd.19872](https://doi.org/10.7322/jhgd.19872). Disponível em: https://www.revistas.usp.br/jhgd/article/view/19872/21946. Acesso em: 15 fev. 2024.

10. Carvalho, A. C. P. L., et al. (2021). Inteligência Artificial: riscos, benefícios e uso responsável. *Estudos Avançados, 35*, 21-36.

11. Carvalho, A. M. P. (2013). *Ensino de ciências por investigação: condições para implementação em sala de aula* (2. ed.). São Paulo: Cengage Learning.

12. Carvalho, A. M. P. (2018). Fundamentos teóricos e metodológicos do ensino por investigação. *Revista Brasileira de Pesquisa em Educação em Ciências*, 1-30. Disponível em:

https://periodicos.ufmg.br/index.php/rbpec/article/view/4852/3040. Acesso em: 15 jan. 2024.

13. Cazelli, S. (2005). Ciência, cultura, museus, jovens e escolas: quais as relações? (Tese de Doutorado, Pontifícia Universidade Católica do Rio de Janeiro, Rio de Janeiro). Disponível em: https://www.fiocruz.br/brasiliana/media/tese_sibelecazelli.pdf. Acesso em: 30 jan. 2024.

14. Marinho, J. C. B., Silva, J. A. da, & Ferreira, M. (2014). A educação em saúde como proposta transversal: analisando os Parâmetros Curriculares Nacionais e algumas concepções docentes. *História, Ciências, Saúde-Manguinhos, 22*, 429-444. https://doi.org/10.1590/S0104-59702014005000025.

15. Freitas, M. M. de. (2019). A influência da atividade física no aprendizado com idade escolar. *Revista Científica do Instituto Ideia*, (2). Disponível em: https://revistaideario.com/pdf/desm/revista.ideario.15n.02_2019/revista.ideario.n15_02.2019.063_a.influencia.da.atividade.fisica.pdf. Acesso em: 04 nov. 2023.

16. Agra, G., Formiga, N. S., Oliveira, P. S. de, Costa, M. M. L., Fernandes, M. G. M., & Nóbrega, M. M. L. da. (2019). Análise do conceito de Aprendizagem Significativa à luz da Teoria de Ausubel. *Revista Brasileira de Enfermagem, 72*(1), 30-38. https://doi.org/10.1590/0034-7167-2017-0691.

17. Gatti, F. N. (2019). Educação básica e inteligência artificial: perspectivas, contribuições e desafios. São Paulo. Disponível em: https://sucupira.capes.gov.br/sucupira/public/consultas/coleta/trabalhoConclusao/viewTrabalhoConclusao.jsf?popup=true&id_trabalho=8132119. Acesso em: 06 nov. 2024.

18. Guerra, L. B. (2011). O diálogo entre a neurociência e a educação: da euforia aos desafios e possibilidades. *Revista Interlocução, 4*(4), 3-12.

19. Guimarães, S. É. R., & Boruchovitch, E. (2004). O estilo motivacional do professor e a motivação intrínseca dos estudantes: uma perspectiva da teoria da autodeterminação. *Psicologia: Reflexão e Crítica, 17*, 143-150. Disponível em: https://www.scielo.br/j/prc/a/DwSBb6xK4RknMzkf5qqpZ6Q/?format=pdf&lang=pt.

20. Hennemann, A. L. (2015). Motivação como ferramenta de aprendizagem. Disponível em: http://neuropsicopedagogianasaladeaula.blogspot.com.br/2015/10/motivacao-como-ferramenta-de.html. Acesso em: 18 fev. 2024.

21. Jacobucci, D. F., Jacobucci, G. B., & Neto, J. M. (2009). Experiências de formação de professores em centros e museus de ciências no Brasil. *Revista Electrónica de Enseñanza de las Ciencias, 8*(1), 118-136. Disponível em:

http://reec.uvigo.es/volumenes/volumen08/ART7_Vol8_N1.pdf.

22. Kenski, V. M. (2012). *Educação e tecnologias: o novo ritmo da informação*. Campinas: Papirus.

23. Laterza, M. C., Rondon, M. U. P. B., & Negrão, C. E. (2007). Efeito anti-hipertensivo do exercício. *Revista Brasileira de Hipertensão, 14*(2), 104-111. Disponível em: http://departamentos.cardiol.br/dha/revista/14-2/10-efeito.pdf.

24. Leite, C. T., Peixoto, R. V., Antero, C. M., Silva, G. Q. da, & Antero, M. F. S. M. (2014). Prática de educação em saúde percebida por escolares. *Cogitare Enfermagem, 19*(1). Disponível em: https://revistas.ufpr.br/cogitare/article/viewFile/35925/22157. Acesso em: 18 out. 2023.

25. Lima, J. M. P. (2019). A importância da sequência didática para a aprendizagem significativa da matemática. *Revista Artigos, 2*, 1-8. Disponível em: https://acervomais.com.br/index.php/artigos/article/view/829/387. Acesso em: 24 out. 2023.

26. Luan, X., Tian, X., Zhang, H., Huang, R., Li, N., Chen, P., & Wang, R. (2019). Exercise as a prescription for patients with various diseases. *Journal of Sport and Health Science, 5*, 422-441. https://doi.org/10.1016/j.jshs.2019.04.002.

27. Marandino, M. (2009). Museus de ciências, coleções e educação: relações necessárias. *Museologia e Patrimônio, 2*, 1-12. Disponível em: http://www.geenf.fe.usp.br/v2/wpcontent/uploads/2012/10/museologia_marandino2009.pdf. Acesso em: 19 fev. 2024.

28. Marinho, J. C. B., Silva, J. A. da, & Ferreira, M. (2014). A educação em saúde como proposta transversal: analisando os Parâmetros Curriculares Nacionais e algumas concepções docentes. *História, Ciências, Saúde-Manguinhos, 22*, 429-444. https://doi.org/10.1590/S0104-59702014005000025.

29. Moran, J. (2015). Mudando a educação com metodologias ativas. Em C. A. Souza & O. E. T. Morales (Orgs.), *Convergências Midiáticas, Educação e Cidadania: aproximações jovens* (Vol. II, pp. 15-33). Ponta Grossa: PROEX/UEPG.

30. Moreira, M. A. (2012). Mapas conceituais e aprendizagem significativa. *Aprendizagem significativa, organizadores prévios, mapas conceituais, diagramas V e Unidades de ensino potencialmente significativas*, 1-14.

31. Nascimento, N. G. do, Pereira, L. L., & Shaw, G. S. L. (2020). Conceitos de interdisciplinaridade em pesquisas publicadas na área de ensino e educação (2009-2018). *Revista de Educação em Ciência e Tecnologia, 13*(2), 143-165.

32. Oliveira, C. A., & Santos, E. R. (2021). *Capacitação Docente e Tecnologias Emergentes: Estratégias para a Educação Personalizada*. Editora Penso.

33. Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacarias, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14*, 47-61.

34. Ponte, M. L., & Maldarine, J. S. (2019). Corpo humano e a saúde na juventude: Estratégia e recursos para o Ensino Médio. *REnCiMa, 10*(6), 76-94. https://doi.org/10.26843/rencima.v10i6.2115.

35. Praxedes, G. de C. (2009). A utilização de espaços de educação não formal por professores de biologia de Natal-RN. Dissertação (Mestrado), Universidade Federal do Rio Grande do Norte. Disponível em: https://repositorio.ufrn.br/bitstream/123456789/16057/1/GutembergCP.pdf.

36. Queissada, D. D., & Pacheco, F. K. (2021). *Fundamentos de Saúde Única*.

37. Rocha, S. C. B., & Terán, A. F. (2010). O uso de espaços não formais como estratégia para o ensino de ciências. Manaus: UEA/Escola Normal Superior/PPGEECA.

38. Russel, S. J., & Norvig, P. (2018). *Inteligência artificial*. Rio de Janeiro: Elsevier.

39. Ruas, F. P., & Araújo, R. R. (2017). O todo e as partes como forma de expressão de pontos de vista sobre interdisciplinaridade em ciências. *Interdisciplina, 11*, 58-71. Disponível em: https://www5.pucsp.br/gepi/downloads/revistas/revistas-11-05-out-2017.pdf.

40. Samora, M. (2020). Diferenças entre os sexos na reativação vagal cardíaca a partir do final do exercício isométrico de preensão manual e no início do isolamento do metaborreflexo muscular. *Neurociência Autonômica, 228*, 102714. Disponível em: http://icts.unb.br/jspui/bitstream/10482/39991/1/2020_MilenaSamoradosSantos.pdf.

41. Santos, E. A., & Lima, J. P. (2022). *Tecnologia e Ensino: Desafios da Implementação da Inteligência Artificial na Educação*. Editora Vozes.

42. Sasseron, L. H. (2015). Alfabetização científica, ensino por investigação e argumentação: relações entre ciências da natureza e escola. *Ensaio Pesquisa em Educação em Ciências*, 49-67. https://doi.org/10.1590/1983-2117201517s04.

43. Sasseron, L. H. (2013). Interações discursivas e investigação em sala de aula: o papel do professor. In A. M. P. Carvalho (Org.), *Ensino de ciências por investigação: condições para implementação em sala de aula* (pp. 41-62). São Paulo: Cengage Learning.

44. Silva, A. R., & Oliveira, F. J. (2021). *Ética e Inclusão na Era Digital: Desafios da Inteligência Artificial na Educação*. Editora Penso.

45. Silva, J. G. S., & Santos, R. dos. (2021). Contribuições de um espaço não formal para a promoção de ensino escolar contextualizado e interdisciplinar à luz da BNCC. *ACTIO:

Docência em Ciências, 6*(1), 1-23. https://doi.org/10.3895/actio.v6n1.12611.

46. Silva, V. P. da, Poian, A. T. da, & Silva, E. P. da. (2021). Desenvolvimento de uma sequência didática investigativa apoiada pelo uso da tecnologia da informação e comunicação. *Revista Educação Pública, 21*, 1-8. Disponível em: https://educacaopublica.cecierj.edu.br/artigos/21/18/desenvolvimento-de-uma-sequencia-didatica-investigativa-apoiada-pelo-uso-da-tecnologia-da-informacao-ecomunicacao. Acesso em: 18 fev. 2024.

47. Vidal, A. S., & Miguel, J. R. (2020). As tecnologias digitais na educação contemporânea. *ID on line: Revista de Psicologia, 14*(50), 366-379. Disponível em: https://idonline.emnuvens.com.br/id/article/view/2443. Acesso em: 23 out. 2023.

48. Vanzela, E. C., Balbo, S. L., & Della-Justina, L. A. A. (2013). Integração dos sistemas fisiológicos e sua compreensão por alunos do nível médio. *Arquivos do Museu Dinâmico Interdisciplinar, 11*(3), 12-19.

49. Vicari, R. M. (2018). Tendências em inteligência artificial na educação no período de 2017 a 2030. Brasília: SENAI/Serviço Nacional de Aprendizagem Industrial, Serviço Social da Indústria.

50. Zômpero, A. F., Andrade, M. A. B. S. de, Mastelari, T. B., & Vagula, E. (2019). Ensino por investigação e aproximações com a aprendizagem baseada em problemas. *Debates em Educação, 11*(25), 222-239. Disponível em: https://www.seer.ufal.br/ojs2-somente-consulta/index.php/debateseducacao/article/view/7740/pdf.