Generative AI Applied to the Design Thinking Process in Knowledge Engineering Projects

Ranieri Alves dos Santos, Fernando Alvaro Ostuni Gauthier, Marcelo Macedo and Vanessa Roberg
Knowledge Engineering Department, Federal University of Santa Catarina (UFSC), Florianópolis, Brazil

ranierisantos@gmail.com
gauthier@egc.ufsc.br
marcelo5360@gmail.com
vanessaroberg@gmail.com

Abstract: The need for user-centered and agile solutions has driven the adoption of methodologies such as Design Thinking in knowledge engineering projects. While the Design Thinking emphasizes empathy, iteration, and innovation focused on user experience, the knowledge engineering aims to build intelligent systems based on formalized expert knowledge. Despite the conceptual alignment between these approaches, the integration of Generative Artificial into this context remains underexplored. This study proposes a model that incorporates generative AI tools into the design thinking process to accelerate and enhance the development of knowledge-based systems. Based on the Design Science Research (DSR) methodology, a narrative literature review and exploratory research were conducted to identify generative AI techniques applicable to each design thinking phase: Empathize, Define, Ideate, Prototype, and Test. A total of 17 generative AI approaches were mapped and organized into a model that supports small and agile teams in knowledge engineering projects. The model was instantiated through the development of GPT-based agents customized for specific tasks, such as persona generation, empathy mapping, requirements analysis, and prototype creation. These agents leverage prompts containing transcripts, observations, or interview data to generate detailed and realistic outputs, streamlining processes that are traditionally manual and time-consuming. One example presented is the Persona Generation Agent, which creates structured user profiles and illustrative images from simple textual input. This integration contributes both theoretically and practically by demonstrating how generative AI can be used to enhance user experience (UX) focused design processes in knowledge engineering. The proposed model promotes more efficient workflows, while keeping the user at the center of development. It also supports interdisciplinary collaboration, faster iteration cycles, and the creation of intelligent systems that are more aligned with user needs. Future work includes empirical validation of the model in diverse application contexts, aiming to refine its use and encourage widespread adoption in knowledge engineering and related fields.

Keywords: Knowledge engineering, Design thinking, UX, Generative AI

1. Introduction

As the demand for increasingly effective, personalized, and adaptable digital solutions continues to grow, user-centered methodologies based on iterative cycles have gained prominence in the development of products and services. Among these approaches, Design Thinking stands out for its creative, collaborative, and user experience-oriented nature, fostering a culture of continuous experimentation, rapid learning, and hypothesis validation based on real usage evidence (Brown, 2010).

These characteristics make Design Thinking particularly promising for fields such as knowledge engineering, whose main goal is to develop intelligent systems based on specialized and structured knowledge. Knowledge engineering requires approaches that enable a deep understanding of usage contexts, user profiles, and the specificities of the domains in which the systems will be applied (Walch & Karagiannis, 2020). The convergence between Design Thinking and knowledge engineering thus emerges as a strategic opportunity to create more effective, usable, and context-aware technological solutions.

Despite the potential synergies between these approaches, the literature still lacks in-depth investigations into how emerging technologies, such as Generative Artificial Intelligence, can be integrated to enhance development processes in both areas (Allen et al., 2024). With its ability to generate original content from large volumes of data and interact through natural language, Generative AI presents itself as a powerful ally for automating tasks, extracting insights, and accelerating iterative cycles, especially within the Design Thinking process applied to knowledge engineering projects (Orenga-Roglá & Chalmeta, 2019).

In this context, this study conducts a narrative review and exploratory research to identify Generative AI techniques that can be applied at different stages of the Design Thinking process. Based on this investigation, the objective of this work is to propose a model that combines Design Thinking principles with the strategic

use of Generative AI tools, aiming to support the development of intelligent systems in the field of knowledge engineering, particularly in environments with small teams, tight deadlines, and high demands for innovation.

2. Methodology

This study adopted the Design Science Research (DSR) model as its methodological foundation, as it is a widely recognized approach in the field of information systems and is well-suited for the development of innovative and applied solutions. DSR is characterized by the construction and evaluation of artifacts, which may take the form of models, methods, system instances, or frameworks, with the goal of solving real-world problems through scientific rigor (Hevner et al., 2004).

In this context, the model proposed in this study is conceived as the central artifact of the research, and its applicability to knowledge engineering projects is treated as the practical instantiation of that artifact. Instantiation refers to the application of the model in real or simulated contexts, aiming to assess its feasibility, usefulness, and potential for generalization.

For this work, the implementation was based on the Design Science Research Methodology (DSRM) proposed by Peffers et al. (2007), which structures the project into six steps:

1. Problem Identification and Motivation: In this initial phase, the general problem and the justification for the development of the study were analyzed;
2. Definition of the Solution Objectives: Based on the problem analysis and motivation, the objectives of the work to be developed were established;
3. Design and Development of the Artifact: Following the objectives outlined in the previous step, the proposed artifact (model) was designed based on the needs identified in the literature;
4. Demonstration: As the next part of this thesis, the artifact was instantiated through the development of agents, based on the proposed model;
5. Evaluation: Evaluation of the artifact instantiation, a step currently in progress using the developed agents;
6. Communication: Communication to the community, where the present work is part of the publication strategy to disseminate the project's preliminary results.

To support the model construction, the study was structured around a narrative literature review aimed at identifying previous approaches that explored the use of Design Thinking methods in the context of knowledge engineering. The review was based on articles, preprints, and theses published since 2019. It also included foundational literature from the relevant domains, particularly the conceptual and methodological foundations of Design Thinking and knowledge engineering. The analysis focused on recent publications that highlight emerging trends and underexplored gaps, especially regarding the integration of emerging technologies, such as Generative Artificial Intelligence, into iterative and collaborative system development processes.

3. Design Thinking in the Knowledge Engineering Context

Design Thinking is a human-centered methodology widely used in the development of innovative solutions. This approach aims to create products, services, or experiences that effectively address real user needs, while also encouraging interdisciplinary collaboration, creativity, and continuous experimentation. It promotes empathy with users, rapid prototyping, and iterative testing elements that are especially valuable in dynamic and uncertain contexts. By adopting Design Thinking, professionals are able to overcome traditional silos and barriers between different areas of knowledge, fostering environments that are more conducive to innovation and integrated problem-solving. Additionally, this methodology enables teams to remain agile and responsive to changing market demands and emerging user expectations, making it a strategic tool for organizations striving to remain relevant and competitive in a fast-evolving landscape (Brown, 2010).

When applied to knowledge engineering projects, Design Thinking supports the understanding of user needs, pain points, and behaviors in relation to the systems being developed. While knowledge engineering plays a fundamental role in the formalization and structuring of knowledge, often in the form of intelligent systems, ontologies, or knowledge bases, Design Thinking contributes by placing emphasis on the human experience of interacting with these systems. This user-centered approach ensures that the design and functionality of knowledge management systems are not only technically robust, but also intuitive, relevant, and usable, especially when incorporating emerging techniques such as machine learning and generative artificial intelligence (Walch & Karagiannis, 2020; Allen et al., 2024).

Moreover, knowledge engineering itself can be enhanced by leveraging Design Thinking principles. It can be used to build systems that gather and process contextual user data, which in turn can inform the ideation and prototyping phases of Design Thinking. This synergy between the two fields allows for the co-creation of solutions that are not only technologically robust but also aligned with real-world user needs an essential focus of the model proposed in this study.

4. Generative AI in Design Thinking

In the research and reviews that gave rise to this study, several works were identified that propose trends and tools leveraging Generative AI to accelerate and automate processes involved in digital product design projects aimed at meeting user needs (UX), with a focus on Design Thinking processes.

The application of generative AI within the context of Design Thinking has emerged as a promising yet still underexplored frontier in academic literature. The possibilities are vast: from automating stages such as persona creation, storyboarding, and interactive prototyping, to providing creative support during the ideation phase, where AI-powered agents can suggest innovative solutions based on contextual data. Furthermore, Generative AI tools can significantly contribute to the analysis of qualitative data derived from interviews, observations, and user testing, transforming large volumes of information into actionable insights in a faster and more accessible manner. However, despite these promising applications, there remain several research gaps that need to be addressed. One of the main challenges is understanding how to balance the use of AI with the core principles of Design Thinking, particularly empathy and human collaboration, which are foundational to the approach. Another critical issue involves validating the effectiveness of AI-generated solutions in real-world environments, as well as managing the risks of bias in both input data and generative models themselves. Additionally, there is a significant gap in understanding how multidisciplinary teams handle the integration of AI into traditional Design Thinking workflows and how this integration impacts creative dynamics and decision-making processes. Thus, while Generative AI holds substantial potential to enhance productivity and enrich user-centered design processes, further research is essential to develop hybrid models, validated methodologies, and best practices that preserve a balance between automation and human sensitivity in the development of innovative solutions (Walch & Karagiannis, 2020; Chung, 2024).

Among the studies that demonstrated applicability to the model proposed in this work, particular emphasis is given to those focused on automating product ideation activities, such as the analysis of sticky notes (Walch & Karagiannis, 2020) and the automatic construction of personas from transcripts of user interactions. Additionally, notable approaches include the automatic generation of storyboards and user flow narratives (Jansen et al., 2021; Salminen et al., 2019; Chung, 2024; Liang et al., 2024), as well as the structuring of software requirements based on text transcripts (Ronanki et al., 2024; Sami et al., 2024).

For prototyping, studies such as those by Takaffoli et al. (2024) and Chivukula et al. (2024) suggest techniques for wireframe creation and layout optimization. Other approaches address automatic prototype generation, transforming low-fidelity versions into mid-fidelity, and these into high-fidelity prototypes (Suleri et al., 2019). In the field of prototype evaluation, noteworthy contributions include simulator agents, usability analysis tools, and emotional state recognition of users (Wallach et al., 2020; Chivukula et al., 2023; Chasalow & Levy, 2021).

5. Proposed Model

Based on the theoretical framework explored throughout this study and focusing on the strategies, trends, and contributions of Generative AI analyzed in the research, this work proposes a Knowledge Engineering project model that leverages Generative AI to accelerate product development processes with a focus on user experience.

The core premise of this model is to involve users, domain experts, and the technical development team throughout the entire process, aiming to ensure the success of knowledge engineering projects by grounding them in Design Thinking principles applied to the development of intelligent knowledge management systems. The proposed model is informed by narrative literature reviews of previously proposed approaches regarding the use of Design Thinking methods in knowledge engineering, as well as foundational literature on both knowledge engineering and Design Thinking, with an emphasis on identifying unexplored potential highlighted in recent studies.

To systematize the proposed model, a graphical representation was developed using the stages of Design Thinking arranged in a circular format, aiming to illustrate the iterative nature of the process as applied to knowledge engineering projects. This representation is shown in Figure 1.

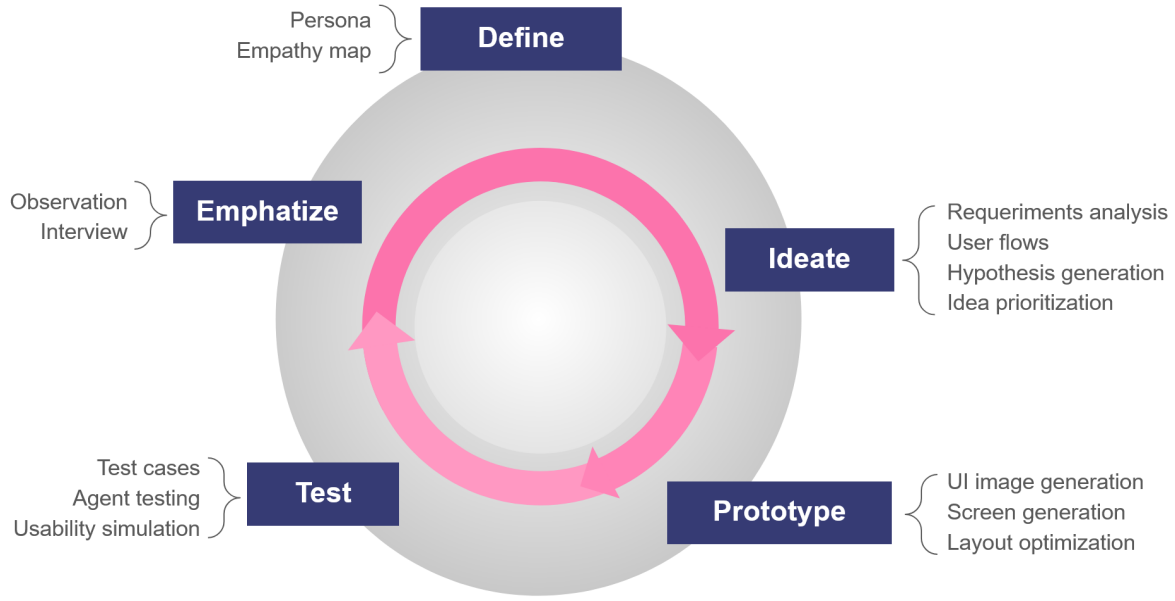

Figure 1: Proposed Model

In the figure, the stages of Design Thinking (empathize, define, ideate, prototype, and test) are displayed in a circular layout, along with the corresponding Generative AI approaches suggested by the model for each stage. These AI approaches were selected based on the research and reviews presented in this study and serve as a foundation for knowledge engineering teams to accelerate their processes within projects, with a focus on enhancing user experience satisfaction. The agents proposed for each stage of the model are listed in Table 1.

Table 1: Agents and Steps

Step	IA Agent	Reference
Emphatize	Observation analysis	Walch & Karagianni (2020)
	Interview analysis	Walch & Karagiannis (2020)
Define	Persona generation	Schuller et al. (2024)
	Empathy map generation	Schuller et al. (2024)
Ideate	Requirements analysis	Ronanki et al. (2024); Sami et al. (2024)
	User flows	Jansen et al. (2021); Salminen et al. (2019)
	Hypothesis generation	Chung (2024); Liang et al. (2024)
	Idea prioritization	Salminen et al. (2019)
Prototype	UI image generation	Takaffoli et al. (2024); Chivukula et al. (2024)
	Screen generation	Suleri et al. (2019)
	Layout optimization	Bilgram & Laarmann (2023)
Test	Test case generation	Nama et al. (2023) Ouédraogo et al. (2024)
	Agent testing	Wallach et al. (2020) Chivukula et al. (2023)
	Usability simulation	Chasalow & Levy (2021)

6. Results

Following the premise of DSR, in which artifacts are realized through their instantiation, and aiming to demonstrate how the model can be used in practice, the instantiation of this artifact was based on the operationalization of the proposed stages and Generative AI agents. To materialize this artifact, the stages

based on and Design Thinking, proposed for the development of knowledge engineering project, were enhanced by the integration of Generative AI agents.

These agents were implemented according to the structure proposed by the model, using GPT (Generative Pretrained Transformers) technology, specifically customized versions of OpenAI's ChatGPT. GPTs are agents developed to perform specific tasks and meet particular needs. These models can be trained using databases, manuals, historical records, or other relevant sources, enabling them to understand technical terminology and the specificities of particular domains.

GPT agents can be created using tools such as OpenAI's GPT Builder and can be made available through the GPT Store, OpenAI's platform for creating, publishing, and monetizing custom GPTs. This marketplace provides an environment for developers and organizations to share their GPT-based solutions with the public.

To illustrate the instantiation of the proposed model through GPT agents, Figure 2 presents the persona generation agent. This agent, part of the second stage of the proposed model (Define), accelerates the work of the knowledge engineering team by automatically constructing the ideal persona framework for use in knowledge management systems.

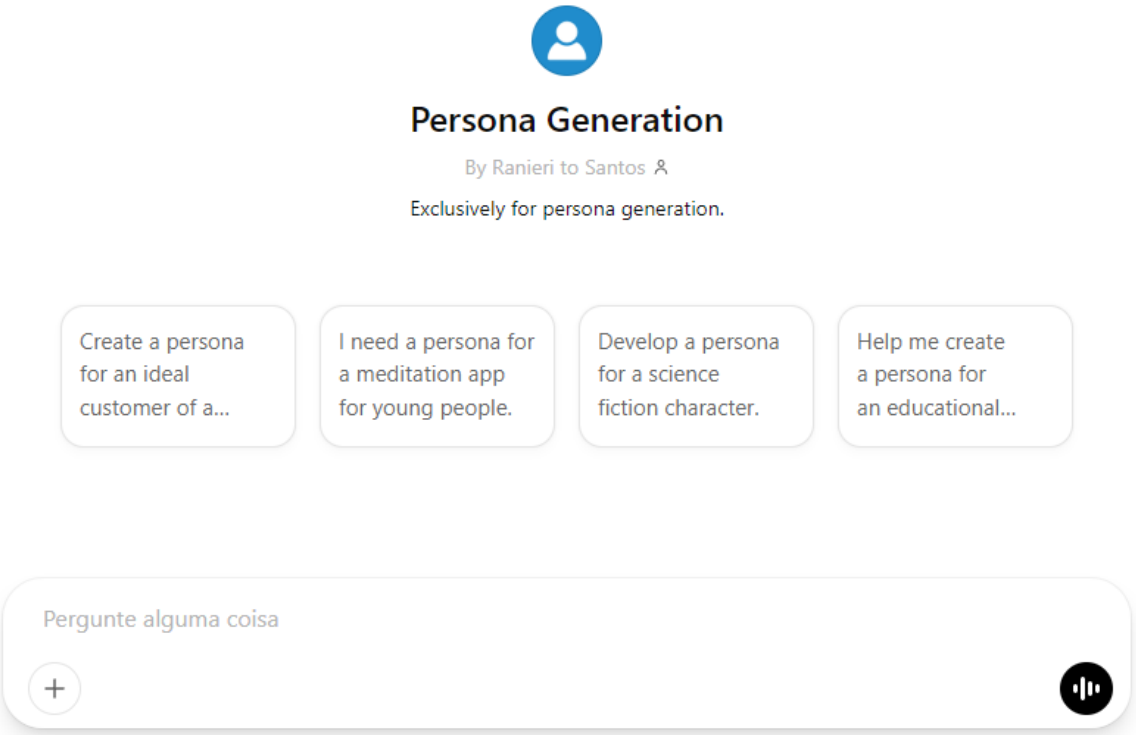

Figure 2: Persona Generation Agent

Using the specific GPT agent, the knowledge engineering specialist can generate a persona for their product by entering a prompt. The prompt may include transcripts of interviews, observations, and other details regarding the behavior of the product's users.

To demonstrate this process, Figure 3 shows a sample result from the persona generation agent, representing a user of a knowledge management product designed for higher education faculty. In the figure, it is possible to see that, in addition to a detailed persona profile, a representative image of the ideal user is also generated.

The implementation of this agent is based on the GPT's ability to process and generate personalized content from specific prompts. This allows personas to be created efficiently and tailored to the specific needs of a given product or service. The methodology used for persona generation involves the collection of demographic, behavioral, and social data, which are essential for creating realistic and relevant user profiles. This information is entered via prompt and can take the form of simple imperatives or transcripts from conversations, interviews, and observations. These inputs are then processed by the GPT to generate personas that reflect the characteristics, goals, and challenges of the target users.

The inclusion of elements such as name, illustrative photo, and contextual background helps make the personas more tangible and easier to understand for design and development teams. This promotes a deeper understanding of user needs and facilitates more informed decision-making throughout the user experience design process.

Name

Dra. Camila Ribeiro

Data

- **Age:**36 years old
- **Profession:** University Professor of Mathematics
- **Training**PhD in Applied Mathematics from the State University of Campinas

Personality

Camila is analytical,

Context

Camila teaches at a university

Wishes

It seeks to make mathematics teaching more accessible.

Figure 3: Persona Generation Agent Result

As can be observed, the output generated by the persona agent delivers a detailed and realistic profile that encompasses the essential characteristics of the target user, based on the agent's programmed pattern even from a simple prompt. The persona generated by the GPT agent not only provides general and illustrative data but also delves into personality traits, life context, desires, needs, and motivations, as well as common pains and frustrations of the intended user group. This depth of information enables design and development teams to better understand who their users are and how they interact with the product or service.

The results show that integrating generative AI techniques into the five stages of Design Thinking can contribute to the automation of critical tasks in knowledge engineering projects: in addition to accelerating persona generation and observation analysis (confirming findings by Walch & Karagiannis, 2020), the model addressed gaps identified by Allen et al. (2024) by demonstrating agents for ideation (hypotheses and idea prioritization) and prototyping (wireframes and layout optimization), which reduce iteration cycles, in line with the projected benefits noted by Jansen et al. (2021) and Takaffoli et al. (2024).

However, based on the results, it was observed that, so far, validation is limited to a single instantiation of the proposed model, restricting the current evaluation to only one agent (persona generation). The study still lacks quantitative performance gain metrics and an exploratory and experimental investigation to validate the proof of concept using infrastructures from other providers analogous to OpenAI.

7. Conclusions

The practical instantiation of the model through the development of agents based on customized GPTs demonstrated how traditionally manual and time-consuming processes, such as persona creation, can be transformed into faster, more systematic tasks that are deeply connected to users real needs. The customization of agents, combined with the flexibility of data input via prompts, enables their application across diverse contexts while respecting the specificities of each knowledge domain.

In addition to contributing to the theoretical advancement at the intersection of Design Thinking and Knowledge Engineering, this work also offers a practical contribution by demonstrating how Generative AI tools can be integrated into project teams workflows, even in resource-constrained environments. The

proposal aims not only to increase productivity but also to maintain user centrality throughout all stages, enhancing teams' ability to deliver more relevant, empathetic, and effective solutions.

As future work, there is a need for empirical validation of the model in different application contexts, through case studies and experiments with real users. It is expected that, with the advancement of AI technologies and the growing accessibility of such tools, the integration proposed here will become a common practice in Knowledge Engineering projects and related fields. Thus, the model can continue to evolve, incorporating new techniques, tools, and practical insights that will feed back into its cycle of continuous improvement.

Ethics Declaration: For the development of this paper and for all reviews and research involved in this work, no ethical authorization was required.

AI Declaration: No artificial intelligence tools were used to prepare this paper. However, AI tools were used to translate and review some specific terms that involved different languages in the writing of the paper.

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