Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

EnerGPT – Enhancing Energy Literacy Education by Customizing ChatGPT

Thimo Schulz[a], Kim K. Miskiw[a], Christina Speck[a] and Christof Weinhardt[a]

[a]Karlsruhe Institute of Technology, Germany

Abstract

The escalating climate crisis and economic pressures underscore the critical need for enhanced energy literacy. As the concept of energy literacy is broadly defined and hardly palpable for individuals, we align the energy literacy dimensions of knowledge, attitude, and behavior with the multifaceted household energy literacy model. Based on this tangible, yet robust construct, this paper introduces EnerGPT[1], a custom Generative Pre-trained Transformer (GPT), designed to elevate household energy literacy among individuals. Based on inquiry-based learning theories the model is equipped with specific datasets and knowledge tailored to household energy literacy education and features adhering to best practices for chat-based educational systems. These include personalized learning experiences, motivational elements, multimodal content delivery, and interactive learning activities. An initial evaluation by energy domain experts highlighted EnerGPT's potential in providing valid content, motivating user engagement, and addressing the need for concise, multimodal educational material. While the study acknowledges limitations such as limited access to custom GPTs and the absence of a structured energy literacy curriculum, it opens avenues for future research in applying generative AI in educational contexts. EnerGPT represents a significant step towards utilizing AI for fostering energy literacy, aligning with inquiry-based learning theories and adapting to users' knowledge and needs. This approach not only contributes to the field of AI-driven education but also plays a crucial role in preparing individuals to navigate and contribute to a sustainable energy future.

Keywords: ChatGPT; Energy Literacy; Education; Inquiry-Based Learning.

[1] Accessible at https://chat.openai.com/g/g-lvbucPM2Z-energpt (requires ChatGPT Plus)

How to cite: Schulz, T.; Miskiw, K. K.; Speck, C. and Weinhardt, C. (2024) EnerGPT – Enhancing Energy Literacy Education by Customizing ChatGPT. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 52-61. https://doi.org/10.4995/SEED2024.2024.19007

1. Introduction

The urgency of addressing the climate crisis is increasingly recognized as a pivotal challenge. This necessitates a profound transformation in our energy consumption, touching every aspect of society, as covered by the sustainable development goals (SDGs) (UN DESA, 2023). The most palpable challenge is the transformation needed in the household sector. Not only does this sector account for 28 % of the energy consumption in the EU making it a crucial area for changes induced by individuals, (Eurostat, 2023), but in the context of notably inflation and rising energy prices, the attention of individuals is also shifting towards their energy consumption. Similarly, energy poverty has been highlighted as a potential challenge for the upcoming decades (González-Eguino, 2015; Streimikiene and Kyriakopoulos, 2023). In this context energy literacy is not merely an academic concept but a practical tool for empowering individuals and communities to make informed decisions about energy use, also referred to as household energy literacy (van den Broek, 2019).

In-line with the fourth SDG (UN DESA, 2023), new avenues for education and public engagement, also in the context of household energy literacy, were opened by the advent of generative AI tools, particularly ChatGPT. The concept of a "custom Generative Pretrained Transformer (GPT)" (OpenAI, 2023) takes this a step further, allowing for the creation of specialized AI models tailored to specific domains and use cases, such as enhancing energy literacy. While hallucinations are an issue of generative AI models (Zuccon et al. 2023), these custom GPTs can be equipped with ground-truth data to counteract this. Additionally, they can easily be updated with new information which is especially important in the face of the evolving diversity of energy generation and storage devices, that individuals are confronted with, e.g., balcony photovoltaic systems or smart meters. This allows for a consistent education application that grows with its demands.

While there are few works shedding light on the usage of conversational agents for energy efficiency, energy feedback, or energy saving (Fontecha et al., 2019; Giudici et al., 2023; Gnewuch et al., 2018), the use of generative AI for energy literacy education is currently unexplored. To address this gap, we explore the development and application of a custom GPT model designed to enhance household energy literacy among individuals. Based on the literature surrounding inquiry-based learning and design elements for educational conversational agents (ECAs), we draw general conclusions for the customisation of ChatGPT models. By leveraging the capabilities of generative AI in energy literacy education, we aim to contribute to the broader efforts in promoting sustainable energy practices and addressing the challenges posed by the climate crisis and economic pressures.

2. Foundations

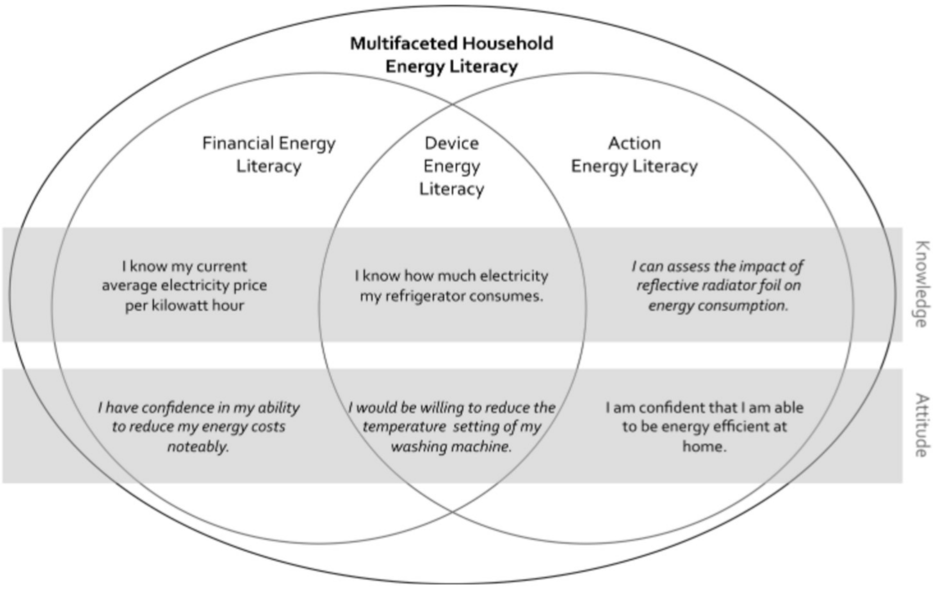
2.1 Energy Literacy and Household Energy Literacy

Integrating energy literacy into education is particularly crucial for building awareness and supporting government programs in national energy conservation (Rohmatulloh et al., 2021). Moreover, studies found that energy literacy levels are only moderate across all educational fields, among others natural and environmental sciences, or life sciences and health (Martins et al., 2019). This suggests the need for an enhanced approach in energy education to achieve higher levels of literacy, which is also in-line with the UN's SDG 4 (UN DESA, 2023).

Different works have come up with diverging definitions for energy literacy. While there are definitions that focus on a rather specific aspect of energy literacy, e.g., financial literacy (Blasch et al., 2018) or economic aspects (Brounen et al., 2013), DeWaters and Powers (2011) present a holistic approach towards energy literacy entailing the dimensions of knowledge, attitude, and behaviour. However, this broad concept is not easily addressable. Exemplarily, Lee et al. (2015) revealed a notable discrepancy between affect and behaviour, indicating that knowledge alone may not lead to responsible energy use.

To tackle this problem of poor tangibility for individuals, van den Broek (2019) define a multifaceted household energy literacy, composed of the concepts of financial energy literacy, action energy literacy, and their intersection device energy literacy. Regarding the concept of action energy literacy, Akitsu and Ishihara (2018) uncovered that awareness of consequences is a powerful predictor for linking basic energy knowledge to energy-saving behaviour. Bluhm et al. (2023) also conclude that for a behavioural change the energy self-efficacy of an individuum needs to be strengthened. Thereby, energy self-efficacy equals the confidence in the personal capabilities to change behaviour (Bandura, 1977). Bluhm et al. (2023) contribute a measurement instrument dedicated towards household energy literacy.

Fig. 1 – Intersection of household energy literacy (van den Broek, 2019) with knowledge and attitude dimensions (DeWaters and Powers, 2011) matched with exemplary questions based on Bluhm et al.(2023)



Source: Own elaboration

To combine both approaches, namely the three-dimensional model by DeWaters and Powers (2011) and the multifaceted household energy literacy model by van den Broek (2019), we align these models and assign the questions from Bluhm et al. (2023) to the intersections (cf. Fig. 1). As the behaviour dimension must be observed in real-life settings, we drop this dimension for our model. As not all intersections are directly targeted by the questionnaires proposed by Bluhm et al. (2023), we complement the intersected model with questions that specifically address these aspects, which are marked as cursive.

2.2 ChatGPT and Generative AI in Education

The advent of ChatGPT and generative AI has brought new educational avenues to existing learning theories, such as self-directed learning and heutagogy (Canning, 2010; Blaschke, 2012; Susnea, 2023), and especially inquiry-based learning (Avsec and Kocijancic, 2014; Cooper, 2023). Inquiry-based learning describes the process where learners educate themselves by critically questioning and exploring topics to come up with an understanding of the learning subject. Pedaste et al. (2015) provide a flexible inquiry-based learning framework consisting of 5 phases, namely orientation, conceptualization, investigation, conclusion, and discussion. Additionally, Ramandanis and Xinogalos (2023) provide an extensive list of design elements for ECAs. To enable a learning experience that covers all stages of the inquiry-based learning framework, we integrate these design elements as described in the following chapters.

3. Approach

To leverage the potential of generative AI, especially ChatGPT for increasing household energy literacy, we utilize the newest ChatGPT feature, namely custom GPTs. Custom GPTs refer to a new class of GPTs developed by OpenAI, designed to be more specialized and adaptable to specific tasks or industries compared to their predecessors (OpenAI, 2023). These GPTs can be fine-tuned or tailored using specific datasets. This customization enables the models to generate more accurate, relevant, and context-specific outputs, enhancing their utility in specialized fields. To generate a GPT for energy literacy education, we first define what aim in educating we pursue. Following the intersected energy literacy model in chapter 2.1 we aim to enhance knowledge concerning financial, device, and action energy literacy on a knowledge and attitude scope. Therefore, we guide the learning experience with the enriched questionnaire from Bluhm et al. (2023). Afterwards, we employ the design suggestions for ECAs by Ramandanis and Xinogalos (2023), to ensure that the GPT adheres to best design practices. Since instructions are given to custom GPT models in a loose setting, the second phase of our approach involves a concise evaluation, from which the feedback was implemented. For a first evaluation of EnerGPT, we asked three independent researchers from the energy domain to thoroughly test it. They identified three main points for improvement, which are already considered in the instructions and resources described in the following chapter. First, EnerGPT's answers were too long and overwhelming. Second, EnerGPT struggled to create a multimodal learning experience, mainly due to a small data basis and lacking emphasis on data visualization. Lastly, EnerGPT but also ChatGPT in general seem to fail to clearly distinguish the terms of energy and electricity.

4. Building EnerGPT

To build EnerGPT – our custom GPT for educating energy literacy – we first thoroughly screened the design suggestions for ECAs by Ramandanis and Xinogalos (2023) to create a list of relevant requirements. As they extracted extensive design suggestions through a literature review, we focus on those that are mentioned in at least three publications.

We build EnerGPT by finetuning and modifying ChatGPT. Aligning ChatGPT's functionalities with the design suggestions by Ramandanis and Xinogalos (2023) shows that some of the most popular design elements for ECA's are present in standard ChatGPT applications. However, to fully exploit the potential for inquiry-based learning, further refinements are necessary to comply with the ECA design elements. Table 1 gives an overview of the design elements and their incorporation in ChatGPT and EnerGPT.

Table 1 – Design elements for ECAs (Ramandanis and Xinogalos, 2023) and their presence in ChatGPT and EnerGPT

Design elements inherently present in EnerGPT through ChatGPT	Design elements additionally added to EnerGPT
(1) Equipment of the ECA with many variations for phrases with the same meaning. *(2) Capability to discuss wide range for discussion topics including casual, non-educational subjects.* *(3) Utilization of previous students' responses to improve its conversational ability and provide personalized communication.* *(4) The ECA should provide feedback to students.* *(5) Alignment of the ECA's function with the ethics policies and rules for the protection of the user data.*	*(6) Alignment of the ECA's function with students' learning needs.* *(7) The ECA should provide educational material in small segments with specific content.* *(8) Provision of motivational comments and rewarding messages to students.* *(9) Utilization of human-like conversational characteristics such as emoticons, avatar representations and greeting messages.* *(10) Explanation of the educational material from various perspectives.* *(11) Handling of quizzes, tests, or self-evaluation material.* *(12) Provision of challenging and interesting student learning activities.* *(13) Provision of educational material in various forms apart from text message.*

Source: Own elaboration

4.1 Instructions and design elements

To further fine-tune EnerGPT we added custom instructions to match the design suggestions. Regarding design elements *(6)* and *(7)*, we see *learning needs* from two perspectives. On the one hand, meaning that an ECA should streamline the conversation to focus on the topic, and our defined learning aims in chapter 3. On the other hand, we understand learning needs as the necessity to adapt the learning experience to the knowledge of the user. To achieve this, EnerGPT assesses its users' knowledge based on their answers and *adapts the conversation*. Furthermore, EnerGPT is instructed to provide *brief, to-the-point answers*, expanding on topics when the user shows interest in more detailed information. This method allows for a more personalized and effective learning experience, gradually enhancing the user's understanding of energy topics in an interactive manner.

As ChatGPT is proficient in theories and practice of motivation and learning (Susnea, 2023), we found it sufficient to instruct EnerGPT to keep the conversation going and provide a pleasant and efficient learning by sticking to suitable *motivation and learning theories*. Thereby, we employ design element *(8)*. In addition to the *human-like conversational characteristics* that are already implemented in ChatGPT, at the start of each new interaction, EnerGPT shortly introduces itself and its purpose to meet *(9)*. ChatGPT is inherently able to illuminate topics different points of view. For design element *(10)*, EnerGPT is set to explain energy-related educational material from *various perspectives*, encompassing scientific, environmental, economic, and societal aspects, to enhance comprehensive energy literacy tailored to different individual backgrounds following Martins et al. (2019) findings.

Furthermore, EnerGPT leverages *gamification elements*, *like quiz questions*, to foster motivation and learning and comply with *(11)*. This is in line with the implementation of *(12)*, as activities are diverse and inclusive, catering to different learning styles and interests, and ultimately foster critical thinking, problem-solving skills, and a deep understanding of the subject matter. In addition to quizzes, the ability of ChatGPT's Code Interpreter allows us to equip EnerGPT with the functionality to visualize data to create a multimodal learning approach as highlighted by design element *(13)*, especially for historical values, statistics, and trends. To use this feature, we equipped it with additional resources as listed in the following.

4.2 Additional resources

In addition to the instructions, we provide EnerGPT with resources to gather knowledge from and to deliver more streamlined and valid information and learning. To supply EnerGPT with an established definition and depiction of energy literacy, we provide it with the research paper by Martins et al. (2019). In doing so, we ensure that the conveyed energy literacy learning is in line with findings from scientific studies. To use a validated question set for gauging users' household energy literacy, we add to EnerGPT's knowledge the items proposed by Bluhm et al. (2023), as well as the newly created questions to match the intersected model as shown in Fig. 1. To create a database for visualizations and a multimodal learning experience, we feed EnerGPT statistical data from Eurostat regarding electricity prices and their components, as well as energy consumption by type of fuel and per capita (Eurostat, 2024). For this data, preprocessing is necessary in order to allow an effective usage through EnerGPT, as custom GPT applications need clean data sheets for their analyses.

5. Conclusion

Overall, we equipped custom GPTs with knowledge and instructions to enhance household energy literacy. For this we leverage the current literature on energy literacy and intersected different literacy models to define the educational aim of the custom GPT. To ensure an effective inquire-based learning environment we assessed the needed design elements and the inherent coverage of them by ChatGPT. By implementing the not covered design elements, we showcase the adaptability of custom GPTs to provide such a learning environment. The generated custom GPT – EnerGPT – for enhancing household energy literacy holds the potential for individuals to educate themselves on the highly relevant topic of energy and sustainability in an interactive and motivating way. This aligns with existing learning theories and further allows the adaptation of content and complexity on user's knowledge and learning needs. The preliminary results show that the content that EnerGPT provides is generally valid and is motivating and pushing its users to dig deeper into the topic.

Thereby, this study contributes to the current research efforts of leveraging generative AI technology for educational purposes. Moreover, it sheds light on generative AI as an effective tool for energy literacy enhancement. This study also opens interesting avenues for future work. EnerGPT does not follow a clear energy literacy curriculum but emphasizes on inquiry-based learning. While there is not one single unified energy literacy curriculum, we see it as useful to enhance EnerGPT with a clearer learning path. Moreover, in the next steps EnerGPT should be tested in a real-world setting with individuals seeking to increase their energy literacy. In doing so, we see great potential of furthering the understanding of generative AI for education, and more specifically for household energy literacy.

Acknowledgements

We gratefully acknowledge funding by the Federal Ministry of Education and Research (BMBF) and the Ministry of Science, Research and the Arts (MWK) of Baden-Württemberg (Grant No.: 16DHBKI004).

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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