Research
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IN SEARCH OF INSIGHTS INTO ARTIFICIAL INTELLIGENCE AND INTUITIVE PROGRAMMING IN MATHEMATICS EDUCATION

EM BUSCA DE COMPREENSÕES SOBRE INTELIGÊNCIA ARTIFICIAL E PROGRAMAÇÃO INTUITIVA NA EDUCAÇÃO MATEMÁTICA

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Abstract: This article aims to present the results obtained from a doctoral research project that explored, based on the relationship between Interaction Design and Artificial Intelligence, understandings about intuitive programming environments used in Mathematics educational processes. Through different navigation routes, this investigation adopted Educational Design Research as its methodology and sought contributions from other areas of knowledge, such as Computer Science and Interaction Design. The path taken also considered reflections on the use of technologies in Mathematics Education; on the existence of mental and conceptual models; and intuitive systems. The thesis highlights that there is a relationship between intuitive programming and Artificial Intelligence that can support the use of digital technologies in Mathematics education processes. This relationship can be fostered by the use of feedback through the use of interface metaphors.

Keywords: Artificial Intelligence; Intuitive programming; Mathematics education. Feedback. Interface metaphors.

Resumo: Este artigo visa apresentar os resultados obtidos de uma pesquisa de doutorado que explicitou, a partir das relações entre o Design de Interação e a Inteligência Artificial, compreensões sobre ambientes de programação intuitiva utilizados nos processos educacionais de Matemática. Por meio de diferentes rotas de navegação, esta investigação adotou, como metodologia, a Pesquisa em Design Educacional e buscou contribuições com outras áreas do conhecimento, como a Ciência da Computação e o Design de Interação. O trajeto percorrido também considerou reflexões sobre o uso de tecnologias na Educação Matemática; sobre a existência de modelos mentais e conceituais; e sistema intuitivo. A tese defendida destaca que existe uma relação entre a programação intuitiva e a Inteligência Artificial que pode apoiar o uso de tecnologias digitais nos processos educacionais de Matemática. Essa relação pode ser propiciada pela utilização de *feedback* com o uso de metáforas de interface.

Palavras-chave: Inteligência Artificial; Programação intuitiva; Educação Matemática. Feedback. Metáforas de interface.

1 Introduction

The development of Digital Technologies (DT) creates different changes in the individual and in society (Tikhomirov, 1981; Lévy, 2010). In Education, the use of

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intuitive programming languages, for example, as comprehended and presented by Balbino *et al.* (2021) and discussed in the section 3.2, makes possible to students and teachers to become creators of technologies and not only consumers. It is observed that among available DTs, the ones with application of Artificial Intelligence (AI) are highlighted for being explored both to help educational management and to contribute to educational processes.

By its increasing presence among DTs, AI presents wide application in society, for example in the detection of objects or people in traffic monitoring or sports; recognition of medical exams, helping in diagnosis; in social media regarding content control, it supports the detection of inappropriate images which may break the law; through processing of natural languages, automatic correction of texts, translations and other possibilities.

One of the models based on AI, highlighted since its release in 2022, Chat GPT developed by OpenAI[3] generates texts through a database which considers context and previous words and other contents. The use of ChatGPT and Other kinds of AI brings reflections in different aspects such as educational, ethical, theoretical, philosophical, among others.

In this context, AI may be considered as an area of study that involves many fields such as: Computational Science, psychology, Cognitive Science and education, being able to transit by distinct areas and contribute to optimization of tasks and problem solving.

The use of computational systems with AI, as other DTs, makes possible the reorganization of human activity in the problem-solving process, including the ones of mathematics education. An application in mathematics education is identified in adaptative platform, in which, based on data collection, smart systems may personalize the educational processes, according to the individual interest and capacity using content, learning tracks and exercises. Khan academy, Matfi, Path2Math, Mazk, for example, may be used by students and teachers and provide different interactive processes.

There are also extensions for web browsers, that through AI tools generate automatically questions forms and video's synthesis. Besides, AO software may also be developed aiming to support teachers in the processes of digital resource construction such as Learning Objects (LO). The construction and use of LO are themes explored in

[3] Available at: https://chat.openai.com/auth/login. Acess on 13 set. 2023.

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research and indicate that these digital resources may add different possibilities to mathematics teaching process (Meireles, 2017; Zoppo, 2017; Curci, 2017; Nesi *et al*., 2020; Balbino; Mattos, 2021).

In this theme, GenIA[4] is a platform developed to build LO using AI resources. In this environment, AI is used to help users building digital resources through recognition of mathematical contents, auto filling suggestions of codes and suggestions of corrections that occurred during the LO programming (Zatti *et al.* 2022).

In this scenario, research about AI in mathematics educational processes are necessary to amplify the comprehensions about possibilities and difficulties originated from its insertion in the processes. To contribute with the discussion, this work presents the results of Mattos (2022) research, which involves comprehensions about AI in intuitive programming used in mathematics educational processes. In the path of the research, we sought to answer the following question: how can the elements of interaction design and AI may relate in intuitive programming environments? To answer the thesis of existence of a relation between intuitive programming and AI which may support the use of DT in educational processes in mathematics education was defended.

Afterwards, there will be presented the paths of the research, routes used and research problem. Then the historic of navigation, stablished connections and the indicative of future scripts that be, future possible investigations that explore different maps, indicating other paths. In the following paragraph, the GPS metaphor here used was also explained.

2 GPS, navigation routes and research problem

In order to drive through the path, it is necessary to start at some point, identified as origin and displace to the other, the destiny. Normally, to perform a car trip to an unknown place by an unknown path navigation apps such as Google Maps, Waze, Here, among others are used. According to the stablished configurations, these Technologies presented navigation routes and the user makes his choice which may differ because of distance, roads, tricks or even by the trajectory time.

During the trip, unseen situations may occur, as for example a blocked road or a stop out of the selected track are factors that will generate updates in the navigation route.

[4] Available at: http://plataformagenia.com/. Acess on 13 set. 2023.

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According to the chosen GPS, the path must be updated in real time and the user must again make his choice and decide the path to follow to the destiny.

Facing this context When starting the investigation the researcher may, by his experience know previously what the steps are permeating his research; having knowledge about the mandatory stops that need to be made: methodological definition, theorical reference, instruments for data collection, etc. He may also not know the destiny, the exact point where he is. However, the different paths tracked, baggage transported, photographical records, investigative exercise will take him to places that may be the destiny.

With the adoption of methodological aspects of qualitative research in which "the researcher used insights and information from the literature as knowledge about the context, using it to verify information and observation about the research theme in those contexts" (Flick, 2009, p. 62), This investigation used as methodology the Educational Design Research (EDR). It relates to the systematic study of conception, development and evaluation of educational interventions (Mckenney; Reeves, 2012; Plomp, 2013; Plomp; Nieveen, 2013; Powell; Ali, 2018). The referred interventions may be considered, according to Plomp (2013), as programs, learning environments, materials, products and systems destined to teaching and learning.

About the definition of this kind of research, there are different understandings in literature, Barbosa and Oliveira (2015, p. 530) explicit "the expression. It is now seen as a big umbrella of methodological approaches interested in the investigation and development of products to be used as solution to a specific problem." Plomp (2013), number other expressions related to this kind of research: design experiments, design-based research, engineering research, participative action research and implementation based in design.

The expression. "Research of development" is adopted by Matta, Silva e Boaventura (2014) and Barbosa e Oliveira (2015). The last authors point that this kind of research has been acquiring the attention from other researchers in educations and mathematics education (Lesh; Sriraman, 2010; Gravemeijer; Cobb, 2013; Meireles, 2017; Powell; Ali, 2018).

Aiming the goal of developing solutions for educational practice problems, to elaborate or validate theories about educational problems, EDR is composed by preliminary phase, prototyping and evaluation. In the first step, analysis of the context in which the educational invention will be inserted must be analyzed, the identification of

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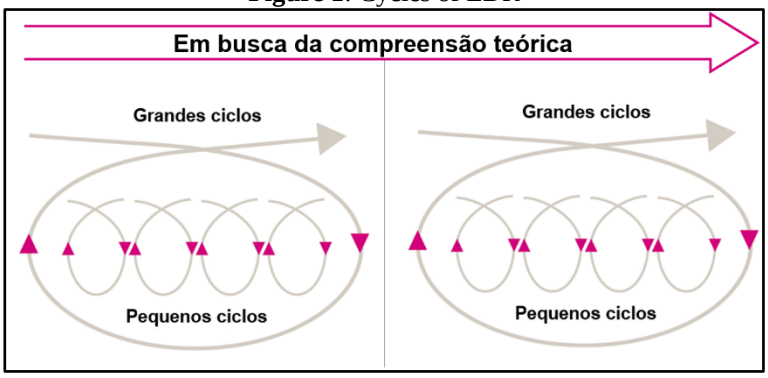
the educational problem to be solved and the literature review with the intent of identify works with similar questions to the ones to be investigated in the intended research.

In prototyping phase prototypes or models must be elaborate. Those will be sharpened with the interactions performed during the investigation. And the last phase, evaluation, comprehends verifying if the intervention matches the criteria previously stablished.

McKenney e Reeves (2012, p. 15,) highlight that the "insights and the interventions of EDR evolve through time due to multiple interactions of investigation, developments, tests and refinement". This process may be started at the end of the evaluation phase but also between preliminary and prototyping or in only one phase. **Figure** 1 illustrates the different cycles that may occur during EDR:

Figure 1: Cycles of EDR



Source: adapted from Gravemeijer and Cobb (2013)

This way, small or big cycles are part of the investigation development. "The Evolution in EDR is generally motivated by new insights which normally lead to new questions." (Mckenney; Reeves, 2012, p. 135,). Those questionings contribute for different routes of navigation that can be tracked during the research.

When considered the purpose of the investigation, EDR also englobes a classification about the types of studies previously made; development and validation. The first aims to develop solutions for the problem of educational practice; the second is related to elaborating or validating of a theory (theorical comprehension).

Although there are two types of study, Plomp e Nieveen (2013) highlight that it is possible to develop the research using the combination between them. By one side there may be investigations about the educational intervention and the Other, the knowledge about such interventions.

In this sense it is fundamental to know different investigations which may contribute with the combination between the two types of EDR studies. The research here

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related classifies mostly as a theorical study, because it is dedicated to the seek for comprehensions about AI related aspects in mathematics education intuitive programming environments. Such comprehensions contribute to the development of an educational intervention, in this case, AI assisted platform to build LO in mathematics. The platform called GenIA was developed by Zatti (2023) in a professional doctorate research which happened *pari passu* with this research.

In the next sessions the reader shall know the historic of navigation of the research: starting point, mandatory stops and the considerations about the research (destiny) as well as indication for possibilities to be explored in future research.

3 Navigation history

During the trip which resulted in the defense of the thesis about existence of relation between intuitive programming and AI that may support the use of digital technologies (DT) in the process of mathematics education, different doubts emerged. It is worth to highlight that the doctorate research here mentioned started in the second semester of 2019 and was developed during the Covid-19 pandemic. Therefore, the places through where the research was going to be, the challenges that would be faced and the king of luggage that would be needed to arrive in the destiny were still unknown.

Curves, up and downhills were part of the path. There were moments which the speed was lower, points of difficulty, attention or deepening were identified. Also, situations when the situation could be elevated with caution, when the comprehensions flowed with no interruption.

In this section the goal is to present, starting from EDR phases, the tracks and iterative cycles performed which brings the possibility to explicit comprehensions about intuitive programming environment used in the mathematics educational processes based on the iteration design and AI.

In order to achieve the goal, some updates in the route were necessary. Thus, the path was not linear during the doctorate research. The phases which compose EDR will be used to show the paths and evaluative micro cycles used during the development of the research.

The first trajectory of the research is illustrated in **Figure** 2. The green hexagons identify the main themes of literature review during the **preliminary phase;** the orange hexagons represent the themes explored during the **development phase** of the research;

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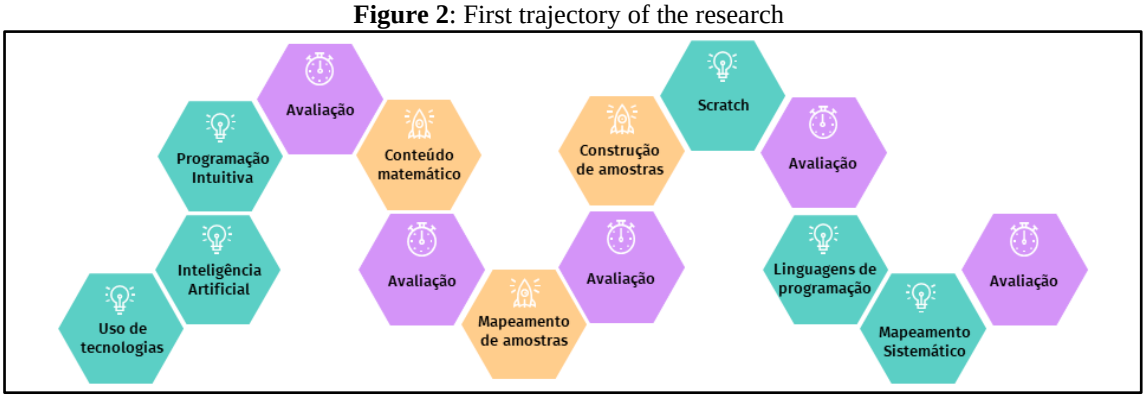
the lily hexagons identify the **evaluations** performed during the process of investigation. It is important to point that most of these themes were explored and developed in all paths of the research. This representation also indicates the moment when the themes started to be inserted in the route of the investigation. As an example, a stop to seek comprehensions about Scratch in literature was added after the step of sample construction and before the fourth evaluation step.

Figure 2: First trajectory of the research



Source: Mattos (2022, p. 141)

Studies about the works of the author who consider the use of technology in society causes change in the ways of thinking, communicating and behaving in community such as Tikhomirov (1981) e Lévy (2010), are part, for example, of the preliminary phase of the research and may be considered the starting point of the path.

Lévy (2010) considers that Technologies of intelligence, techniques associated to memory and knowledge (orality, writing and informatics), modify the way how humans produce and transmit knowledge. Tikhomirov (1981) present the idea of activity reorganization of creative activity in the utilization of computer.

Starting from the relation between the ideas of these two authors, Borba and Villarreal (2005) present comprehension about the production of knowledge mediated by technologies of information, within the concept of collectives built by human-beings-with-media. Some aspects involved in this collective considered there is a reciprocate molding between thinking and technology (Borba; Silva; Gadanidis, 2014). Souto and Borba (2016, p. 7) highlight that:

> Um conceito central desse construto é a noção de moldagem recíproca (Borba, 1993, 1999), segundo a qual, os *feedbacks* dados por uma determinada mídia influenciam no raciocínio de quem interage com elas, em outras palavras, a mídia molda o ser humano. Mas, os seres humanos também a moldam na medida em que a utilizam. Um exemplo pode ser observado na forma como os estudantes fazem uso de um determinado *software*, que muitas vezes é diferente da maneira como a equipe que o desenvolveu havia pensado. Por

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> outro lado, a equipe que desenvolve um software procura elaborar um *design* levando em consideração a forma como os estudantes têm utilizado.

An area that dedicates to identify the needs of the user, for example, students and teachers, and to project interactive processes is Iteration Design (Rogers; Sharp; Preece, 2013). This area is part of the reflections presented by the second mandatory stop in the research which will be further presented.

Considering the notion of reciprocate notion in the last decade of XX century, it is possible to identify that this relation is more and more present in society. It is pointed that DT advance with AI and IoT resources, for example, present different forms for production of knowledge. Since it is a recent technology, it is important to highlight the necessity of further research about possibilities and challenges present in the use of these technologies in educational processes.

Aiming the studies about the use of DT in mathematics education was important, however it was not enough to arrive in the destination of the research. In this sense, it was necessary to make a mandatory stop to approach questions about AI.

3.1 First Stop: Artificial Intelligence

By the first semester of 2021 an adjustment in the route was made. Since the reality in the moment was the Covid-19 pandemic, it was chosen to develop an investigation aiming theorical comprehensions about AI and intuitive programming in mathematics education.

The result of the search about the investigations about AI and intuitive programming; AI and mathematics education identified the need to amplify the research directed to this area. In these research in the databases such as Biblioteca Digital Brasileira de Teses e Dissertações (National Library of Dissertations and Thesis), Google platform, it was observed a tendency of results in computational science highlighting this way the technical characteristic of systems which use AI resources in education. This tendency shows one of the possible contributions of this research to mathematics education.

AI used in education is considered by Vicari (2018) as an multi and interdisciplinary area of research seen with intent of using systems supported by AI being directed to teaching and learning. Some AI applications in education may contribute with educational management and learning and teaching processes such as intelligent tutoring

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systems as Mazk; Tools of analysis and management of data such as Power BI; chatbot etc.

Wayne Holmes (ERTE DGE, 2020) brings discussion about AI in, organizing the area in three categories: Learning with AI; Learning about AI and Learning to the AI. The first option is related to the use of AI as support to the teaching systems. The second to the possibility of teaching AI to the students of Basic and Superior Education and managers. And the last category to understand the impacts of AI in society.

Research about the possibilities of AI usage in Mathematics Education may be found in Schuck; Giraffa (2001), Castro (2010), Damasceno (2011), Seffrin *et al*. (2012), Seffrin (2015), Bittencourt (2018), Moro (2019), Valeriano (2019) and Mello; Canto Filho; Lima (2020), that in its majority approach comprehensions about the use of intelligent tutoring systems and chatbot.

The use of chatbot as an assistant of interaction and mediator of extra classes tasks, for example, may consider the participation and performance of students.

> Nessa interação entre aluno e Chatbot, muitos dados de acesso são gerados, o que permite **compreender as necessidades do usuário**, além de atualizar e aperfeiçoar as informações que serão disponibilizadas na plataforma. Como exemplo da utilização desses dados, os mesmos poderão auxiliar na **compreensão das dificuldades dos alunos**, através da observação das suas principais demandas e necessidades, ou seja, acompanhando os botões mais acessados, bem como as palavras mais digitadas pelos alunos, além do tempo de permanência em cada atividade apresentada (Mello; Canto Filho; Lima, 2020, p. 9, grifos nossos).

The comprehension of the necessities of the students may lead the teacher to reorganize the pedagogical practice. The data generated, when grouped by the interactivity with the virtual assistant, enables the teacher to verify which topics need to be discussed one more time. In this context, the use of AI is considered, using chatbot, may contribute with the mathematics educational processes.

After the data gathering it was possible to verify that there are still few research, published or available, discussing the use of AI in the educational processes. The development of environments such as GenIA, PAT2Math e Mazk, among others, may amplify the reflections and comprehensions over the impact of AI in mathematics education.

In order to be able to continue navigating a second stop was necessary and was necessary to better understand intuitive programming. This stop was responsible to present elements and possible connections between the areas of interaction design, computational science and mathematics education.

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3.2 Second stop: Intuitive programming

Through the second path in the research trajectory, another stop was added to the original navigation route: literature review was amplified and deepened the studies about intuitive programming and included areas of interaction design and mathematical intuition.

The justificative to include interaction design, an area of study that refers to the interactive products projection (Rogers; Sharp; Preece, 2013), is related to the development of an educational intervention. From the study of the area other themes have emerged and made possible the conjecture of connections between intuitive programming, intuitive systems and education.

Balbino *et al.* (2021) points that educators and informatics professionals do not share a common specific definition for the term "intuitive programming". They have, however, a dialogue between elements of computing programming and its use in the educational area to propose a definition for the term. For this author, the pillars of intuitive programming involve the characteristics of similarity, visualization and accessibility.

The two first pillars are also present in interaction design, in what refers to usability (Nielsen, 2020), such as, combination between system and real world, recognition instead of recording. In the use of a digital resource for educational purposes, it is understood that usability is the capacity that such resource "has to be easily used by teacher and student. For that purpose, the interfaces must be developed in order to guarantee the quality and efficiency of the object, providing improvement in interactivity" (Nesi *et al.* 2020, p. 100).

The investigations about intuitive programming language indicate that the connection between this language and interaction design may be stablished starting from the characteristics present in the intuitive system and heuristic of usability. In this sense it is important to consider the elements present in the interface of the system, conceptual models (CM) and mental models (MM) developed in the projection and use of an interactive product. To comprehend these models a small deviation in the route was necessary.

MM is related to the user. This model is unique since each user creates its own. MC on its turn, is related to the system. An user, while using a software for the first time, makes connections of how that software works, imagine the functions of icons and how to interact with the system. That is MM

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On the Other hand, there is a team that probably developed the software. That is MC and can be translated as the way that the product works. It is common for these models to be distinct and sometimes very different. In this sense when the MC is similar to the MM, it is understood the system is intuitive.

Lévy (2004) considers that a MM are mental representations. These representations may be used to record, reason and make decisions. "Cognitive psychology experiences showed that subjects build a mental model starting from coherent descriptions and determined places" (Lévy, 2004, p. 209). Based on the theory proposed by Johnson-Laird, Lévy (2004) algo highlights that the activation of MM allows to reason:

> a) A partir de premissas (isto é, de dados disponíveis formulados de modo proposicional) e de nossos conhecimentos gerais do campo em questão, construímos um modelo mental, ou seja, uma interpretação de premissas. b) A exploração desse modelo mental permite-nos chegar a uma conclusão provisória. c) Buscamos em seguida, sistematicamente, interpretações de premissas (isto é, de modelos mentais alternativos) que contradiriam essa conclusão. Se a busca for completa, bem-conduzida e sem qualquer registro de contraexemplo, a conclusão é válida. d) Se encontramos um exemplo que invalide a primeira conclusão, o ciclo recomeça com outra conclusão provisória até encontrarmos uma que não seja desmentida por nenhuma interpretação das premissas, isto é, que seja compatível com simulações de todos os modelos mentais passíveis de ser inferidos a partir de premissas e de nossos conhecimentos (Lévy, 2004, p. 112).

The referred processes of (re)construction and reflection about MM is also present in the use of DT. For example, a student of Mathematics in college who starts to use GeoGebra for the first time in his course (considering he never used before), after opening the software, may build a MM (item a); in a second moment interacting with the system, he observes that certain actions previously imagined do not work as he supposed they were. In this sense he uses his MM (items b and c) and uses the software again. If he finds flaws in his new MM the cycle will restart (item d)

Besides the present characteristics of an intuitive system, the connection between intuitive programming and interaction design may also be stablished from the heuristic of usability. They are considered by Nielsen (2020) as general principles for interaction design due to visibility of the system; combination between system and real world; user freedom and control; consciousness and patterns; mistake prevention; recognition instead of recording; flexibility and efficiency of resources; aesthetical and minimalist design; support to users for recognizing, diagnosing and recovering from mistakes; help and documentation.

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Those heuristics consider the target public who will use the interactive product. The design of a system needs to adopt, for example, familiar words, phrases and concepts and a way to power interactivity and provide feedback.

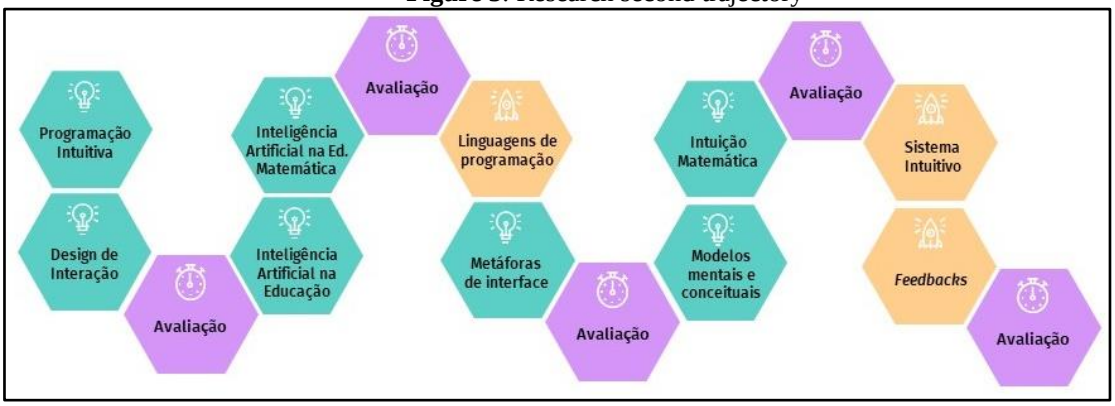
In this sense, considering Rogers, Sharp and Preece's (2013), p. 88) ideas, it is possible to contribute with the refinement of user's MM by explaining, thus, making the system more transparent. This means to provide useful feedback regarding the user's input, intuitive easy ways to understand while interacting and clear and easy to follow instruction.

The thesis here defended and presented highlights a relation between intuitive programming and artificial intelligence, which may be provided by the use of feedback with interface metaphors. Such metaphors "have the intention of provide familiar entities which allow people to easily understand the conceptual model and what to use the interface for" (Rogers; Sharp; Preece, 2013, p. 44).

Considering the use of these metaphors in the system's elaboration, it was possible to observe the possibilities of contribution for the user's understanding about interactivity in intuitive systems.

In synthesis, and retaking the previous steps, the second trajectory are represented in **Figure** 3 in the following way:

Figure 3: Research second trajectory



Source: Mattos (2022, p. 142)

It can be observed that the use of evaluative micro cycles made possible the development of connections and contributions of the research to mathematics education, among them, how can feedback help user, as well as the indication of future scripts and routes of navigation in the map of DT usage in education. To use it also made possible to Walk between the preliminary and research development phases, amplifying the map vision of what was to be explored and what was already built.

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The third trajectory was stablished after the qualification committee, when interaction design, AI and possible relation to be discovered between these areas and mathematics education were resumed.

As exposed, the starting point was the use of technology in mathematics education. This origin presented elements which contributed com the reflections about AI with emphasis of the aspects which involve the human-beings-with-media construction…, as the reciprocate molding between thinking and technology (Borba; Silva; Gadanidis, 2014; Souto; Borba, 2016).

In the first mandatory stop, it was necessary to acquire another luggage in order to continue navigating. AI history was verified and the studies of AI in education either, particularly in mathematics education such studies are recent and different possibilities about the use of AI and different possibilities about its uses were observed. They involve task optimization, problem resolution and use of techniques which may contribute to mathematics educational processes.

In the second stop, to amplify the comprehensions about intuitive programming, it was possible to identify elements of interaction design that revealed themselves to be fundamental in the dialogues about mathematics education, through the existence of mental and conceptual models, intuitive systems, programming language and intuition.

4 Considerations about the research (destiny) and future tracks

The paths of the research were only possible to be finished due to the use of the GPS metaphor and the route's constant updates which showed necessary, also the micro cycles of evaluation of EDR methodology.

One of the stablished connections in the research is identified by the existence of reciprocate molding in the use of technologies. The ideas of Tikhomirov (1981) about the theory of reorganization; Technologies of intelligence by Lévy (2010) and the aspects involved in the construction of human-beings-with-media... (Borba; Villarreal, 2005) that enables the understanding that the user's activity is reorganized with the technology used. In this context, while interacting with a software, for example, a "two-way influence" happens, because the "media shapes the human". However, human beings also shape Technologies while using it" (Souto; Borba, 2016, p. 7).

This influence is possible to be observed in the forms of AI use in education, intelligent tutoring system (ITS) or chatbots, for example, may personalize the process.

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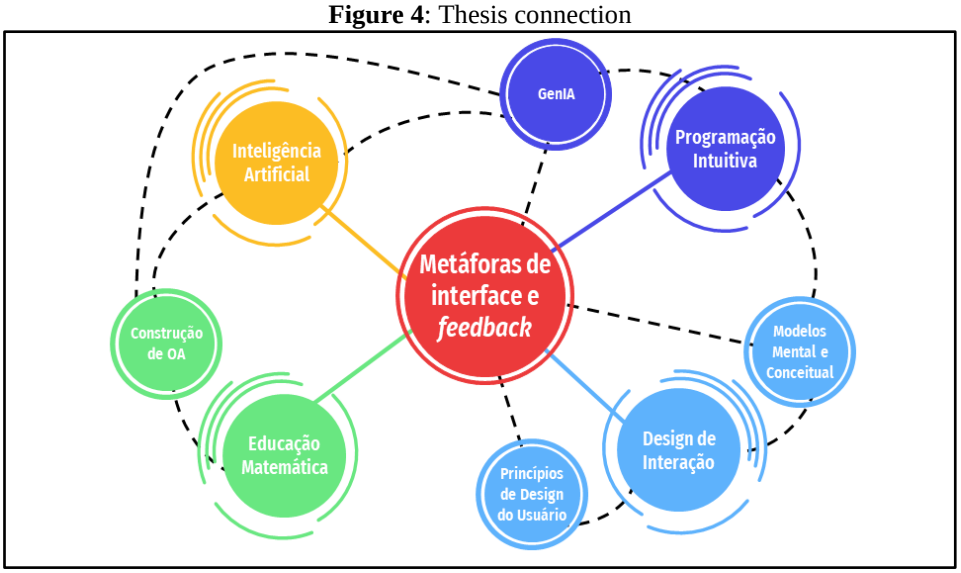
Other connections were also stablished during the route and provided the final result, as illustrated by **Figure** 4. The background of this connections is the use of technologies in education. These relations started in AI areas, intuitive programming, interaction design and mathematics education.

Each of the four areas is represented, respectively, by the colors yellow, dark and light blue and green, related to the GPS metaphor, indicating steps of the trajectory such as starting point and mandatory stops.

Figure 4: Thesis connection



Source: Mattos (2022, p. 129)

The destiny highlighted in the center of **Figure** 4, in red, is identified by the research's thesis, which defends the existence of a relation between intuitive programming and artificial intelligence, what may support the use of digital technologies in mathematics educational processes. The lines drawn show the convergence points between the arear and the thesis. Such lines are continuous.

The relation between intuitive programming and AI involves the use of feedback and interface metaphors. As exposed, this relation may contribute to the update of MM as well as with the comprehension about the MC of systems. This happens due to the Such lines are continuous functioning of elements already known by users.

In this sense, it is observed that the use of interface metaphors comes to the encounter of an intuitive system. "The closer are the metaphor logics to the to the object of a software, probably, the better will be the interaction with the users and easier it will be to use it" (Fernandes, 2005, p. 1). In this manner, it is possible to understand that the convergence between MM and MC is essential because it will help the user understanding mathematical concepts explored by using AI in a software. Thus, an intuitive system may

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reveal through the use of AI techniques that privilege the constant updates of MM by the users.

Starting from the connections stablished in the research, it is suggested the creation of future scripts and investigations that explore different maps indicating other paths of investigation such as:

- Identification and study about AI techniques which may make possible MM updates in intuitive programming environments.
- Application of interface metaphors in intuitive systems used in education.
- Deepening about AI categories: Learn with AI, about AI and for AI.
- Teacher's comprehensions about the use of techniques and application of AI in education through the formation of teachers.
- Amplify reflections about ethical and philosophical aspects of AI using involved in educational processes.

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