

Enhancing problem-solving and data protection through the integration of function-oriented search and ChatGPT

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Abstract

As a large language model, ChatGPT's ability to learn from big data and respond to diverse user queries makes it a powerful tool for research and development. Despite the potential benefits of using ChatGPT, there are risks concerning users' data protection. To address this issue, this study proposes utilizing Function-Oriented Search (FOS), a methodology based on Theory of Inventive Problem Solving (TRIZ). FOS provides an innovative approach to problem-solving by functionally defining a problem and generating solutions from areas where the function can be optimally performed. Thus, this study argues that applying FOS when using ChatGPT can ensure accurate results while mitigating the exposure of sensitive information. Although implementing FOS requires specialized training and sufficient hands-on experience to identify and conceptualize problem focus areas, ChatGPT can serve as an efficient tool for developers adopting this methodology. For both experts and novices in FOS, ChatGPT enables users to conduct efficient and comprehensive problem explorations and devise solutions. By demonstrating the application of FOS in practical cases, the study's findings support the potential benefits of ChatGPT as a dynamic collaborator in problem-solving. The findings also indicate that FOS can guide the use of ChatGPT to generate suitable solutions while maintaining the protection of personal or corporate information. Overall, this study contributes to the emerging field of artificial intelligence by illustrating the possible synergy between TRIZ-based FOS and ChatGPT, a large language model.

Keywords: ChatGPT, Data Protection, Function-Oriented Search, Large Language Model, Prompt Engineering, Theory of Inventive Problem Solving, TRIZ-Informed Prompt Engineering

1. Introduction

The field of artificial intelligence (AI) has developed rapidly in recent years. In particular, the Generative Pre-trained Transformer (ChatGPT) has garnered significant attention due to its large-scale language model with a conversational interface. ChatGPT's ability to generate human-like text not only provides users with personalized interactions but also has numerous applications in areas, such as customer service, education, and healthcare (Aljanabi et al., 2023; Bang et al., 2023). It can also serve as a versatile

tool for complex problem-solving, research, and development (Sinha et al., 2023; Tafferner et al., 2023).

Despite these benefits, ChatGPT has certain limitations, including privacy and security risks, bias, misuse, and the potential for misinformation (Borji, 2023; Dwivedi et al., 2023; Oviedo-Trespalacios et al., 2023; Wach et al., 2023). In particular, this study focuses on the risk of unintentional exposure of sensitive data, which can range from privacy breaches to corporate confidentiality leaks and intellectual property theft. Therefore, there is an urgent need to explore methodologies that leverage ChatGPT's

capabilities while protecting personal or sensitive information.

The main purpose of this study is to apply the Theory of Inventive Problem Solving (TRIZ)'s Function-Oriented Search (FOS) as a countermeasure to these vulnerabilities. Specifically, this study has two main objectives. The first objective is to investigate the potential of implementing FOS, a methodology within TRIZ's systematic problem-solving framework. FOS emphasizes a function-oriented perspective, defining problems functionally and generating solutions across diverse areas. By applying FOS to data protection challenges, this study aims to elucidate whether it can ensure accurate and relevant responses from ChatGPT without compromising sensitive data. The second objective is to examine how the integration of FOS and ChatGPT enables efficient and comprehensive problem exploration and solution development. This approach aims to improve users' problem-solving abilities, both for FOS experts and for developers unfamiliar with FOS, demonstrating a synergistic collaboration between ChatGPT and TRIZ's FOS.

2. Literature Review

2.1. ChatGPT and its Limitations

Developed by OpenAI, ChatGPT is a generative pre-trained transformer widely recognized for its advanced machine learning algorithms, capabilities, and interactive applications. Its remarkable ability to understand and generate human-like text from vast amounts of data allows it to provide meaningful responses to diverse prompts, making it applicable in fields, such as coding, nursing, tourism, writing, and publishing (Aljanabi et al., 2023; Bang et al., 2023; Dwivedi et al., 2023).

However, ChatGPT has limitations. One major limitation is that it generates responses based on patterns learned from training data. Given that ChatGPT cannot yet fully capture the nuances of human language and social communication, its understanding of context is limited, potentially resulting in inappropriate or meaningless responses in complex or ambiguous situations (Aljanabi et al., 2023). Data protection is also a critical concern. Due to the way ChatGPT learns from accumulated data at OpenAI, there is a risk of inadvertently compromising privacy or exposing sensitive information (Dwivedi et al., 2023). This vulnerability presents a significant obstacle to wider application, which this study addresses using TRIZ's FOS methodology.

2.2. TRIZ and FOS

The TRIZ, developed by Genrich Altshuller in the 1940s, is a systematic methodology for understanding

and solving complex problems (Altshuller, 1984; 1999). TRIZ transforms a specific problem into a generalized problem model through abstraction and formalization, and identifies corresponding general solution models. It then provides systematic methods, such as solving specific problems through analogy and interpreting the general solution model (Cameron, 2010; Haines-Gadd, 2016; Ilevbare et al., 2013; Orloff, 2017). One of the core techniques in modern TRIZ is FOS.

FOS translates the key problem into a functional language, formulating generalized functions to identify technical solutions from other areas and transferring existing technologies to address the initial problem (Litvin, 2005). As shown in Fig. 1, FOS is based on TRIZ, and its problem-solving process is analogous to that of TRIZ.

The FOS procedure, based on TRIZ's general problem-solving process, is as follows (Wang et al., 2023; Zhang et al., 2023): (i) Identify the target problem; (ii) abstract the target problem into a conceptual problem and generalize it into a functional language; (iii) search the existing solutions using a function-based technology database (leading area); and (iv) apply the existing solutions to the target problem.

By defining and abstracting the essence of a problem as a function that needs to be performed, FOS expands the solution search to areas where the identified function can be optimally executed. FOS deviates from conventional problem-solving methodologies, which largely depend on pre-existing solutions within the immediate problem domain. While many prevailing strategies draw from cases addressing analogous challenges, FOS characterizes the problem in functional terms. This broadened search can lead to innovative, cross-disciplinary solutions that might not have been recognized if the problem remained contextualized within its original field, seeking resolutions in alternative fields where the function is optimally performed.

Several studies have attempted to implement FOS using data mining techniques (Wang et al., 2023; Zhang et al., 2023). These approaches are noteworthy because they provide algorithmic methods for FOS, but they can present barriers for users who are unfamiliar with the technology in this area.

Theory of Inventive Problem Solving methodologies, including FOS, requires extensive training and practice. In this study, we suggest an approach to implementing FOS by leveraging ChatGPT, regardless of the user's level of expertise.

3. Methodology

FOS solves problems by abstracting them using functional terms instead of specific terms that might reveal product brands or problem targets. This strategy

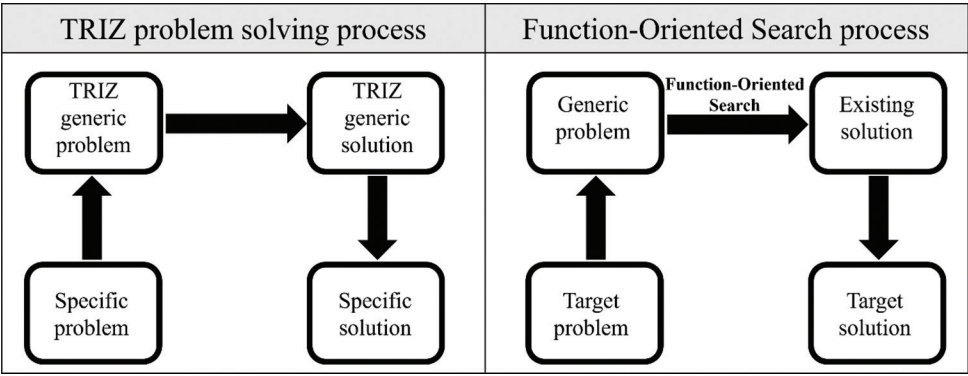


Fig. 1. Comparison of TRIZ’s general problem-solving process and FOS’s process
Abbreviations: FOS: Function-Oriented Search; TRIZ: Theory of Inventive Problem Solving

not only broadens the scope of problem-solving but also protects sensitive details from being exposed. In addition, FOS’s tendency to look beyond the immediate problem context, combined with ChatGPT’s ability to access a wide range of knowledge, creates a synergy that improves both problem-solving efficiency and data security.

For this study, we designed an FOS implementation using ChatGPT. We examined the applicability of ChatGPT’s solutions from the perspective of TRIZ’s FOS and validated the approach by comparing it with actual development cases.

In large language models, prompt engineering refers to the systematic formulation and refinement of input prompts to guide the model’s behavior toward outputs that are useful, reliable, and contextually appropriate. This is achieved by designing structured instructions and interactions that clearly articulate goals, constraints, roles, and reasoning styles.

In this study, prompt formulation was conceptualized and implemented as TRIZ-informed prompt engineering. Specifically, FOS was employed to represent the target problem in functional terms. These resulting functional descriptions were subsequently used to structure the prompts provided to ChatGPT, guiding its problem-solving process while minimizing the risk of disclosing sensitive information.

The procedure followed in this study is as follows:

- (i) Case description: Outline the target engineering problem, its constraints, and the core function to be achieved
- (ii) Prompt design and implementation: Develop ChatGPT prompts from a FOS perspective, using TRIZ-informed functional abstraction and interaction patterns to translate the problem into function-oriented prompts
- (iii) Evaluation: Assess the results generated by ChatGPT and compare them to real-world problem solutions to demonstrate the effectiveness of FOS implementation.

All procedures were performed using ChatGPT Plus (GPT-4, OpenAI, US).

4. Case Study

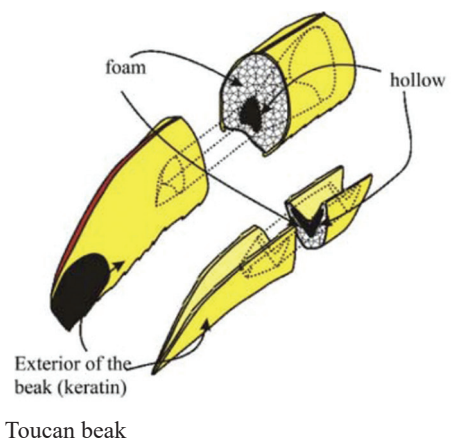
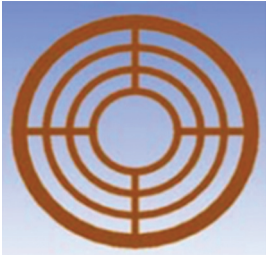
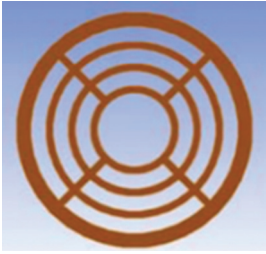
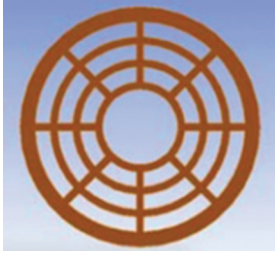
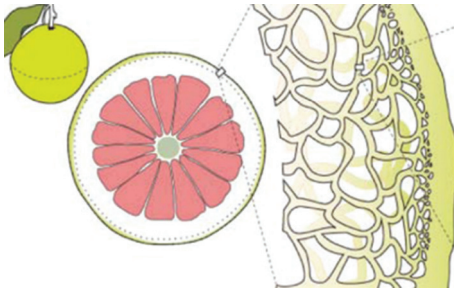
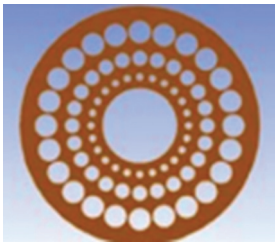
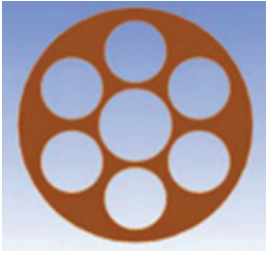

4.1. Description of Case Study

As a case study, we consider research on side-door impact beams by Shaharuzaman et al. (2020). The side-door impact beam was first introduced by General Motors in the late 1960s to safeguard the passenger compartment from external collisions. Side-door impact beams, which improve the strength, stiffness, and energy absorption of a vehicle door in a side impact, come in a variety of designs, with ribs for the beam being a common feature, and a circular cross-section being the most widely used design type.

With the growing emphasis on sustainable design and environmentally friendly products, automakers are increasingly adopting natural fiber composites (NFC), which are characterized by specific strength, rigidity, recyclability, and their appeal as natural materials, in place of synthetic fiber composites. The use of NFC is a significant trend in the automotive industry due to its lightweight properties, which enhance fuel efficiency and offer eco-friendly options for recycling and disposal. As natural fibers exhibit diverse mechanical and material properties, thorough analysis during material selection is essential in the early stages of product design and development.

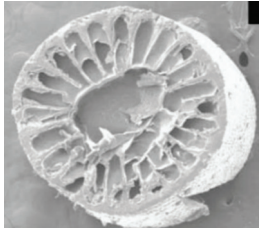
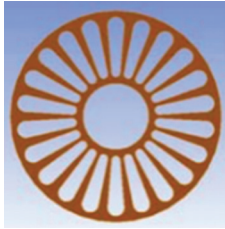

As shown in Table 1, Shaharuzaman et al. conducted FOS and biometric methods using ideas obtained from asknature.org and derived eight design proposals through finite element analysis. Afterward, one of the pomelo peel models (B-03) and one of the hedgehog spine models (C-02) were selected as the optimal choices for the side-door impact beam using VlseKriterijumska Optimizacija I Kompromisno Resenje.

Table 1. Key ideas proposed by Shaharuzaman et al. (2020)

Biomimetic strategies	Design	Name
 <p>Toucan beak</p>		A-01
		A-02
		A-03
 <p>Pomelo peel</p>		B-01
		B-02
		B-03

(Cont'd...)

Table 1. (Continued)

Biomimetic strategies	Design	Name
 Hedgehog spine		C-01
		C-02

4.2. Design and Implementation of ChatGPT Prompt Engineering from a FOS Perspective

To design an NFC side-impact beam from an FOS perspective, this study used the persona pattern and flipped interaction pattern during prompt engineering (White et al., 2023). For the persona pattern, we assigned ChatGPT the role of an experienced TRIZ (FOS) expert and incorporated biomimetics following the research method of Shaharuzaman et al. (2020). Afterward, we explained the usual FOS procedure and allowed ChatGPT to proceed accordingly. This study also applied the flipped-interaction pattern, which gives ChatGPT the right to ask questions so that it can provide more accurate answers (Fig. 2).

We asked ChatGPT to design a “circular lateral force absorber–distributor made of natural fiber composite” using FOS biomimetics (Fig. 3).

ChatGPT generated a response to the request, as shown in Fig. 4. Due to space constraints, only a partial view of the content is presented here; the full content can be accessed at the following link: <https://chat.openai.com/share/bfda4e5d-4ee7-4046-8069-db2a3acdee9d>.

The problem was expressed in the functional language “circular lateral force absorber–distributor made of natural fiber composite” for a side-door impact beam made of NFCs. The conversion of a specific description into a functional language was chosen after discussion with the research participants. Of course, it is also possible to utilize ChatGPT, in which case we took measures to protect against the unintentional disclosure of information, such as using a third-party account. When this description was entered into the prompt, ChatGPT provided several answers. To better emphasize functionality, we further simplified the functional language from “circular lateral force

absorber–distributor made of natural fiber composite” to “absorb and distribute forces.”

As presented in Fig. 5, ChatGPT suggested several biomimetic solutions: Bamboo, spider silk, the woodpecker’s beak and head, and shell structures.

If another response is desired, the user can simply click the “Regenerate” button. Fig. 6 shows the second response generated after clicking the button. In this response, ChatGPT attempted to provide a more accurate answer by asking clarifying questions. Each time the user clicks “Regenerate,” ChatGPT can produce different, yet related, responses that offer the user additional knowledge and insights.

4.3. Evaluation of ChatGPT’s Response and Comparison with the Solutions of Shaharuzaman et al.

This study also compared the answers obtained by running FOS on ChatGPT with the study of Shaharuzaman et al. (2020). Identifying the similarities and differences between the two studies serves as the primary means of judging ChatGPT’s validity and its potential to provide insights for problem-solving.

4.3.1. Relevance to the research of Shaharuzaman et al. (2020)

The findings indicated that ChatGPT’s response contained ideas similar to those presented by Shaharuzaman et al. (2020). Both results referenced designs inspired by the same woodpecker order, including the toucan and the woodpecker. The idea of using pomelo shells presented in their study can also be inferred from the shell-based structures proposed by ChatGPT.

✧ GPT-4



In this session, you are now a highly skilled master of TRIZ (the theory of inventive problem solving) with knowledge in a wide range of technical areas. For 30 years, you have used TRIZ solutions, particularly Function Oriented Search (FOS)-Biomimetics, to solve a wide variety of problems. The FOS procedure, which is based on the general problem-solving process of TRIZ that you use, is as follows.

1. Identify the target problem.
2. Abstract the target problem into a conceptual problem and generalize it into a functional language.
3. Search the existing solutions using a function-based technology database (leading edge).
4. apply the existing solution to the target problem.

Your task is to provide the best solution from a TRIZ perspective to my assignment written in the prompt. You may ask me questions as often as necessary until you are able to provide the best answer. Do you fully understand your assignment? Please respond with a yes or no.



Yes.

Fig. 2. Prompt engineering of the Function-Oriented Search-biomimetics perspective
Abbreviation: TRIZ: Theory of Inventive Problem Solving



I am trying to design a 'Circular lateral force absorber-distributor made of natural fiber composite' using FOS-biomimetics. I hope you can give me some excellent advice for this design.



Absolutely. Let's proceed systematically through the FOS procedure to devise a solution.

Fig. 3. Prompt provided to ChatGPT
Abbreviation: FOS: Function-Oriented Search



I am trying to design a 'Circular lateral force absorber-distributor made of natural fiber composite' using FOS-biomimetics. I hope you can give me some excellent advice for this design.

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Absolutely. Let's proceed systematically through the FOS procedure to devise a solution.

1. Identify the target problem.

You're trying to design a 'Circular lateral force absorber-distributor made of natural fiber composite'.

2. Abstract the target problem into a conceptual problem and generalize it into a functional language.

Conceptual Problem: We need a mechanism that can absorb and distribute lateral forces efficiently.

Functional Language: "Absorb and distribute forces."

Fig. 4. Response from ChatGPT
Abbreviation: FOS: Function-Oriented Search

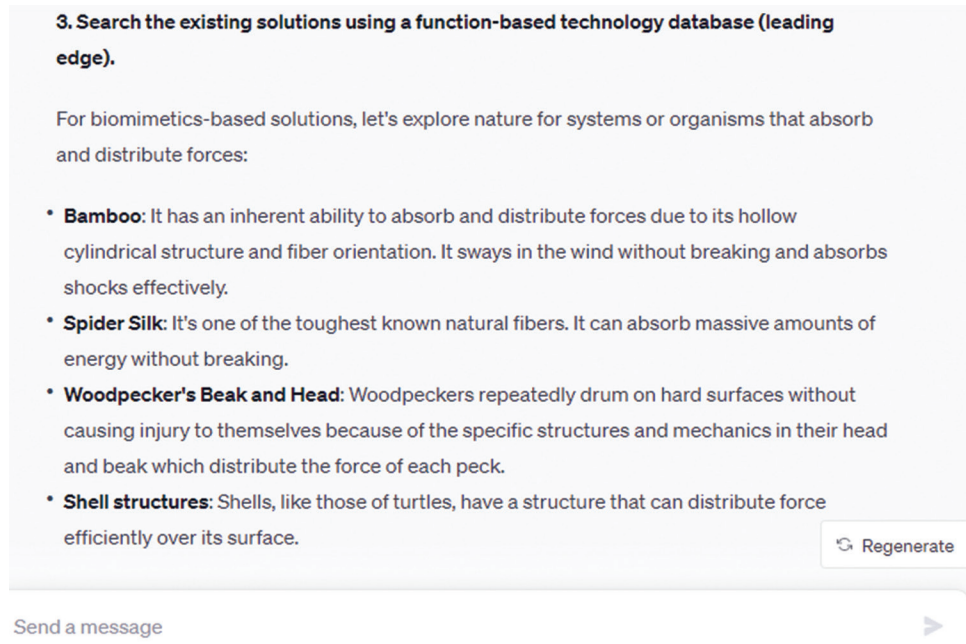


Fig. 5. Biomimetic suggestions generated by ChatGPT

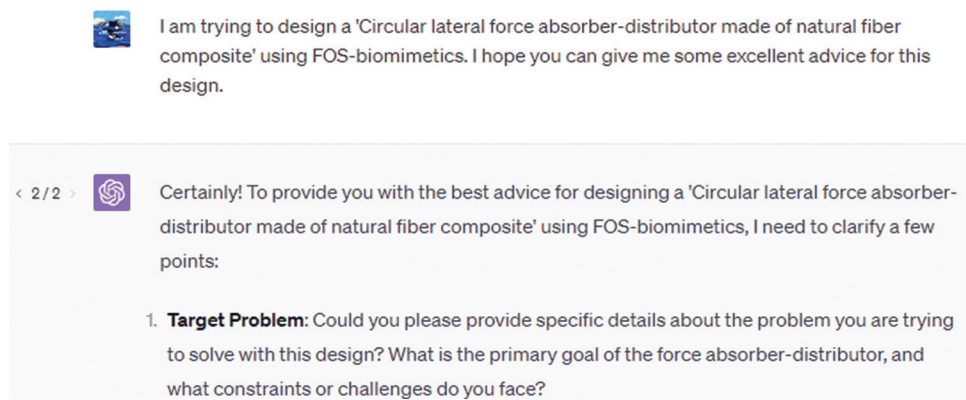


Fig. 6. Second response from ChatGPT

4.3.2. Biomimetics inspiration

The solutions proposed by ChatGPT were based on biomimetics, derived from the prompted input. ChatGPT did not simply identify biological analogues but also provided explanatory information that could inspire design ideas—for example, bamboo's concentric layer structure, the strength properties of spider webs, woodpecker-inspired cushioning mechanisms, and segmented shell structures.

4.3.3. Dynamic interaction design

This study utilized the flipped-interaction pattern to allow ChatGPT to ask users additional questions and respond based on their specific intentions. This created a dynamic interaction, rather than a simple one-time input/output exchange, supporting collaborative engagement between the user and ChatGPT.

When we clicked the “Regenerate” button, ChatGPT generated more specific questions about what user goals, constraints, and requirements. This enabled ChatGPT to provide more contextually relevant and personalized advice. Such dynamic interaction supports a user-centered approach to generating results.

4.3.4. Evaluation

The results of Shaharuzaman et al. (2020) were compared with ChatGPT's outputs to investigate the feasibility and effectiveness of applying FOS through ChatGPT. The similar outcomes suggest that ChatGPT can provide valid FOS-based results. Furthermore, ChatGPT provided various additional suggestions not found in Shaharuzaman et al.'s study (2020) and proposed customized solutions through interactive

dialogue. This demonstrates both the effectiveness and utility of implementing FOS via ChatGPT. In addition, although traditional FOS requires substantial learning and practical experience to use effectively, this study found that even inexperienced FOS users can apply it easily through the simple prompt-engineering strategies demonstrated here.

5. Conclusion

In recent years, collaboration between humans and AI has garnered significant interest. Contrary to earlier apprehensions, AI is increasingly recognized not as a detractor from human creativity but as an enhancer of human cognitive capabilities, enabling new scientific and artistic pathways (Colton et al., 2009; Wingström et al., 2022). Cropley et al. (2022) underscored the potential integration of human and AI creativity and advocated for a deeper understanding and development of the synergy at their intersection.

The findings of this study contribute to this evolving field by examining the feasibility and effectiveness of implementing FOS within ChatGPT. The specific contributions of this study include:

- i. Effective implementation of FOS through ChatGPT
As demonstrated in the case study on side-door impact beam design, this study showed empirically that FOS can be effectively implemented in ChatGPT via TRIZ-informed prompt engineering. Among the outputs generated by ChatGPT, woodpecker-inspired structures and shell structures aligned with the results of Shaharuzaman et al. (2020), supporting the validity of this study. In addition, ChatGPT continuously generated user-centered solutions through interactive dialogue, providing users with efficient and diverse design concepts.
- ii. Mitigating data security vulnerabilities
Using functional language in FOS abstracts sensitive information and minimizes the exposure of important details. This enables users to obtain ideas and insights from ChatGPT while reducing the risk of data disclosure.
- iii. Broadening FOS accessibility
Effective application of FOS traditionally requires significant learning and experience; however, ChatGPT makes it easier for a broader range of users to apply FOS. This allows individuals with varying levels of expertise to analyze complex problems or create innovative solutions by integrating FOS with ChatGPT.

Nevertheless, this study is not without its limitations. A key limitation is its reliance on a single in-depth case study. Therefore, to move

beyond the constraints of a single case and evaluate the generalizability of the proposed approach, future research should undertake a broader range of case studies. Furthermore, although the synergy between FOS and ChatGPT appears promising, its implementation requires further refinement for wider applicability. Future progress will benefit from developing user-friendly tools, such as plugins, apps, or interfaces to facilitate the use of FOS through ChatGPT.

Since its release in November 2022, ChatGPT has received an overwhelming response, and ongoing efforts continue to explore its potential across various sectors. This study represents one step in that direction and aims to serve as a foundation for future research.

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Conflict of Interest

The authors declare that they have no competing interests.

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