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PROSPECTIVE NARRATIVES ON GLOBAL ISSUES: AN AI-BASED PEDAGOGICAL MODEL FOR ASSESSING COMPLEX THINKING

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Abstract

This study proposes a narrative pedagogical model for creating and developing case studies that highlight the challenges and issues surrounding the megatrends of the Fourth Industrial Revolution, specifically "People and the Internet." This proposal, framed in an online learning environment, represents the second stage of an educational platform to guide university students in facilitating an ideathon to address the megatrends of the 4th Industrial Revolution. Designing a model for case study creation related to the megatrends aims to foster complex thinking in university students, especially innovative thinking, a sub-competency of complex thinking. Fostering complex thinking highlights the importance of cognitive, practical, and adaptive skills to address interdisciplinary challenges. The Design Process and Practice Methodology and the case study methodology facilitated the narrative case study design model. The outcome of this study is a tangible product that enriches the debates on education and complex systems thinking in the context of the Fourth Industrial Revolution.

Keywords **–** Emerging methodologies, Digital narrative, Complex thinking, AI-powered assessment, Innovative education, Higher education.

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1. Introduction

The rapidly evolving landscape of the Fourth Industrial Revolution is characterized by the convergence of digital, physical, and biological technologies, reshaping various facets of human life. Identifying and comprehending the megatrends that drive societal shifts in this transformative era becomes crucial. This

study introduces a model for creating narrative-based case studies that examine Fourth Industrial Revolution megatrends in an online learning environment. The design supports an educational platform intended to foster ideation and enhance the complex thinking skills of student users.

1.1. Complex Thinking As a Macro-Competency in the Educational Context

In the contemporary world, problems and phenomena have emerged that are challenging and require a systemic approach and understanding. Morin (1998), proposed by the philosopher and sociologist Edgar Morin, offers a theoretical framework that seeks to capture the complexity inherent in current phenomena. Morin proposes a way of thinking that integrates and considers the multidimensionality, interconnectedness and uncertainty of phenomena (Heath-Carpentier, 2022: pages 41-44). Instead of analyzing elements in isolation, complex thinking seeks to understand the relationships and interactions between them (Morín, 2005). Complex thinking and education are key themes in the work of Morin, who stresses the importance of a new understanding of knowledge that is transdisciplinary and relevant (Lorenzi & De Andrade, 2023). Morin's analysis highlights the need for a holistic and integrative approach to education. The significance of complex thinking as a macro-competency in higher education is manifest through its pivotal role in equipping students with essential skills to navigate the intricate challenges of the contemporary world. This assertion rests upon a multifaceted argument that underscores how complex thinking enhances students' cognitive, practical, and adaptive capacities (Young, 2016; Brown, 2019). One of the central justifications for the importance of complex thinking is its capacity to address interdisciplinary challenges (Ramírez-Montoya, Castillo-Martínez, Sanabria-Z & Miranda, 2022). The current landscape of issues transcends traditional disciplinary boundaries, necessitating a holistic approach that considers diverse perspectives. Complex thinking allows students to consider various aspects of a problem, encouraging a detailed understanding resulting from combining ideas from different fields. It equips students to break down complicated systems, recognize the interplay of factors, and predict potential results (Pacheco & Herrera, 2021). Within the context of the Fourth Industrial Revolution, complex thinking becomes even more crucial. Accelerated advancement and integration of technologies such as AI, robotics, and the Internet of Things (IoT) are bringing about new challenges and opportunities that are deeply interconnected and multifaceted. Complex thinking enables students to comprehend these technological trends not only in isolation, but in how they interact with social, economic and environmental factors. Such a holistic understanding is essential to prepare students to navigate and contribute to a world where technological and human systems are increasingly interwoven. This analytical insight is indispensable for making informed decisions considering the far-reaching consequences of actions in complex contexts. Fostering students' capacity to identify non-obvious relationships and novel patterns empowers them to generate original solutions to multifaceted problems. It catalyzes creativity, enabling students to approach challenges with fresh perspectives and inventive strategies.

Given the evolving nature of contemporary challenges, a disposition for lifelong learning is imperative (Aspin & Chapman, 2011; McLean, 2021; Sung, Sheng, Liau, Xinhui, Liu & Coates, 2022). Complex thinking inherently nurtures a mindset for curiosity, adaptability, and a willingness to continuously self-reflect. Those who develop complex thinking are better equipped to embrace new information, synthesize it within existing knowledge frameworks, and apply it effectively to emerging complexities. The collaborative nature of complex problems requires working across disciplinary boundaries. In this sense, complex thinking facilitates communication and the integration of different points of view and knowledge, thus promoting transdisciplinarity (Okamura, 2019; Petersen, Ahmed & Pavlidis, 2021). Students versed in this competency are better prepared to engage in meaningful cross-disciplinary collaboration, drawing on the collective wisdom of diverse stakeholders. In addition, the Fourth Industrial Revolution stresses the need for complex thinking to gain an understanding of global interdependencies and technological implications. While technologies evolve at an expedited rate, students must be able to analyze and adapt to these shifts. Complex thinking equips them with the ability to discern the broader implications of technological advances, from ethical considerations to social repercussions. This

proficiency is indispensable in an era in which technology shapes every aspect of human life and demands a nuanced understanding of its benefits and challenges.

In addition, the globalized nature of the modern world underscores the importance of considering diverse cultural, political, and economic perspectives. In the context of the Fourth Industrial Revolution, shaped by automatization, artificial intelligence, digitalization and integration of emerging technologies, the relevance of promoting complex thinking is based on the need to prepare students to face the challenges and take advantage of the opportunities that arise in a world characterized by rapid technological advances, global interconnections and constant change (Domínguez, 2020; Ramírez-Montoya, Álvarez-Icaza, Sanabria-Z, López-Caudana, Alonso-Galicia & Miranda, 2021). In this sense, complex thinking empowers students to analyze intricate webs of global interdependencies, fostering a nuanced appreciation of multifaceted global challenges and the development of context-sensitive solutions (Forsman, Linder, Moll, Fraser & Andersson, 2012; Gröschl & Gabaldon, 2016; Rojas, Ramírez-Montoya, Mazo-Cuervo & Lopez-Caudana, 2022). Furthermore, complex thinking transcends the realm of cognitive ability, permeating personal and ethical dimensions, as it prompts students to recognize the limitations of their understanding, encouraging them to seek alternative points of view and to remain open to diverse interpretations, thus fostering an ethical stance. The essential nature of complex thinking in higher education manifests through its multifaceted contribution to cognitive skills, innovative aptitude, holistic problem-solving, and ethical behavior. By cultivating this macro-competency, higher education institutions produce graduates with the skills and dispositions necessary to thrive in the intricate landscape of the contemporary world.

1.2. People and the Internet As a Megatrend of the Fourth Industrial Revolution

The Fourth Industrial Revolution reshapes our lifestyles and professional landscapes by integrating digital, physical, and biological technologies. Megatrends often drive and are driven by the technological advances that characterize the Fourth Industrial Revolution. These trends are deeply rooted and far-reaching, often with long-lasting effects on various aspects of human life (Lorenz, Sverdrup & Ragnarsdóttir, 2017; Jeflea, Dănciulescu, Sitnikov, Filipeanu, Park & Tugui, 2022). In other words, they are transformative forces shaping how we live, work, and interact.

The megatrend "People and the Internet" refers to people's increasing global interconnectivity through the Internet. It has become especially apparent in recent decades due to the swift progression of information and communication technology. According to the World Economic Forum, the "People and the Internet" megatrend includes new technologies integrated into wearables that allow people to interact with objects innovatively (World Economic Forum, 2020). This megatrend is associated with various issues, including global connectivity, social networks, access to information, the digital economy, and changes in communication. For instance, global connectivity has enabled billions of people worldwide to access the Internet, thereby expanding communication and the ability to share information (Schroeder, 2018, 2019; Atzori, Iera & Morabito, 2017). Furthermore, social networks play a pivotal role in this megatrend, enabling individuals to create new forms of social interaction and collaboration across the globe, connecting with their friends, family, and colleagues. Simultaneously, the Internet has democratized information by providing the potential for universal access (Peterson, Anderson, Katti, McKeown, Parulkar, Rexford et al., 2019). People access educational resources and real-time news on various topics through the Internet.

The megatrend of "People and the Internet" is paramount and significantly relevant in the landscape of Higher Education, bringing with it transformative changes that go far beyond traditional educational paradigms. While this trend has brought numerous benefits and opportunities, it has also created challenges and issues requiring attention. Concerns about online privacy and security have grown due to the collection and mishandling of personal data, which can lead to identity theft and cyberstalking (Nyoni & Velempini, 2018; Gogus & Saygin, 2019). Cybersecurity is vital to combat rising cyber-attacks, which can interfere with services and steal confidential information (World Economic Forum, 2021). The spread of false information and fake news on the Internet diminishes trust in information sources

and subverts the process of making well-informed decisions (Vosoughi, Roy & Aral, 2018). Excessive Internet and social media usage poses addiction risks and harms mental health by prompting continuous comparison and pressure to uphold a positive digital image (Kargin, Polat & Şimşek, 2020; Henzel & Håkansson, 2021).

Furthermore, there remain disparities in internet access that widen the digital gap in information and opportunities. Online communication may exacerbate social isolation by replacing personal interactions (Costa, Patrão & Machado, 2018; Veisani, Jalilian & Mohamadian, 2020; Fumagalli, Dolmatzian & Shrum, 2021). Inadequate regulations for the digital sphere and massive data collection raise questions about rights and privacy. Online information bubbles restrict exposure to varied perspectives, and the increasing consumption of electronic devices harms the environment (Buechler, Zyaykina, Spencer, O'Donnell, Ploss & Hua, 2020; DeNardis, 2020; Amador-Alarcón, Gastelú, Domínguez, Medina-Cruz & Argüello-Rosales, 2022). The solution to these challenges would require cooperation among individuals, businesses, and governments to maximize online connectivity's benefits while addressing its negative impacts.

1.3. Developing Complex Thinking with Educational Technologies

The development of complex thinking is paramount in contemporary education as it equips students to comprehend and tackle interrelated and multidisciplinary challenges prevalent in an increasingly intricate world. Educational technologies offer potent tools and approaches to foster this thinking among students (Wang & Li, 2022; Wang & Burdina, 2023). The cultivation of complex thinking can occur through the utilization of educational technologies, such as online platforms and social media. These tools enable students to share and discuss ideas in virtual environments, fostering the interconnectedness of concepts and perspectives as students observe how diverse ideas interconnect and converge to address complex issues. Another attribute of educational technology is that it enables problem-based learning (Zakaria, Maat & Khalid, 2019; Bijsmans & Versluis, 2020), where students face real-world challenges and analyze them from multiple perspectives. Online platforms can offer data and context to students to overcome complex issues and generate comprehensive solutions.

In addition, educational technologies can empower students to become self-directed learners. Through online resources, courses, and tutorials, students can delve into complex subjects based on their interests at their own pace (Haidari, Yelken & Akay, 2019). Various technological tools can integrate into educational platforms, promoting data analysis and visualization, allowing students to analyze complex information and reveal hidden patterns (Greydanus & Olah, 2019). Ultimately, this enhances their understanding of complex issues and situations. Educational technologies can provide novel assessment approaches by allowing students to showcase their comprehension of complex concepts through interdisciplinary projects, multimedia presentations, and online content creation.

Moreover, educational technologies offer various prospects to promote intricate reasoning abilities among students. By efficiently utilizing these technologies, educational institutions can foster students' critical abilities to tackle the intricate challenges of the 21st century through knowledgeable and innovative approaches.

1.4. Educational Platform for Developing and Assessing Complex Thinking

Assessing complex thinking is challenging because it requires students to analyze how they approach multifaceted problems, consider different perspectives, and develop innovative solutions. To enable educators to analyze students' approaches to interrelated problems and their ability to generate innovative solutions considering multiple perspectives, a technology platform for assessing complex thinking should include various features. First, it must consider that educators should be able to design specific exercises that assess complex thinking. The design can encompass case studies, interdisciplinary projects, simulations, debates, and additional approaches.

"Ideatón CxT Megatrends" is an educational platform that allows higher education students to position themselves on a topic related to the megatrend of the "Sharing Economy" (Sanabria-Z, Castillo-Martínez, González-Pérez & Ramírez-Montoya, 2023). The user navigates through six boards based on the Transition Design methodology by Irwin (2015) using a dashboard format, each presenting an activity that facilitates a comprehensive and in-depth examination of a complicated scenario where users identify the various factors contributing to the issue. Some boards allow students to place themselves at different points to understand the problem's historical background and visualize potential futures, i.e., it encourages retrospective reflection to envision a future outlook. The set of activities created for each platform space encourages complex thinking and related sub-competencies, such as critical thinking, scientific thinking, innovative thinking, and systemic thinking. Regarding the assessment mechanism, the platform relies on artificial intelligence tools, which evaluate the number of connections users make between the different factors associated with the megatrend and the complexity of the judgments users make during the related activities. The following Figure 1 shows the flow of activities that the student users experienced in this study:

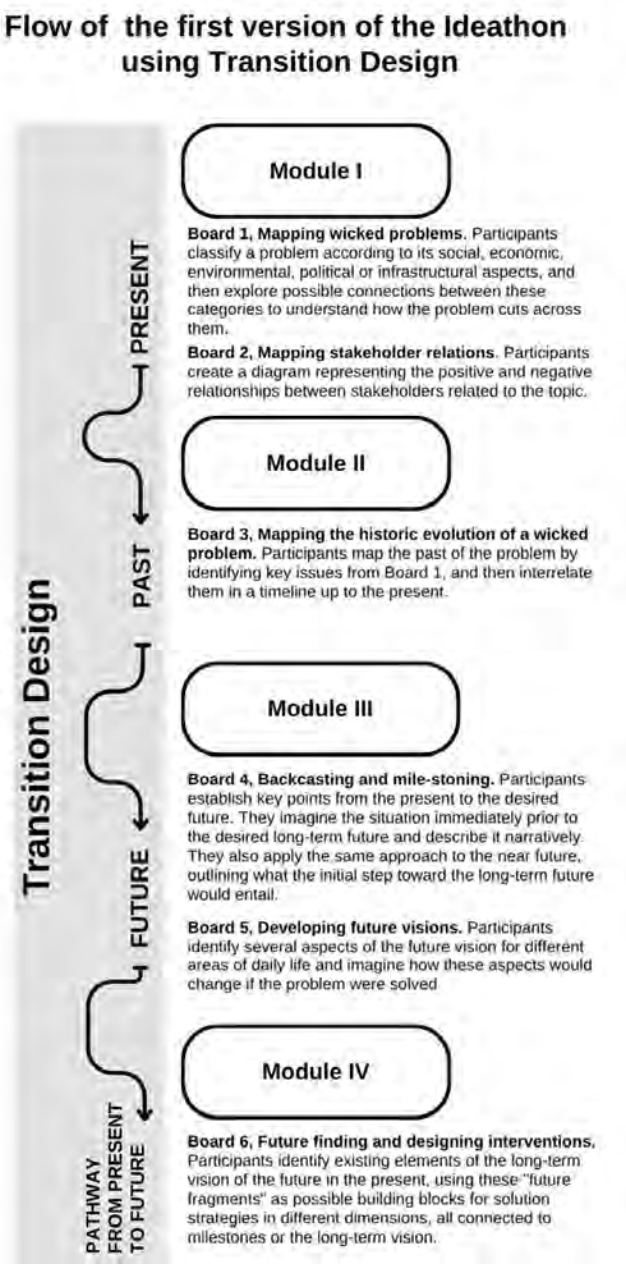

Figure 1. Flow diagram of the first version of the Ideathon

Considering the work process completed by the users and the observations collected during the platform's implementation, the authors designed the pedagogical innovation described above to advance to a second design phase. This second phase entails introducing novel problem scenarios associated with additional megatrends and suggesting innovative strategies to stimulate students' involvement and foster a feeling of belonging in the context produced by the megatrends. It also aims to provide future perspectives by connecting with the problems, showing their human meaning through personal experiences, challenges, and triumphs in the broader context of societal changes.

1.5. Narrative As a Tool for Designing Case Studies Around the Megatrends

Incorporating a narrative structure into the design of case studies that motivate analysis, reflection, and creation processes around megatrends can yield several substantial benefits that enhance cognitive processes, such as understanding and analyzing the issues and challenges associated with these extensive global trends. Megatrends, which represent far-reaching changes affecting various areas of society, economy, and technology, benefit from a narrative representation that highlights and explores their intricacies from multiple perspectives. The narrative provides a framework that deeply contextualizes the case study by placing participants in a concrete setting (Bal, Butterman & Bakker, 2011). It can recreate reality and intricate relationships that characterize the megatrends, allowing a complete understanding of how these trends influence different aspects of everyday life and how they interact.

Narratives as a mediative personal act (Ketschik, Krautter, Murr & Zimmermann, 2021) uniquely captivate the audience's attention and create an emotional connection by presenting information in a story format. Participants are likelier to become engaged and invested in the subject matter (Busselle & Cutietta, 2019; Bilandzic, 2019). Likewise, offering to have students generate the stories from a problem will allow them to identify, in a sense, the personal point of view on the given problem. This heightened engagement can facilitate a deeper understanding of the intricate interplay between various factors influenced by megatrends, making the learning experience more relatable and meaningful.

As mentioned above, megatrends are multifaceted and often interconnected across different domains. A narrative structure can effectively capture this complexity by illustrating how various aspects of society, economy, technology, and culture interact and influence each other. This approach allows participants to develop a more holistic understanding of the broad implications of megatrends. A narrative allows for the presentation of events chronologically, making it easier for participants to trace the developments' origins, progression, and consequences (McAlpine, 2016; Currie & Sterelny, 2017). This analytical approach enhances the exploration of the underlying drivers and mechanisms shaping these trends.

On the other hand, a characteristic of megatrends is that they develop over long periods, often spanning decades. In this sense, a narrative structure can effectively capture this temporal dimension by presenting events and developments over time (Rodrigues, Figueiras & Alexandre, 2019). This extended perspective helps participants appreciate megatrends' gradual evolution and profound impact on various aspects of life.

2. Methodology

The "Design Process and Practice" approach, presented by Buchanan and Margolin (1995), is a design methodology that seeks to understand and address complex issues through an iterative, user-centered approach. In this scenario, the "user" signifies the learners of the educational platform. As a design methodology, "process and practice" acknowledges the importance of collaborative work in design, encouraging exploration, contemplation, and continuous adaptation for effective and meaningful solutions. This approach is applicable in formulating a fresh pedagogical strategy for implementation on an educational platform, aiming to guide an Ideathon event to examine the possibilities, obstacles, and issues presented by megatrends. The design of the pedagogical strategy produces a model that allows users to create new scenarios to generate case studies following a narrative structure. This methodology is appropriate for creating a comprehensive and compelling case study, captivating the audience, and

allowing students to take ownership of the story they develop. On the other hand, the case study method has a long tradition in research where theory and practical experience overlap; they are helpful for research and teaching focused on that transition (Groenland & Dana, 2019; Berasategi, Barandica, Jaureguizar, Aizpurua, Guerra & Arribillaga-Iriarte, 2020). This format has been used in various fields and has proven its effectiveness in design (Breslin & Buchanan, 2008).

The methodology that guided the present study for the model design corresponds to a variation of the proposal made by Buchanan and Margolin (1995). Based on his formulation, we adapted it for the following phases: Problem Definition and Seeking Inspiration, Idea Generation and Preliminary Model Design, Prototyping, Evaluation of Complex Thinking, Model/Activity Evaluation, and Reflection/Ongoing Learning. The details for each stage are as follows:

2.1. Problem Definition and Seeking Inspiration

The methodology prioritizes the need to thoroughly understand the problem before addressing it. In the execution of this stage, researchers scrutinize and analyze in detail the effects of the "People and the Internet" megatrend on society, culture, and other facets, which helps to identify specific challenges and realistic and complex situations in which people interact with the Internet in various contexts.

2.2. Idea Generation and Preliminary Model Design

At this stage, the methodology encourages interdisciplinary collaboration to generate ideas and design a pedagogical strategy to guide the creation of case studies. Subsequently, researchers from diverse fields, such as educational innovation, design, computer science, AI, philosophy, and scientific communication, contribute their observations. From various perspectives, the objective was to guarantee that the proposed model encompasses the creation of stories that explore various megatrend facets to enable users to cultivate a complete comprehension of the challenges presented.

2.3. Prototyping

During this methodology stage, the focus is on prototyping the model. The researchers utilized model examples to develop narrative-based case studies. The examples illustrate and assess the narrative structure to identify elements enabling innovative and complex thinking development. Additionally, they aid in comprehending the interaction between platform users and the pedagogical strategy.

2.4. Evaluation of Complex Thinking

Indicators of complex thinking are defined and incorporated into the model. From there, activities are designed, and questions are fabricated to require participants to analyze interdependent relationships, consider multiple perspectives, and propose holistic solutions. Assessing such relationships allows for measuring complex thinking skills. The questions established to determine the indicators and guide the evaluation of the narrative resource are: Can the learner discern relationships and links among the different aspects of the narrative, for example, between the challenges presented and the strategies proposed? Does the learner develop the underlying causes of the challenges and understand how they affect the groups or sectors? Does the learner manage to represent different aspects of the megatrend and how they relate? Does the learner propose solutions that consider multiple factors of the megatrend and avoid simplistic solutions? Does the learner articulate their ideas effectively?

To assess the mechanisms for evaluating the students' results, the researchers chose artificial intelligence tools to implement in configuring the platform, which supports automated evaluation and makes it possible to show the results of the students' work. Artificial intelligence can help assess narrative stories constructed by students to identify their development of complex thinking. For example, the more relationships and challenges reflected in the text, the higher the score and the identification of causal and consequential relationships. AI tools support other tasks, such as analyzing proposed solutions, measuring, modeling, understanding relationships between ideas, and assessing complex thinking.

2.5. Model and Activity Evaluation

Researchers evaluate how the prototype model addresses the challenges of the "People and the Internet" megatrend and its potential to stimulate complex thinking among participants. Through this evaluation, the team provides a more precise definition of the pedagogical strategy initially developed as a prototype.

2.6. Reflection and Ongoing Learning

At the conclusion of the process, the authors considered Bennett, Agostinho and Lockyer (2016), who stressed the significance of ongoing reflection and learning. At this point, researchers use the lessons learned throughout the process and develop strategies for implementation in future model redesigns.

The "Design Process and Practice" approach facilitates comprehension and accurate problem definition, creativity in idea generation, replication via prototyping, and ongoing evaluation. This methodology enhances the model's quality for generating case studies and its potential to actively engage participants in exploring the challenges posed by the megatrend.

3. Results and Discussion

This model case study design considered the megatrend of "People and the Internet" and its associated implications. Before presenting the resulting model, it is relevant to recall the existing platform that would be adapted according to this proposal. In the first phase of the design of the educational platform, six stages were established and represented on boards. Users can map the problem, show the causes and effects, recognize the parties involved, and devise how the problem can evolve with a transition to desired futures. In this version, user participation focuses on generating a mapping from the design of schemes in the six boards.

For the second stage of design and improvement of the platform, it was decided to add a new megatrend, People and Internet, for students' analyses and reflections but with a pedagogical strategy focused on creating case studies having a narrative structure supported by AI so that the activity designed promotes innovative or creative thinking as a sub-competency of complex thinking by constructing narrative stories (Gube & Lajoie, 2020).

With the support of AI tools, each user automatically receives a brief description of the "People and Internet" megatrend that incorporates benefits, issues, and challenges. Then, the user interacts with the platform to select key elements that guide them to create their story. Among the elements to select is one of the issues involved in the megatrend, representing the fact or action that will define the story, given that events are the primary material of any narrative. As a second choice, participants must choose the scenario in which their story will take place and identify the sectors that could be involved in the selected problem. Finally, the user assumes the role of protagonist and narrator. The intent is to motivate their involvement in the problem and the approach of the story from his or her point of view. With the above data, the platform can provide a brief initial context that is the starting point for building the story, considering past and possible scenarios that evolve toward the future. Figure 2. illustrates the flow of information presented to the user.

In the second phase of the activity, the platform provides guidance (Lorenzetti, Maguitman, Leake, Menczer & Reichherzer, 2016), supported by artificial intelligence, to construct the story. For the story's future, the user visualizes a context in which the initial problem has dissipated so the student can learn to foresee critical moments of transition from the present time with the problem active to situations involving possible resolution.

Part of the guidance provided by the platform is a series of recommendations that allow the user to develop the story: The target audience is their peers, although this is not a determining characteristic. On the other hand, they receive storyboard templates that provide a sequence of events to their story, identifying the section where the problem is in the present, its origins in the past, and the point in the future where the problem has diminished or disappeared. The storyboard as a tool can be simple or

complex, depending on the user. Another tool that can complement the story is the design option, which includes multimedia material to accompany the created story.

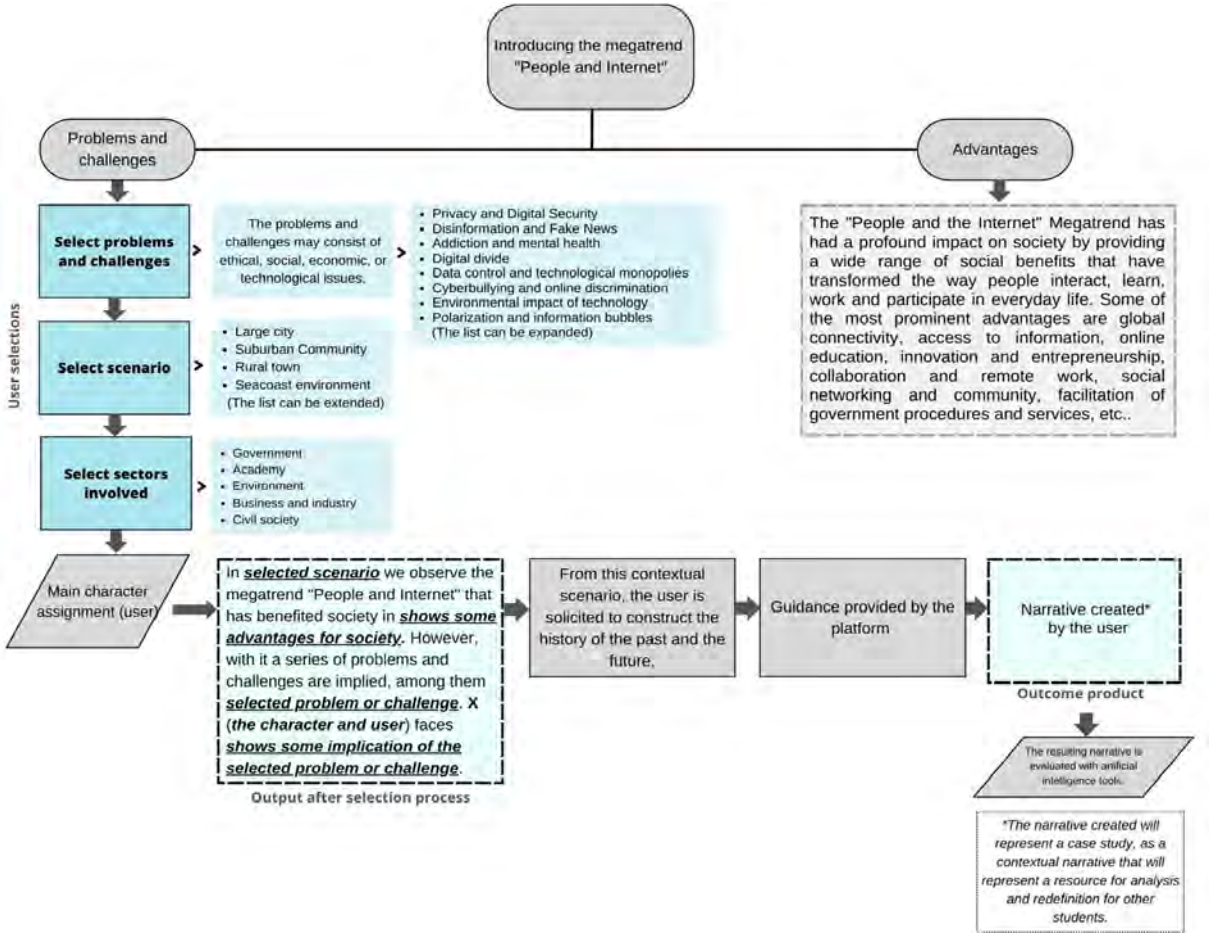

Figure 2. User experience flow on the platform for the creation of a narrative based on the "People and the Internet" megatrend

The narrative generated by the student is assessed through artificial intelligence tools that account for the indicators established to quantify, model, or understand associations between ideas and other facets that support some assessment of complex thinking. Some functionalities of artificial intelligence tools that would be useful for the purposes we have described and implemented in the platform are:

- **Semantic embeddings:** Models such as Word2Vec, GloVe, and BERT (Chandrasekaran & Mago, 2021) generate vector representations of words or phrases. These representations (or embeddings) capture semantics and can be used to measure similarity or relatedness between ideas.
- **Recurrent Neural Networks (RNNs) and Transformers:** These neural network architectures are especially good for processing sequences, such as time series or text, and can identify relationships and patterns within these sequences (Karnik & Kodavade, 2023)
- **Recommender Systems:** These systems, which often rely on collaborative or content-based filtering techniques, can infer relationships between items (such as articles, books, or movies) based on consumption or preference patterns (Zhang & Hara, 2023).
- **Social Network Analysis:** Tools based on graph and network theory that analyze the structure and dynamics of social networks, helping to understand how ideas spread and how they are related to each other (Li, Wolinski & Lin, 2017)

- **Cluster Analysis:** Traditional clustering techniques, such as K-means or DBSCAN, can group similar ideas or concepts based on defined characteristics. However, better clustering techniques dealing with high dimensionality have been reported recently (Mehta, Bawa & Singh, 2021)
- **Topic modeling:** For this task, Latent Dirichlet Allocation (LDA) can be used to identify and group topics in large sets of texts. These clusters or "themes" reflect relationships between ideas and concepts (O'Reilly & Gray, 2022; Chen, Zanocco, Flora, & Rajagopal, 2022)
- **Visualization tools:** The ability to analyze, interpret, and gain insights from large amounts of heterogeneous data within complex dynamic systems acquired from the Internet of Things can receive support from visual analytics, role-based collaboration, and augmented reality (Wachowiak-Smolikova & Zhu, 2023; Ens, Goodwin, Prouzeau, Anderson Wang, Gratzl et al., 2021). Other tools, such as Gephi (Zhong & Lin, 2022) or Tableau (Gous, Nyaruhirira, Cunningham & Macek, 2020), can visualize complex data and relationships, providing insights into the interconnectedness between ideas or concepts to support complex thinking examples like global health issues.
- **Concept Mapping Tools:** There are tools such as CmapTools (Novak & Cañas, 2008) that, while not inherently AI-driven, can be complemented with machine learning algorithms to analyze and evaluate the complexity and relationships between concepts in a map (Lorenzetti et al., 2016).

One notable point is that no single tool can fully capture complex thinking. A practical assessment of complex thinking will likely require a multi-tool approach and consideration of the specific contexts and goals of the assessment. Finally, it is also convenient to recognize that the outcome produced by the student should serve as an illustrative example of a new educational resource, which can be shared with other students for analysis and redefinition, encouraging innovative and creative thinking.

The proposed model designed for the Ideathon project, exhibits significant potential across various educational contexts. In the realm of curriculum design and revision, the model proves invaluable for systematically addressing complex challenges, engaging stakeholders, and planning for future improvements. Similarly, within the domain of educational policy development, the model aids in comprehensively understanding and mitigating complex issues, fostering collaboration among diverse stakeholders, and envisioning a strategic future with targeted milestones. Furthermore, when applied to institutional change and innovation, the model facilitates a systematic approach to navigating challenges, understanding diverse perspectives among stakeholders, and setting achievable milestones for transformative initiatives. In each of these crucial educational contexts, the model provides a structured framework that empowers educational practitioners to navigate complexities, foster collaboration, and strategically plan for a more effective and responsive future in education.

4. Conclusions

This study aimed to design a pedagogical model based on an AI-powered platform that facilitates the creation and development of case studies, focusing on the "People and the Internet" megatrend associated with the 4th Industrial Revolution. This model, framed in an online learning environment, aims to guide university students through an ideation-style learning situation, emphasizing the development of complex thinking, particularly innovative thinking. The methodology employed, "Design Process and Practice," was instrumental in the iterative design of the educational platform, leading to a narrative case study that encourages students to confront and address the multifaceted challenges presented by the megatrend.

Development of complex thinking is highlighted in the model, a vital skill in higher education. It enhances students' cognitive, practical, and adaptive abilities to address interdisciplinary challenges. This thinking style helps students to analyze complex systems; and make better decisions by recognizing connections and predicting outcomes. From a research standpoint, the study underscores the potential of tech-based narrative case studies to foster complex thinking, offering a tangible dimension to the discourse on

education in the context of the Fourth Industrial Revolution. Incorporating narrative structures in the design of a case study offers substantial advantages. It enhances cognitive processes, such as the understanding and analysis of issues related to global trends. Narratives provide a concrete setting that makes learning more relatable and meaningful. They make it easier to understand how social, economic, and technological aspects are interconnected.

The "Design Process and Practice" approach was vital for developing the educational platform. This methodology helped create a model based on an iterative process and user-centered approach, that guides students in making narrative case studies. From a practical standpoint, the designed educational platform offers a novel approach for educators to engage students in contemporary challenges. By integrating AI tools and a narrative structure, the platform fosters students' understanding of the intricate relationships that characterize megatrends and equips them with the cognitive tools needed to devise innovative solutions.

Regarding the pedagogical model and AI integration, the study proposes an educational platform designed to guide students through the ideathon concept. This platform uses AI tools to assess how well students can connect factors related to megatrends and judge their complexity. Other AI tasks, like quantifying, modeling, or understanding associations between ideas and other facets that support some assessment of complex thinking, are involved in the platform. New developments in AI research, such as recommender systems, social networks, or generative AI, can be strengthening the platform and increase its capacity and functionality to generate a better user experience. Attending the previous methodologies and tools, the design of the educational platform was structured to involve students in mapping problems, understanding their causes and effects, and devising future transition processes. AI tools assist in the evaluation of narratives created by students, focussing on the development of complex thinking.

This approach, therefore, holds promise for producing graduates adept at navigating the complexities of the modern world, underscoring the importance of complex thinking in higher education in linkage to the professional world. Mainstreaming complex thinking in the context of the Fourth Industrial Revolution is all the more meaningful. Just as this revolution continues to unfold, it brings with it a rapidly evolving scenario of technologies and societal changes. Preparing students to think complexly in this context is not only about understanding the technology itself, but also about appreciating the broader implications these technologies have on society, ethics, and global challenges. Their understanding is crucial if students are to be prepared to be responsible leaders and innovators in a technologically advanced world.

While the study provides valuable insights for improving an educational platform that relies on AI to measure complex thinking traits, there are certain limitations. Focusing exclusively on the "People and the Internet" megatrend may not encompass the full spectrum of challenges associated with the Fourth Industrial Revolution (e.g., Collaborative Economy). Moreover, as we venture into this era of unprecedented digital connectivity and technological integration, it becomes increasingly important to understand how these advances influence human behavior, social structures and global systems. While methodical, the study's adherence to the "Design Process and Practice" methodology could be enriched by integrating other design methodologies to achieve a more holistic approach. Future research should consider broadening the scope to include other megatrends, delve deeper into their interrelationships, and evaluate the platform's effectiveness in various educational contexts. Evaluating the platform's effectiveness in different educational settings is advised to increase its reach. Moreover, as the platform progresses, it would be significant to integrate the views of more people with vested interests, such as students, educators, and industry professionals, to ensure its continued relevance and effectiveness. These findings reflect a holistic approach to leveraging AI and narrative structures in higher education to equip students with the skills needed to meet the challenges of the Fourth Industrial Revolution.

Note that this research did not distinguish its insights from the gender perspective. While no gender-based disparities were envisioned in this study, the possibility of such differences in future research should be acknowledged.

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The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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