Augmented Reality and Interdisciplinarity: the Use of LandscapAR Application in the Teaching of Mathematics and Geographys

Realidade Aumentada e Interdisciplinaridade: o Uso do Aplicativo LandscapAR no Ensino de Matemática e Geografia

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Abstract

This article is guided by the results of a research that sought to reflect on a didactic action. The methodology used is deployed by means of qualitative research, in the perspective of a case study, with a class in the public school of the Paraná state, where all individuals are high school students and belonging to a generation Z, which the general objective of the research was to verify if abstractions occurred and if cognitive appropriations were legitimized, in an interdisciplinary case of geography and mathematics, using the application LandscapAR. The results pointed to a more participatory learning process of the students in the interaction with this augmented reality application, and, in the same measure, they appropriated the intended concepts.

Keywords: Geography teaching. Mathematics education. Media literacy. Augmented reality. LandscapAR.

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Resumo

Este artigo é norteado pelos resultados de uma pesquisa que buscou refletir acerca de uma ação didática, com lócus em uma escola pública da rede estadual do Paraná, onde todos os sujeitos eram alunos de ensino médio e, pertencentes a uma geração Z, que consolida de forma mais eficaz seu aprendizado via tecnologias digitais.O objetivo geral da pesquisa foi verificar se ocorreriam abstrações e se legitmimariam apropriações cogntivas, em um viés interdisciplinar da geografia e matemática, através do aplicativo LandscapAR. Os resultados apontaram para um processo de aprendizagem mais participativo dos alunos na interação com esse aplicativo de realidade aumentada, e, na mesma medida, apropriaram-se dos conceitos pretendidos.

Palavras-chave: *Ensino de Geografia. Educação matemática. Literacia midiática. Realidade aumentada. LandscapAR.*

1. Introductory notes

The Technological Determinism theory (Toronto School) indicates that technological advances have transformed the way people communicate and behave. Such advances have changed society, now called the Information Society. Various social segments go through this interregnum seeking to adapt, innovate and reframe their way of acting in the face of current demands (TOURAINE, 1998; TOFFLER, 2001; LÉVY, 1999; CASTELLS, 2005; SANTAELLA, 2013).

Technological advances have changed the ways of communicating, thinking, creating and interacting with people in different places and parts of the world. The spread and evolution of the internet brought the virtualization of communication to the information society and the increased flow of information in cyberspace, which attracts more followers every day.

In the school space, this is no different, although it is walking slowly (MORAN, 2014). The discomfort of this traditionally conservative structure reflects the gap between the social model for which it was created and the current generation of students increasingly connected to cyberspace and immersed in cyberculture (GADOTTI, 2003; LÉVY, 1999; PRENSKY, 2001).

Thus, when considering all this contemporary context permeated by technological bias, the research that originated this article had as main objective to analyze an interdisciplinary didactic action. This teaching-learning situation involves teaching geography and mathematical education through an augmented reality application addressed to the current generation of "digital native" students, a term conceptualized below.

Exposed to digital culture from the first years of life, the recent generation of native digital students, or even Generation Z (VEEN; VRAKKING, 2009) divide their attention between the real and the virtual world. The intense use of digital technologies by this audience has led to cognitive changes related to the memorization of information, learning and educational development.

> [...] this potential of digital technology is directly linked to its capacity to excite the individual, generating stimulation of the auditory, visual and emotional systems. Thus altering, their cognitive capacity, whether beneficial or harmful, depending of how it is used and the intensity of its use (HOOGEVEEN, 1997 apud SILVA, 2017, p.293).

On the relationship and coexistence of different generations in the school environment, Prensky (2001, p.1) states that: "students have changed radically, today's students are not the same ones for whom the educational system was created". Still according to Prensky (2001), digital immigrants are individuals / teachers who grew up in the decades before 1980. They had a late relationship with DT, show some insecurity when using technological devices and resources applied to education, although they are able to appropriate and to learn the language, obtaining digital wisdom (PRENSKY, 2012).

Kucharski (2019) continues to indicate that "Generation Z" is immersed in digital technologies, in order to understand how to download them, install them and use them. They have even taught those who were born earlier generations. For Generation Z, "the main criterion for adopting the technology is not the fact that the software or program has good usability, but whether or not it meets its requirements and needs." (VEEN; VRAKKING, 2009, p. 17).

We emphasize that in this text we will consider that the term digital native is not associated with the simple relationship of digital technologies with age groups. There are several factors involved such as economic class and cultural characteristics.

The adoption of hybrid teaching methodologies, in a context of crisis and transition of paradigms, seems to be the path to be followed. This is to provide opportunities for interdisciplinary, meaningful, creative, interactive, engaged, collaborative and mediated by digital information and communication technologies (TDIC). Following this conception, the teaching of geography, in Basic Education, seeks to clarify the student about the relations established between society and nature, in different scales of approach over time-space. In turn, mathematical education seeks to guide its understanding for the exercise of citizenship and to understand mathematical constructs as cultural and scientific heritage.

Used in a rational and targeted manner for educational purposes, digital technology facilitates the acquisition of information in different media, as well as bringing native digital students closer to their context. It does this by stimulating its skills and capacities to adapt to environments that require computer and technological skills to build knowledge (PEREIRA et. Al., 2018; SILVA, 2017).

Fadel (2020) in his final course work entitled "Augmented reality applied to Geography: bibliographic survey in digital repositories" presents a list of Brazilian open access repositories where he cataloged all publications that researched augmented reality in themes related to Geography. He found that this number is still timid and that TDs have the capacity to promote greater and better cognitive appropriations in the field of geography.

In this direction, an interdisciplinary didactic-pedagogical action with the use of digital resources and locative media through technology and, in particular, through augmented reality, seems to contribute to what has been developed.

2. Augmented reality and LandscapAR

Augmented reality is an innovative resource with great potential to remedy the student's difficulties in abstraction, since it makes it possible to manipulate and simulate the visualization of three-dimensional

virtual objects integrated with his sensory perception of the real environment. This makes it possible for students to immerse and interact in a natural way, while bringing them closer to their daily habits.

According to Kirner (2011), augmented reality allows the mixing of real and virtual objects in the user's physical space. The interaction is in real time, through the information generated by the computer in 3D and visualized through technological devices, such as smartphones. Regarding the differences between virtual reality and augmented reality, the author argues that:

> Unlike virtual reality, which seeks to transport the user to the virtual environment, augmented reality keeps the user in his physical environment and transports the virtual environment to the user's space, through some technological device. Thus, the user's interaction with the virtual elements occurs naturally and intuitively, without the need for adaptation or training. (KIRNER; KIRNER, 2011 p.16).

In the wake of ubiquitous realities, of technologies in the classroom, geography also seeks to be inserted. This which describes, explains and relates the existing interactions between society and nature, over time and space, uses numerous digital artifacts to become more attractive. In the ride of the proposed action, in a natural and contextualized way, we seek to explain geometric concepts of mathematics permeated in other areas and spaces, as well as, to promote and deepen the discussion about abstraction.

Corroborating with the very concepts of geography that studies the relationships between man-nature, man-man and man-machine established over time, the objects show the peculiar characteristics of each historical moment and configure spatial and social arrangements that reflect the techniques and technologies employed in their way of being, acting and thinking.

Virtual reality enables visual abstractions as well as the notion of space for both geography and mathematics. Applied to the first, it allows the student to go beyond the boundaries of physical space, while the second, allows the visualization of the extensibility of the infinity of a line.

Immersion in the virtual environment allows the student to have a similar multisensory experience, as if he were physically on site, in a field class. Despite the benefits of empirical learning in loco, it is emphasized that this can be exclusionary when facing the limitations of mobility and / or phobias, which can even bring risks to the student's physical integrity. This is without counting the myriad of possible unforeseen events such as bad weather and costs with organization and transportation. Such mishaps are controlled in virtual reality environments, favoring living in a distant or difficult to access space, thus having greater inclusion. Research in the teaching of geography (PINTO; CENTENO, 2012; SILVA et.al., 2014) indicates that the use of AR interfaces with geographical connotation allows the generation of an engaged, interactive, creative and collaborative learning environment, in which the students' autonomy and protagonism are stimulated from the projection and mixture of virtual and real elements in an immersive social context. Furthermore, it makes it possible to understand how mathematics fits into the geometric perspective of measuring areas, of terrestrial / spatial location and, what is indispensable, using common sense to adapt mathematical measures to everyday reality. Thus, as mentioned earlier, this article focuses on an interdisciplinary didactic action promoted through an augmented reality application called LandscapAR (WEEKEND, 2018).

LandscapAR is configured as a digital resource with great potential to be explored by the discipline of geography and mathematical education in conjunction with the first. This augmented reality application makes it possible to explore, associate and integrate information, themes and concepts involving cartography, geomorphology, hydrography and spatial orientation, spatial, flat and spherical geometry. It recognizes the level curves drawn on the sheet of paper (a concept also worked in mathematics as

topology), and through the smartphone camera projects a virtual topographic profile, making it possible to identify the altimetric differences of the lower and higher portions of the surface. it is also possible to observe the different forms of relief such as mountain ranges, plains, plateaus and their variations (mountain range, valley, hill, escarpment, coastal plain, among others), coastal geomorphological features such as cove, bay, cape, gulf, fjords, isthmus and, in addition, it can be seen that in mathematics it was exemplified and inferred as a graph of functions of several variables (CHRISTOFOLETTI, 1980; PENTEADO, 1983).

This application presents many pedagogical possibilities, among them the study of perception and spatial reading, geographic concepts on landforms, geometry of flat and curved areas, landscape, altitude, topographic profile, contour lines on maps and cartograms. The perception and spatial reading of the forms of relief on maps, is an abstract and unattractive task for many students of Basic Education, given the difficulty of observing the level curves in the cartogram and imagining / projecting its contours and forms of relief in reality.

An interdisciplinary reflection is able to bring together concepts from different areas. Thus, the bias of mathematical education about previous geographical concepts guides the student so that:

> […] can perceive its spatial surroundings beyond what can be seen physically, but not only immersed in the processes of abstraction in geometry, and furthermore, the objective is to have the understanding that not all tracings and measures are linear, demarcated by Euclidean geometry. There is also the perspective of the appropriation of the concept of territory and territoriality necessary for the socio-political bias that one seeks to print. […]. (LIAO et. al., 2020, p.177).

The learning mediated by this application allows the student to overcome his limitations of abstraction and imagination when receiving multisensory stimuli from the information represented in 3D - mathematical concept of space, usually represented on a slate using the x, y and z axes, detached from the spatial representation of a natural environment This favors and gives space to creativity by providing the manipulation and simulation of scenarios, which can be explored in geography teaching strategies, such as: natural processes (phenomena and peculiarities of the climate, relief, soil, vegetation and hydrography), appropriation and land use (urbanized and / or industrialized, agricultural, mineral and vegetable extraction / exploration areas, tourist attractions, among others). There is also the possibility of working with other mathematical concepts such as proportionality, capacity measures, reason in the discussions of irrigation, plantation, harvest, among others.

> The reconceptualization of measurement is […] sometimes na arduous task to perform, since, by deconstructing an officially imposed paradigm and necessarily, it underlies a rethinking of regional specificities, in the diversity of units of length, area and volume. However, this intention goes further, when this concept was not woven in order to sustain the fundamental concepts in a way […] (AUTOR et.al., 2020, p.185)

The three-dimensional images, viewed on the smartphone screen by the application, are generated with the aid of the device's camera, from scanning, capturing and recognizing the level curves drawn on a sheet of paper (Figure 1).

Figure 1: Scanning of countour lines via LandscapAR

Source: The authors (2019).

For this process to occur satisfactorily, the lines representing the contour lines must be drawn on light paper, with the use of a black pen with a thick tip, without the lines overlapping (Figure 2). In order to facilitate scanning, the paper must be clearly visible from a dark background (WEEKEND, 2018).

Figure 2: Recognition and scanning via LandscapAR
Source: The author (2019).

After scanning and capturing the image using the markers (code previously recognized by the software), the level curves are obtained. The program generates a 3D virtual projection (Figure 3), represented by a topographic profile, with great wealth of details (islands, surface shapes, shading and apparent movement of the liquid surface) allowing the user to overcome their imagination and abstraction difficulties on how they would be the shapes of the surface in reality, from the interpretation of the level curves (CARDOSO, 2014 p.332 apud RESENDE et. al., 2016).

Figure 3: Image projected in 3D viaLandscapAR
Source: The author (2019).

From the contour of the contour lines, three-dimensional images are generated and projected that represent scenarios of large and small islands, providing the partial immersion of the student when viewing virtual objects overlaid on the wallet and the physical space of the classroom. surface / relief from reading the level curves on a sheet of paper. Furthermore, the image generated by the application allows the student's interactivity in different perspectives (Figure 4).

Figure 4: Different perspectives in 3D
Source: The author (2019).

AUTHOR et. (2020), in its interdisciplinary proposal between geography and mathematics education, also warns about the concept of perimeter worked in classrooms. The presentation of this concept is usually guided by small objects, when in reality it is possible to "measure" areas and perimeters through Google Earth with good precision and in a way that the concept of area becomes more significant.

After projecting the 3D image, the software offers the possibility for the user to save and / or share the file in the software's share menu represented by a camera icon on the right side of the display. In this icon are available the options of 1) save in the LandscapAr.imagens directory, created when downloading the application in the smartphone's internal memory; 2) share by clicking on the universal share icon, in which multiple channels open, and 3) share directly from the Facebook icon, available in the software menu (Figure 5).
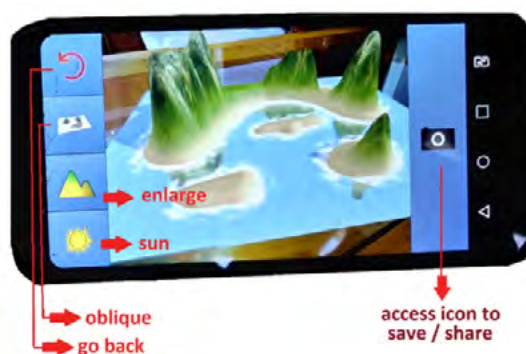

Figure 5: Storage and shares via LandscapAR
Source: The author (2019).

4. Teaching methods and action

The research that originated this text is of a qualitative nature, inserted in an approach through a case study, in which a didactic action was carried out with students from the 1st year of high school at a state school in Paraná.

Alves and Silva (1992, p.1) indicate that "Qualitative data analysis is a recently taken up phenomenon, which is characterized by being an inductive process that focuses on fidelity to the subjects' everyday life universe". complemented by André (1983) when he says that "it aims to apprehend the multidimensional

character of phenomena in their natural manifestation, as well as to capture the different meanings of a lived experience, helping the understanding of the individual in his context" (p.45).

We also reiterate that methodological steps in a qualitative approach are not proposed in a prescriptive measure. The researcher must not take into account only his intuition, like an isolated subject: it is necessary to consider the contact with the investigated reality, related to the theoretical assumptions that support his project. Thus, when refusing inflexibility, the researcher must not lose the accuracy of his work, a sine qua non condition for the materialization of a scientific project that may contribute to knowledge in the area.

> Therefore, when intending to carry out a qualitative analysis, it would be fundamental to verify how the data collection should occur, more specifically, which interview format would be the most pertinent [...] the studies preferentially forward to interview proposals defined by Cannel and Kahn (1974) as semi-structured, asking for a script composition with general topics selected and elaborated in such a way to be addressed with all interviewees. (ALVES; SILVA, 1992, p.1).

In this way, approximation behaviors such as empathy and respect based on the researcher's attitudes are what reverberate the subjects' fluidity and their commitment as informants. This leads to the validation of the collected data, which provides a moment to resume facts, values, reflection and previous attitudes.

Fernandes (1991) argues that the researcher, when in an interview via oral report, consolidates ties with the interviewees and that:

> [...] far from being a task attributed to debutantes, it concretizes the privileged place where bookish knowledge and spontaneous reality are articulated, universal principles. (FERNANDES, 1991, p.10).

Thus, qualitative analysis qualifies in the process of apprehending meanings in the subjects' discourse, articulated to the context in which they are inserted and delimited by the researcher's theoretical conceptions. He takes into account, in the conception of his text, a systematization guided by quality, residing in the fact that a work of this nature does not intend to reach the threshold of representativeness (FERNANDES, 1991).

The didactic-pedagogical action that dealt with the use of the LandscapAR application was developed and promoted with a group of students from the state public school system. It took place in the months of March and early April 2019, with 50 students aged 15 to 17 years, attending the 1st year of high school, in the evening.

The choice of these subjects was due to the fact that since childhood most of these individuals have been in contact and under the influence of digital technologies, generation Z. However, little use them in school activities in favor of their cognitive appropriations and the development of a meaningful learning, something that would allow them to exercise citizenship better and allow them to actively and creatively compose a new society.

The educational institution serves students from the initial grades of elementary school to high school. The physical structure is precarious, with some wooden rooms, absence of laboratory, insufficient and / or outdated technological park. Most of the school's students have a relatively structured family nucleus, with parents who have finished high school and who have an extensive workday throughout the week. They fit

the income profile of social classes D and E (IBGE, 2019). This action made it possible for students to learn both in the virtual space and in the physical space of the traditional classroom, through an activity made possible by digital technologies. For the effectiveness of this hybrid teaching proposal, using the web, mobile devices, using the LandscapAR, Whatsapp and teacher mediation applications, it was necessary for the teacher to program four class hours of 45 minutes each, in the classroom , not counting the students' independent study time for research, information sharing, production and delivery of the final report.

At this point, we will discuss the development of the action that basically consisted of three steps described below:

1st stage) The students received guidance on the name of the application to be downloaded on their mobile devices and the materials to be used. They became aware of the themes to be researched (altitude, topographic profile, scale, contour lines and relief forms); how they would be evaluated; and received a report template to be delivered in PDF, via WhatsApp application individually.

2nd stage) Dialogical exposition class, interaction and feedback between teacher and students about the basic, geographical and mathematical concepts. In this step, the teacher organized the research themes in slides, punctuating the key concepts. Students were able to organize themselves in groups of three, allowing learning to be opportune, appropriating the themes and concepts that should be discussed and shared.

3rd stage) In this stage the students learned by practicing. With the materials in hand, the process of drawing the level curves on the sheet of sulfite paper and discussion of concepts that we sought to work on began. Then, the step by step was recorded through photos, followed by the use of the application.

5. Results and discussions

It was verified the relevant dedication of the students in the activity developed by the fact that it is an activity operated by digital technology and, also, due to the protagonism of their learning throughout this proposal. It is worth highlighting the sharing of ideas, difficulties and limitations regarding involvement with media literacy and digital wisdom.

As for the evaluation process of the students, we opted for the procedural instrument that considered the involvement and development of the student in each stage. Thus, this final report made it possible to verify the learning mediated by digital technology, bringing together and providing the student with the exercise of media literacy skills, or even favoring his digital inclusion, which also counted on the appropriation of geographic and mathematical knowledge.

The fact that not all students have android smartphones and the installed applications did not prevent the application of didactic action. This is because, at that moment, cooperation between students was encouraged. They helped, taught and showed their findings to each other, sharing information, intensifying interaction in an interactive, creative and fun way.

Once the use of LandscapAR was completed and data collection and storage, the report's completion phase began. The highlight at this point in the activity was the performance of students in the working group created on WhatsApp. The volume of messages exchanged between students increased, the protagonism and the collaborative way of sharing information of some students stood out.

Interventions took place only in situations of spreading misinformation, or when something emerged that the working group was unable to resolve. Near the deadline for the delivery of the activity, the works were gradually posted via application, which promoted more interaction between students in the

discussion group. The interaction was due to contacting the productions of colleagues as the reports were posted, which served as a mirror for those who had not yet finished their production.

At the cognitive level, it was possible to observe the appropriation of both geographical and mathematical concepts that sought to be worked on, since in the subsequent meetings there was a "resumption" of the topics previously taught.

Final Considerations

This text presents an end point; however, it is paradoxically continuous in the sense that new artifacts and technological conceptions may compose new scenarios for the appropriation of concepts of geography through an approach with mathematical education, regarding its perspective of discussions of social, human and space character. Technological innovations have transformed the way of being, acting and thinking of individuals in this Information Society and, consequently, real and virtual social life. Learning and teaching in a technological context, in which information is ubiquitous, becomes more challenging task. It requires: understanding the educational demands of the current generation of "digital native" students, who confront the traditional teaching model, perpetuated for decades; teaching and learning to learn, as well as producing, through technological resources and in digital language, without spreading the false impression of knowledge; and be able to provide contextualized, creative and meaningful learning, mediated by digital information and communication technologies. Thus, teachers must reflect on the same concepts worked in different areas of knowledge, taught from different perspectives, as if they were different elements between them. In this sense, mathematical concepts and operations would gain more meaning, not detaching themselves from a more palpable reality, so rightly claimed by students that they do not attribute meaning to what they learn.

In this article we seek to show that technological innovations have created new educational demands that are closer to everyday life and to legitimize knowledge, the ease of access to information, the forms of communication and the behavior of the current generation of students directly affect teaching-learning relationships. They require the adoption of new pedagogical approaches. These should be contextualized, active, creative, collaborative, compatible with the current generation of students, who, contrary to what is perpetuated in common sense, does not have intrinsic digital knowledge or even congenital digital wisdom. They need to learn how to learn and produce in digital language, exercise and expand their involvement with media literacy. In this context, the didactic action brings an interdisciplinary teaching proposal that considers the technological context, explores the hybrid teaching space, understands that access to information and learning can occur at any time and space, uses the locative media of students and provides opportunities teaching geography themes and concepts, bringing them closer to mathematical concepts through the use of digital resources, the web and the LandscapAR application.

The fact of providing active and integrated teaching-learning situations with a digital technological approach, with the help of available and accessible digital resources, brings students closer to their technological, social and cultural context. It stimulates their role and makes the teaching-learning process more meaningful, a fact that was seen throughout the application of the didactic-pedagogical action. It facilitated access to subject-students who, in turn, became involved with the learning situation and made use of augmented reality technology to learn, have fun, collaborate and share information about geography content. The teaching strategy facilitated the process of abstraction and imagination of students on the forms of relief and concept of area and volume, using the LandscapAR application. In addition to the visualization of virtual objects positioned in the classroom environment, the teaching-learning situation allowed to insert and explore the contents on spatial perception, landscape, altitude, topographic profile, contour lines and cartographic scale, as the proposal aroused the students' interest and made them accessible - an element that greatly contributed to their cognitive appropriations. About

the LandscapAR application, the research demonstrated its pedagogical vocation for teaching geography, presented some limitations such as the lack of representation of depressed areas and the unavailability in IOS devices. It is believed that from this research new teaching-learning situations can be created and explored with the use of the mentioned application, as well as being applied to other levels of teaching and areas of knowledge.

It is also worth noting that the results of this action show possibilities for future studies aimed at the development of augmented reality applications correlated to the theme explored by LandscapAR. This is because its limitations can serve as a stimulus for the creation of new digital educational resources, with new functions that add value and can be used for teaching geography.

However, it is expected that this has contributed to teacher training, stimulating new teaching-learning situations mediated by TDIC and promoting pedagogical conduct, appropriate to the current generation of students.

References

ALVES, Z. M. M. B.; SILVA, M. H. D. Análise qualitativa de dados de entrevista: uma proposta. **Paidéia**. Ribeirão Preto.1992. Disponível em: <https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-863X1992000200007>. Acesso em: 31 jan.2020.

ANDRÉ, M. E. D. A. **Texto, contexto e significado: algumas questões na análise de dados qualitativos**. Cadernos de Pesquisa.1983

CARDOSO, R. G.S.; PEREIRA, S. T.; CRUZ, J. H. M.; ALMEIDA, W. R. M. Uso da realidade aumentada em auxílio à educação. **Computer on the Beach**. São Luiz. MA. p.330-339. 2014. Disponível em: <https://siaiap32.univali.br/seer/index.php/acotb/article/view/5337>. Acesso em: 28 maio 2019.

CASTELLS, M.; CARDOSO, G. **A Sociedade em Rede do Conhecimento à Acção Política**. Centro Cultural de Belém, Belém, 2005. Disponível em: <https://cienciastecnologiassociedades.files.wordpress.com/2011/11/sociedade-em-rede-manuel-castells-gustavo-cardoso-org.pdf>. Acesso em: 23 maio 2019.

CHRISTOFOLETTI, A. **Geomorfologia**. 2. ed. São Paulo: Edgard Blücher, 1980.

FADEL, J.E. **A realidade aumentada aplicada na Geografia**: **levantamento bibliográfico em repositórios digitais**. 2020. Trabalho de Conclusão de Curso (Especialização em Inovação e Tecnologias na Educação). Universidade Tecnológica Federal do Paraná. Curitiba. 2020.

FERNANDES, M. E. Memória camponesa. Em, M.A. Matos; D.G. Souza; R. Gorayeb e V.R.L. Otero (Orgs.) **Anais da XXI Reunião Anual de Psicologia**. Ribeirão Preto: Sociedade Brasileira de Psicologia. 1992.

GADOTTI, M. **História das idéias pedagógicas**. São Paulo: Editora Ática, 2003. Disponível em: <http://acervo.paulofreire.org:8080/xmlui/handle/7891/2787>. Acesso em: 10 maio 2019.

IBGE – Instituto Brasileiro de Geografia e Estatística. **IBGE divulga o rendimento domiciliar per capita 2018**. Agência de notícias IBGE, Estatísticas sociais, Brasil, fev. 2019. Disponível em: <https://agenciadenoticias.ibge.gov.br/agencia-sala-de-imprensa/2013-agencia-de-noticias/releases/23852-ibge-divulga-o-rendimento-domiciliar-per-capita-2018>. Acesso em: 05 jun. 2019.

KUCHARSKI, M. V. S. **Fundamentos de Inovação e Tecnologia na Educação**. Especialização em Inovação e Tecnologias na Educação (INTEDUC). Universidade Tecnológica Federal (UTFPR). 2019.

KIRNER, C.; KIRNER, T. G. Evolução e Tendências da Realidade Virtual e da Realidade Aumentada. *In*: SYMPOSIUM ON VIRTUAL REALITY AND AUGMENTED REALITY, 13., 2011, Uberlândia-MG. **Realidade Virtual e Aumentada**: Aplicações e Tendências.Uberlândia, MG: SBC, 2011. cap. 01, p. 10-25. Disponível em: <http://www.de.ufpb.br/~labteve/publi/2011_svrps.pdf>. Acesso em: 28 maio 2019.

LÉVY, P. **Cibercultura**. São Paulo: Editora 34. 1999.

LIAO, T.; SANTOS, S. A.; DUARTE, C. G. Educação Matemática: O Google Earth na Percepção Geoespacial. *In*: MOTTA, Marcelo Souza. CAMARGO, Iolanda Camargo; KUCHARSKI, Marcus Vinícius Santos. (Org). **Tecnologias na Educação: Aprendizagem, Ensino e Inovação**. 1ª edição. Ed. UTFPR. Curitiba. p. 176-194. 2020.

MORAN, J. M. Uma lenta evolução. [Entrevista concedida a] Gabriel Jareta. **Guia de Educação a Distância**, São Paulo. p. 8-10, 2014. Disponível em: <http://www2.eca.usp.br/moran/wp-content/uploads/2013/12/evolucao.pdf>. Acesso em: 10 maio 2019.

PENTEADO, M. M. **Fundamentos de geomorfologia**. 3. ed. Rio de Janeiro: IBGE, 1983. Disponível em: <https://biblioteca.ibge.gov.br/visualizacao/livros/liv81427.pdf>. Acesso em: 30 maio 2019.

PEREIRA, F. C.; AZEVEDO, D. P. G.D.; ALMEIDA, A. S.; FELÍCIO, C. B.; RISSE, L. S.; MOREIRA, L. B. Funções cognitivas e os impactos das tecnologias digitais na memória. **Temas em saúde**, João Pessoa, v. 18, n. 4, 2018. Disponível em: <http://temasemsaude.com/wp-content/uploads/2018/12/18412.pdf>. Acesso em: 01 jul. 2019.

PINTO, F. S.; CENTENO, J. A. S. A realidade aumentada em smartphones na exploração de informações estatísticas e cartográficas. **Boletim de Ciências Geodésicas**, Curitiba, v.18, n.2, p. 282-301, Abr./Jun. 2012. Disponível em: <https://revistas.ufpr.br/bcg/article/view/27856/18444>. Acesso em: 31 jan. 2020.

PRENSKY, M. Digital Natives, Digital Immigrants. **OntheHorizon**, Bradford. v. 9. n. 5. p. 2-6, out. 2001. Disponível em: <http://poetadasmoreninhas.pbworks.com/w/file/fetch/60222961/Prensky%20-%20Imigrantes%20e%20nativos%20digitais.pdf>. Acesso em: 15 maio 2019.

PRENSKY, M. **Aprendizagem Baseada em Jogos Digitais**. São Paulo: Senac-SP. 2012.

RESENDE, V. **Literacia midiática:** Breve panorama sobre os estudos no Brasil.São Paulo: COMUNICON, 2016. Disponível em: http://anais-comunicon2016.espm.br/GTs/GTPOS/GT8/GT08-VITOR_RESENDE.pdf. Acesso em: 20 maio 2019.

SANTAELLA, L. **Comunicação ubíqua**: repercussões na cultura e na educação. São Paulo: Paulus. 2013.

SILVA, M.; VILAR, E.; REIS, G.; LIMA, J. P.. **AR Jigsaw Puzzle: Potencialidades de Uso da Realidade Aumentada no Ensino de Geografia**. *In*: Congresso Brasileiro de Informática na Educação. Recife. Pernambuco. p. 194-203. Disponível em: <https://br-ie.org/pub/index.php/sbie/article/view/2945>. Acesso em: 20 jun. 2020

SILVA, T. O.; SILVA, L. T. G.. Os impactos sociais, cognitivos e afetivos sobre a geração de adolescentes conectados às tecnologias digitais. **Revista de psicopedagogia**, São Paulo, v. 34, n. 103, p. 87-97, 2017. Disponível em <http://pepsic.bvsalud.org/scielo.php?script=sci_arttext&pid=S0103-84862017000100009&lng=pt&nrm=iso>. Acesso em: 29 jun 2019.

TOFFLER, A. **A terceira onda**. São Paulo: Record, 2001.

TOURAINE, A. **Poderemos Viver Juntos?** Iguais e Diferentes. Petrópolis: Editora Vozes, 1998.

VEEN, W.; VRAKKING, B. **Homo zappiens**: educando na era digital. Porto Alegre: Artmed, 2009.

WEEKEND, Labs UG. **LandscapAR**. versão 1,5. Berlin (Alemanha). Jul. 2018. Disponível em: <https://play.google.com/store/apps/details?id=de.berlin.reality.augmented.landscapar> Acesso em: 30 maio 2019.